WEC 2023

7TH WORLD ENGINEERS CONVENTION

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ABSTRACTS

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Abstracts

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Enabling Our Sustainable Futures Beyond 2030: What it will take, what is being done

Marlene Kanga *(World Federation of Engineering Organisations, Maison de l'UNESCO, Paris, France)*

The UN Sustainable Development Report 2019, recognized that science and technology are key levers to advance the UN 2030 Agenda for Sustainable Development. With just 8 years remaining, engineering technology is advancing quickly to address issues such as climate change, food security, improved health outcomes, especially during the pandemic, access to reliable clean water and sanitation, and energy. This has been and will continue to be the work of engineers.

But technology alone will not deliver the changes we need. We need a paradigm shift in the way technology itself is developed and how the benefits are shared across the world, especially beyond 2030. This will require an increase in the capacity and capability for engineering and technology and equity of access and agency for underrepresented groups including women, young people, the rural poor, many in developing countries.

Enabling more engineers with the right skills in these countries is therefore key to ensuring our futures in a rapidly changing technological world. The review of the international engineering education benchmarks for Graduate Attributes and Professional Competencies (GAPC) by the International Engineering Alliance (IEA) in partnership with UNESCO and the World Federation of Engineering Organisations (WFEO) has enabled the transformation in the way engineering is taught and the outcomes of engineering for the future.

The GAPC Framework underpins the basis of mutual recognition of engineering qualifications and professional credentials in engineering through the signatories of the International Engineering Alliance, located in some 30 economies on every continent. The review is the most significant change that has occurred to the Framework since it was first developed in the early 1990s and will ensure that engineering education and professional development programs reflect contemporary values and employer needs as well as equip engineering professionals of the future to incorporate practices that advance the UN Sustainable Development Goals and beyond 2030. Implementation of the Framework has commenced and is expected to transform engineering education and practices with engineers who are inclusive and able to work effectively in diverse teams, think critically and thoughtfully about the impact of their work, considerate of broad ethical considerations and be committed to adapting to new technologies and pedagogies as well as lifelong learning.

Recognition by UNESCO will ensure that the GAPC Framework will be the pre-eminent international benchmark for engineering education and professional development.

Dr Marlene Kanga will speak about the role in transforming engineering especially in education and will provide valuable insights into the changes that have been made and the imperative for these and the expected global impact of these changes.

Energy: a challenge but also an asset for achieving the SDGs

Jean Eudes Moncomble *(World Federation of Engineering Organizations Committee, France)*

The history of mankind shows that energy has played a decisive role in economic development and social progress. Today, however, it is often the disadvantages of producing and using energy that are highlighted, and sometimes with good reason.

The aim of this conference is to show that energy can make a decisive contribution to sustainable development. Energy choices are key to achieving the Sustainable Development Goals. To do this, they must be based on a long-term global vision and implemented by energy policies and strategies that are relevant, technologically robust, accepted by the citizens and conceived within an international framework.

How Space Data and Services contribute to a more sustainable future

Fiammetta Diani *(European Union Agency for the Space Programme)*

Fiammetta Diani will explain how space is contributing to a more sustainable world, focusing on the Space Program of the European Union. The world reached a significant milestone as the global population hit 8 billion people. This remarkable achievement in human development is a result of gradual improvements in public health, nutrition and medicine, which have led to an increase in the human lifespan. However, the increase in population presents both challenges and opportunities that must be addressed through relevant frameworks and initiatives, ensuring continued development while considering the sustainability of human activities. With these challenges in mind, the European Union Agency for the Space Programme (EUSPA) and the United Nations Office for Outer Space Affairs (UNOOSA) are cooperating to promote the use of space technology, data and services for achieving sustainable development. During the lecture, Fiammetta will discuss the main findings of a joint study by EUSPA and UNOOSA analyzing the role of the European Union Space Programme components, namely Galileo, EGNOS, Copernicus and GOVSATCOM/Iris 2, and their synergies in addressing the sustainable challenges facing an 8 billion world today. This includes how EU Space and its synergies can actively contribute to tackling several sustainability challenges, including food security, water management, environmental impact and climate change, disaster management and emergency response, migration, urbanization and energy. During the lecture you will learn also about how EUSPA is fostering entrepreneurships in Europe to create a new generation of space innovators and entrepreneurs, in many cases young engineers, that are contributing to change the space sector and to leverage the space data for a more sustainable future.

Sustainability-orientated Engineering Education for Future Entrepreneurs

Diana Elizabeth Lezcano Zapata (Germany), Jürgen Kretschmann (Germany)

Entrepreneurship in engineering education is a key factor for the future. It gives students a wider perspective, encourages creativity and innovative thinking, and allows them to apply their skills and knowledge in a variety of contexts. Entrepreneurship skills can also be a source of motivation and personal satisfaction by creating innovative solutions and solving complex problems.

Teaching entrepreneurship in combination with sustainability especially regarding natural resources is expected to foster the creation of sustainable working companies that meet challenges like resource optimisation, product and process innovations, waste recycling, reutilisation of raw materials amongst others. The results can have a significant impact on the world, local and global, and contribute to the SDGs.

The authors explain two initiatives, one from the European Union and one from Germany, that aim to train and mentor engineering students in entrepreneurship, and motivate them to start their own companies within a network of partners.

Keywords: Sustainability, Engineering Education, Entrepreneurship, Natural Resources

Novel Approaches to Manage Water Use in the Food Industry to Support Circular Bioeconomy

R. Paul Singh *(Biological and Agricultural Engineering, University of California, Davis, USA)*

During the past several decades, the food industry has dramatically improved manufacturing efficiencies to meet the goals of providing consumers with plentiful, safe, healthy, and affordable foods. Traditionally, this industry has primarily relied on linear systems from the farm to the fork. Availability of resources such as energy and water at low cost were major factors in the industry's growth. Significant attention to resource use began as environmental regulations were introduced restricting untreated waste water discharge from processing plants. In many locations, the cost of water increased as competing demands from urban areas impacted the availability of freshwater needed in processing operations. Similarly, the increasing energy cost made it imperative for the food industry to seek improved equipment and processes to support conservation. More recently, there has been a rising interest in transforming the food and agricultural systems into circular systems that support a sustainable bioeconomy. While still in its early stage, the concept of circular economy seeks ways to reduce the use of natural resources by closing material and energy loops. The strategies encompass reduce, reuse, recycle and regenerate. There are plentiful opportunities to seek circularity in water management in food processing operations. A comprehensive study at the University of California identified modifications for numerous food processing industries that address the four circular economy strategies. The ongoing quest to meet the increasing population's food needs will require innovations in resource management to seek sustainability in the food processing industry.

1. New Solutions for Energy

Hydroelectric power generation from pit dewatering excess water for the benefit of mine sites' surrounding communities

Chriss Monga Kabongo (Electrical and Computer Engineering, Mississippi State University and Kamoa Copper SA Mine, Kolwezi, Congo, the Democratic Republic of), David Ilunga Kalenga (Polytechnics Faculty, Department of Electromechanics, University of Lubumbashi, Lubumbashi, Congo, the Democratic Republic of)

Aim: One of the mining operations' constraints is the requirement to continuously dewater the existing aquifers and rainwaters, by different means, to maintain smooth production. The amount of water involved could represent up to several hundred million liters daily. All or part would be used during the ore processing and for large operations a considerable amount would be ultimately wasted. This represents a huge quantity of lost resources sent to the environment, mainly to streams and rivers. Such a practice is common in the Democratic Republic of Congo; a country whose economy strongly depends on the mining industry.

The present submission aims to evaluate the opportunity to generate electric power from the energy contained in the above excess water in an efficient way. This energy can be considered a free resource as the pumping cost of the mine-dewatering water is already taken care of by the mining production capital expenditure and operational expenses.

In the Democratic Republic of Congo, the electrification rate was estimated to 19.1% in 2020; of which 40.7% was in urban areas, and only 1% in the rural area. Therefore, recovering as much energy as possible from such currently wasted resources could serve to supply at least part of the communities living around the mine sites with green electrical energy. This would serve to participate in the rise of the country's electrification rate especially in rural areas. Interestingly, the recent liberalization of the electricity sector, effective in 2014, in the country favors such a project as any actor part of the private sector now has the green light to generate and sell electricity at a recommended tariff.

Methods: Our study uses actual water volumes measured over a period of four years at two operational copper mines in the Southeastern part of the Democratic Republic of Congo. With that in mind, we evaluate an efficient way to generate electric power for each site based on the survey data, water volumes, and velocity. Thereafter, key indicators such as the total power that could be generated from each site, the energy consumption per household, the number of surrounding community households likely to be impacted by such a project, and the corresponding monthly bill per household are estimated. Additionally, the means to distribute power from the production point to end consumers are investigated. Any cost is derived from the recommended energy tariffs, by the Congolese National Ministry of energy, for local producers and consumers in the country's Southern region. Consequently, the worthiness of the project is evaluated and criticized.

Results: Our findings are as follows for the two considered copper mines in the South of the Democratic Republic of Congo.

Mine #1 is located in the very South of the country, in the Haut-Katanga province. A total of approximately 6,000 m3/h of excess mining dewatering water is continuously discharged in a 332m canal with a velocity of 2.18 m/s and only a net head of 5.38m, from one end to another. As a result, the best-suited solution would be installing a hydrokinetic or similar turbine along the canal with the potential to only generate up to a few tens of kW.

Mine #2 is located in the country's Southwest, in the Lualaba province. Its operations discharge over 10,000 m3/h in two different canals which join at a ravine that offers a net head of 35m. This makes it suitable for a small-capacity hydroelectric power station capable of delivering between 400 and 700 kW. Hence, we

selected this specific mine site to study how many households could benefit from the electricity generated from dewatering excess water.

We have considered an average household in the rural environment in the DR Congo Copperbelt region. It will usually comprise two bedrooms, a living room, an outdoor veranda-type kitchen, a bathroom, and a restroom facility. Its power draw and monthly energy consumption can be estimated to be 1.4kW and 259 kWh. Hence, between 300 and 500 households would benefit from the above hydropower plant. At the current producer's energy tariff of $0.12 per kWh, as recommended by the central government, each household would be billed at $31 every month.

For ease of power distribution, the hydropower generator would be synchronized with the existing mine's power systems. Consequently, the generated energy could be distributed, at medium voltage, to the different villages that are crossed by some of the powerlines. In the Southern DR Congo, a mine would often be supplied from the local power supply utility (SNEL), the Zambian electrical network, Diesel generators, and, in our case, distributed renewable energy resources, such as the hydropower plant in question. Hence, the power system must be strictly controlled.

Conclusion: This paper presents the opportunity to generate some electrical energy from free water resources continuously discharged into the environment via streams and rivers around mine sites. This may contribute to rising the very low electrification rate in the Democratic Republic of Congo, especially in the rural areas where most mines operate.

Although dewatering water volumes would generate some cheap energy using surplus resources from mining operations, the purchasing power is usually very low in the rural areas and only a small amount of people would afford a monthly energy bill. As an alternative, the adoption of a lower tariff for consumers in rural areas could be studied, subject to guaranteeing that such a project would remain viable.

In particular, synchronizing the power supply with the existing network should facilitate access to electricity for community members. Nevertheless, this raises additional constraints, mainly due to the generally poor quality of supply in the country. Thus, electrical systems must be closely controlled at all times.

Finally, the above project is not entirely sustainable as it depends on the mining operations and therefore the lifespan of the mines. Additional energy sources should therefore be considered. One option could consist of financing more sustainable alternatives using the project revenue.

Energy efficiency is key for more sustainable energy systems and cities

Daniel Favrat *(EPFL Energy Center/ WFEO Energy Committee, Lausanne, Switzerland)*

There is a large consensus that the world needs to curb its greenhouse gas (GHG) emissions. As shown by the international Energy Agency (IEA) as early as in their 2009 outlook report, energy efficiency is key to achieve this goal with a relative contribution even more important than renewables, nuclear and Carbon Capture and Storage (CCS)considered separately. Of course, energy efficiency is a broad domain and major inefficiencies exist. Nuclear is perhaps the most striking one, since some fourth generation concepts like the molten salt reactors could generate up to 50 times more electricity per kg of uranium compared to Second or Third generation (Tani, Haldi, Favrat; ECOS 2010). This is linked to a better use of nuclear fuels with, in particular, a limitation of the production of very long-life wastes. However economic aspects have so far prevented their development, even if new projects emerge along this path. In road transportation operational efficiency gains of the order of a factor 3 can be achieved with the transition to electrical vehicles, thanks, in particular, to braking energy recovery, better batteries and more efficient motors. Substitution of direct electric heating systems with heat pump allows an efficiency improvement of a factor 3 to 5 depending on the heat source and the heat convectors. Replacing fuel boilers by a combination of heat pumps and cogeneration units, not necessarily at the same location, can offer efficiency improvements of a factor 2 to 3. Decentralized power technologies also have a significant margin for efficiency improvement. Apart from discussing performance indicators, this contribution intends to focus on two innovative technologies, which separately or combined, have a great potential to contribute to more sustainable communities and cities.

Present cities are wasteful with little synergies between users. Heating and hot water services are still predominantly supplied by simple boilers with fluegas loaded with local pollutants being eliminated through chimneys. In the meantime, waste heat from cold users (office building, shops, supermarket, servers) in the same area is dumped into the atmosphere. On the global level, climate change increases the number of weeks per year with high temperatures in many parts of the world where air-conditioning was not a major concern. Hence the need for planners to not only think about infrastructure for heating but also for heating and cooling in a way that does not increase heat islands in cities. In terms of efficiency most cities offer a contrasted picture with a mix of retrofitted buildings with up-to-date insulation and non-retrofitted buildings with high energy needs. Therefore, the previous generation of District energy networks with a high supply temperature to meet all the various heating needs or District cold networks with excessively low temperature for air-conditioning purposes are to be questioned.

Emerging low temperature (5 to 15°C) district heating and cooling (DHC) of 5th generation sometimes called “anergy” networks can substantially improve the synergies between users by providing heat to local heating heat pumps and direct cooling to most cold users while offering a way to recover the waste heat from heat emitters and avoid the dissemination of cooling towers. Of course a balancing plant needs to be implemented at the district level with a central heat pump and/or a cogeneration unit compensate for the unbalance between the needs of the various users. Heat or cold sources for the balancing plants can be based on environmental heat: treated water from sewage water treatment plants, lakes or rivers, fields of shallow geothermal probes under parks, or centralized cooling towers. Two types of 5th generation DHC are currently proposed. Water networks with small differences of temperature requiring large piping systems or networks using CO_2 in closed loops as a transport fluid with more compact pipes requiring less digging of the streets and less embedded energy. In the latter case the CO_2 network with one vapor pipe and one liquid pipe at about the same temperature and pressure acts like an umbilical cord through the district and plays mainly on the latent heat of this inert natural refrigerant. One such network has been recently commissioned in the Swiss city of Sion (ExerGo.com). While performance results are not yet available a theoretical study with such a system in a district in Geneva has shown that more than 80% the energy

required can be saved compared to the existing boilers and standard cooling units (Henchoz, Weber, Marechal, Favrat; Energy 2015). However, the new approach implies a slight increase in electricity consumption of the district, hence the interest to integrate cogeneration.

Solid Oxide Fuel Cells (SOFC) that operate at high temperature are particularly efficient for decentralized electricity production or cogeneration of heat and power without the emissions of local pollutants. They can directly convert most methane (CH_4) from natural gas (NG) and have the intrinsic interest of separating O_2 from the other components of air like N_2. Air is typically introduced at the cathodic side and partly reformed NG at the anodic side. At the operating temperature (about 800°C) the oxygen selectively crosses the membrane from the cathodic to the anodic side and oxidise some 80 to 90% of the fuel. The remaining inoxidized gas needs to go through a post combustion step ideally with hydrogen input. The anodic out flow is then essentially made of CO_2 and H_2O. The lower the cooling temperature of the fluegas can be, the better can the H_2O be condensed and the CO_2 be separated. Hence the interest of combining CO_2 networks with SOFC cogeneration units at the district level providing access to a low temperature all year around and a way to potentially transport the separated CO_2 via a separate low pressure pipe to various collection points throughout the city. One further efficiency improvement can be achieved by combining the SOFC with a gas turbine cycle (GT or Brayton) making a so-called hybrid SOFC-GT cogeneration unit. Since most practical SOFCs are planar rather than cylindrical, atmospheric pressure is preferred in the cells. One patented hybrid concept introduces a sub-atmospheric Brayton cycle. The whole anodic flow from the post combustion is expanded in a turbine to a pressure of the order of 0.3 bars abs., the water vapor is condensed and pumped separately to the atmospheric pressure and only the CO_2 needs to be compressed in a compressor to the original atmospheric pressure. Extra power can thus be recovered topping the electricity production of the SOFC. Overall electrical effectiveness of more than 69% (based on the fuel lower heating value) and exergy efficiency of more than 70% can be theoretically achieved with even 7 to 8 extra percentage points with more advanced configurations based on the same process (Facchinetti, Favrat, Marechal; Fuel cells 2014). This is of course valid for both NG and synthetic natural gas (SNG). Even more promising is the same concept applied to hydrothermally gasified waste biomass because then the captured CO_2 would be a net cleaning of the CO_2 from the atmosphere (Facchinetti, Gassner, d'Amelio, Marechal, Favrat; Energy 2012). Electrical effectiveness of 63% could be achieved when these two technologies are integrated at the same location, meaning an improvement of some 4% compared to situations where the two technologies are applied on different sites and therefore not integrated. While there is a lot of discussion about dismantling natural gas city networks in the context of zero carbon societies, their complementary use to distribute more and more SNG to feed efficient cogeneration units with CO_2 separation should be seriously considered.

Flexibility is also important in the context of energy systems and SOFC have an additional advantage that the flows can be reversed. They can operate as high temperature electrolyzers (SOEC) when there is an oversupply of electricity available from the grid and generate hydrogen for other uses including energy storage, feeding hydrogen vehicles, supplying methanation plants or simply feeding the post combustor of the hybrid SOFC-GT plant at high electricity or heating demands.

Thanks to the emerging use of high-pressure composite pipes from the offshore gas industry, CO_2 based DHCs are well in line both economically and energetically to compete with other DHC systems. The question is more difficult for SOFC units that still suffer from high specific costs due in part to the small production level and to life-time issues due to potential deposits on, or structural transformation of, the cathodes and anodes. Significant progress is being made on these two fronts and we can expect major advances in the years to come. What is nice with that technology is that contrary to low temperature fuel cells it does not rely on expensive catalysts or require drastic purity of hydrogen feed.

We cannot talk about energy efficiency without having the appropriate tools to measure it. Unfortunately, in practice, still rudimentary indicators based only on the First Law of thermodynamics are being used. Since the First Law states that energy is being conserved most of the time the performance values obtained are mainly measuring the degree of thermal insulation of the energy system considered and not its ability to provide useful energy services. Energy in Greek was supposed to characterize the capacity to do work and not to designate a value that is conserved. In fact, the capacity to do work is expressed by the notion of exergy, a notion that combined First and Second Laws of thermodynamics. A typical example is the fact that the First Law "efficiency" of home boilers is quoted in the commercial literature with values between 70 and 105%, while their exergy efficiency is indeed only of 3 to 10% depending on the temperature of the heat delivered and on the atmospheric temperature. Higher than 100% values in First Law efficiencies result from the different choices of fuel heating values for reference. Such a confusion does not exist for exergy efficiencies (Borel, Favrat; EPFL Press 2010). A proposal to include the exergy efficiency as the performance indicator for the active part of energy systems in communities was applied in a local Law on energy (Favrat, Marechal, Epelly; Energy 2008). The proper way to analyse the different possibilities to heat or cool buildings is summarized with a decomposition in 4 subsystems going from a power plant typically outside town, a DHC plant, a building plant and room convectors. The exergy efficiency associated with the possible technologies for each subsystem can be documented in structured lists and the overall efficiency calculated as a product of the efficiencies of each subsystem. One of the important conclusions was the following: "Supply heat at the lowest temperature as possible and supply cold at the highest temperature as possible". The early results penalized DH systems because of the assumption made of the need to supply heat at 80°C. Applying the two technologies described above (Fifth generation CO_2 networks and SOFC-GT) significantly improve the positioning of these DH systems in the ranking of the best solutions.

Another important methodological approach is to have an appropriate documentation of the demands for heating and cooling, in particular. Geographical Information Systems (GIS) should not only include the amount of energy needed but also the temperature level required since it plays a major role when dealing with heat pumps systems (Girardin, Marechal, Dubuis, Calame, Favrat; Energy 2008). Developing more sustainable systems implies a change of paradigm for comfort energy and power supply. For heating the idea is not to start with the high flame temperature and downgrade it to satisfy the different services but to start from the environmental temperature upwards to satisfy the same services. For power supply the idea is not anymore to count only on a centralized power grid but to also consider decentralized cogeneration solutions with their increasing efficiency to complement the supply from other local renewables.

Energy solutions using dual use technologies: The role of Project Governance in choosing investment options

Edward J Tooher *(Civil Engineering, TGA Pty Ltd and University of Sydney, Sydney, Australia)*

The aim of this paper is to address the issues of Engineers failing to apply multi discipline solutions to renewable energy investments, particularly the focus on the business case for large generator such as solar and wind farms, SNR, battery storage and grid connection. The problem to be addressed is that consumer focused models are ignored, whilst exponential growth continues in household and single industry, solar, battery and EVs. The massive tidal wave of EV (car and truck) each with 50 to 500KWH at household, industrial or city parking stations (30% of cars and trucks will be Battery powered by 2030) is an opportunity to avoid expensive and environmentally damaging outcomes.

Methodology used is asset investment and demand management (AI and Kraken software), based on technology disruption as applied to business cases for this type of investment.

Results show that reduction in grid investment of the order of 50% are achievable. Also efficiency gains (2 to 3 times rated capacity) can be achieved from rooftop solar (household and Industrial) though avoiding transmission losses, higher load factors, house as a battery. The outcome is massive environmentally damaging investments in pumped Hydro, wind / solar farms including battery storage can be avoided.

It is concluded that this failure is due to two factors, firstly options involving non conventional and multi-use technologies are not analyzed, and secondly, disruptive innovations with beneficial impact on the environment are often ignored for commercial reasons. Both factors arise from conflicted and ineffective Project Governance.

Energy Performance of Buildings: From EU Directive to Implementation in Slovakia

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Abstract: A new Directive no. 2018/844/EU has been implemented in Slovakia since 1st January 2021, that aims to reduce the energy consumption and the dependence of the European Union member states on primary energy sources. New form of directive introduces the definition on nearly zero energy buildings, and the global indicator for total energy use in buildings was changed to primary energy use, which also altered the EPC template. The decree sets out a gradual tightening of the minimum requirements since 2021. Simultaneously, the directive aims to promote the use of renewable energy sources to cover the energy consumption and reduce the harmful CO2 emissions, that impact the environment. More than 100 000 family houses in Slovakia were built in the 1950s to 1970s. These houses have similar floor plans, indoor dispositions, and material design. They do not meet current thermal insulation requirements. This paper aims shows the possibilities to implementation of energy-saving measures for old family house, to attain a nearly zero energy standard and meet the current energy standard of the 21st century.

Introduction

The revised version of Directive no. 2018/844/EU on energy performance of buildings was approved by the Parliament and the Council and contains many changes. The most important one is that all new buildings in the EU built since 1st January 2021 have to consume “nearly zero” energy and the energy should to a significant extent be covered from the renewable sources. General definition of a nearly zero energy building (nZEB) says that nZEB is typically a grid connected building with very high energy performance which balances its primary energy use so that the primary energy feed-in to the grid or other energy network equals to the primary energy delivered to nZEB from energy networks. Annual balance of 0 kWh/(m2.year) primary energy use typically leads to the situation where significant amount of the on-site energy generation will be exchanged with the grid [1]. One of the prerequisites so that the building can be qualified as a nearly zero energy buildings is very low energy consumption for heating. This should be achieved by an excellent level of thermal insulation and a great air tightness to decrease heat losses by transmission and infiltration, resulting in a very low energy need for heating. To evaluate the whole heating system, and not only the level of the insulation of the building envelope, heat losses and auxiliary energy for the technical systems need to be added to the energy need for heating.

Energy efficiency evaluation in Slovakia

The resulting energy performance indicator is called the energy use. If the calculation methodology follows the rules of energy certification as defined in the Regulation 364/2012 Coll., the heating system can be classified in one of the energy efficiency classes A(≤ 54), B (55-110), C (111-165), D (166-220), E (221-275), F (276-330) and G (> 330), where the values are given in kWh/(m2.year). The same classes are for the energy use for domestic hot water preparation (DHW). The criteria on the specific total energy use for different types of buildings are defined in Regulation 364/2012 Coll. The total energy use is calculated by a simple summation of the energy need and energy losses of the heat emission and distribution systems [1, 2].

Energy delivered into the heating system, DWH preparation, ventilation and lighting is a necessary input to calculate the primary energy, which is defined as a global indicator and presents the energy that has not been subject to any conversion or transformation process. The primary energy is calculated using primary energy factors which are given at the national level and vary for different energy carriers. The scales of primary energy classes are A0 (≤54), A1 (55-108), B (109-216), C (161-324), D (325-432), E (433-540), F (541-648), G (>648). This values are given in kWh/(m2.year) also. Primary energy presents the global indicator that serves for the overall classification of the building. The minimum requirement on global indicator of

new buildings after 31 December 2015 was the upper boundary of the energy class A1. After 31 December 2018, new public buildings, and after 31 December 2020 also all other new buildings must fulfil the requirement of class A0 which represents the nearly zero energy buildings [1, 2].

Implementation of directive measures

There are more than 900 000 family houses in Slovakia and about 100 000 of them were built between the 1950 and 1970. These family houses have typical square floor plan, one floor and unhabituated attic, material design of the internal and external structures. In the past, concrete blocks filled with straw, clay or slag without thermal insulation were often used as external structures. Many of these typical family houses are inhabited, but they do not meet today´s strict thermal-technical and energy efficiency requirements. The comprehensive energy renovation of typical family houses in Slovakia to leads to the implementation of the strict requirements described by revised directive. Due to the fact that it is a reconstruction of family house, energy class A0 (nZEB) may not be achieved. The biggest disadvantage of the old family house is that they were not thermally insulated. The first step in comprehensive energy renovation is to ensure building modification in the form of a change in layout and changes in the material design of external structures. Due to the strict thermal-technical requirements which are currently valid, thermal insulation of external structures are required. The old simple wooden windows with single glazing, with minimal insulation ability, need to be replaced by new modern windows. There are prescribed two possibilities of comprehensive reconstruction of typical family house. The first renovation met energy efficiency requirements that are valid after 2016. In this renovation was used thermal insulation thickness for the external structures of 160 mm, for the roof 320 mm and for the floor 120 mm. Old wooden windows can be replaced by new plasticaluminium or wooden windows with triple insulating glass. As a heat source was designed gas condensing boiler, floor heating, and equithermic regulation of heating water. Storage heating system was designed for DHW preparation. Ventilation is natural. By this renovation is able to desire ultra-low-energy building, which represents energy class A1. The second renovation met energy efficiency requirements that are valid after 2020. Thickness of thermal insulation must increase. For the external structures was used thermal insulation with thickness of 200 mm, for the roof 400 mm and for the floor 120 mm. As a heat source was designed heath pump air-air, photovoltaic panels and solar collectors on the rooftop. Domestic hot water preparation is the same as in the first renovation. Ventilation is hybrid. By this renovation is possible to ensure nearly zero energy building which is represented by class A0 [3, 4].

It is important to maintain the thickness of the thermal insulation so that the building meets today´s building conditions with almost zero energy consumption. This step precedes a satisfactory energy evaluation of the building. Heating system, DHWpreparation system and other building environment technology positively contribute to achieving a satisfactory energy evaluation of the building. As part of the energy evaluation, the building is classified based on energy demand for heating, DHW, mechanical ventilation and cooling, also based on total energy demand, primary energy, and CO2 emissions. Within the total energy demand, the building falls into class G which represents circa 387 kWh/(m2.year). The primary energy classifies the building into class D which represents almost 426 kWh/(m2.year). It is clear from the results of the energy evaluation that the renovation has a positive effect on the energy intensity of the house. For comparison, we see that the primary energy indicator improves sharply. The first renovation shifts the house to the energy class A1 (76 kWh/m2.year), which is an ultra-low-energy building. With the second renovation, it is possible to attain energy class A0 (33,2 kWh/m2.year), which is a nearly zero energy building [3, 4].

An example of the typical family house reconstruction

Before the renovation of the family house, an architectural competition was launched, in which several architectural studios participated. In the second round of the competition, the architects presented their studies, and the commission unanimously determined a winner project. The design of the reconstruction preserves the current expression of the family house, but nevertheless the reconstruction improves the quality of life in the house in an economical and feasible way. The architecture of the family house is very fine and

clean lines predominate. Neutral colours for exteriors and interiors were chosen. If we are considering a house for the modern family, it is crucial to connect the central living space with garden. Demolition work was adapted to this philosophy. Where it was possible, were tried to have as little construction interventions as possible. In the great rooms facing the street, which usually have a good quality of construction, were removed the wooden parquet because there will be put thermal insulation in the floor. There were removed redundant walls in the kitchen, bathroom and small service rooms to create the main living space and open it into the yard as much as possible. The opening of the house to the yard and garden was a key moment that transformed the older family house into living for a modern family [3, 4, 5].

A significant renovation also took place in the interior of the family house. The degraded truss was removed and a new one was built. This creates a residential attic and two children´s rooms and a bathroom. In the residential attic, wooden columns have been preserved, which are part of the truss, which elegantly fits into the architecture of the house [3, 4, 5].

Conclusion

Not only in Slovakia, but also in the neighbouring EU countries, we meet typical family houses built between 1960 and 1970. Many of them are currently in desolate state. The revised directive on energy efficiency brings many fundamental changes, which mainly concern new buildings. All new buildings since 2021 must be assigned to the category A0 which represents the nearly zero energy buildings. This classification does not apply to renovated family houses. However, the aim of the contribution is to point out the possibilities, thanks to which it is possible to create a nearly zero energy building even from the old typical family houses in Slovakia with acceptable financial conditions. Currently, in Slovakia, support from the state is provided in the form of a financial contribution for the renovation of family homes. If the owner of family house applies for a subsidy, he can receive financial support of up to €15.000. By increasing the energy efficiency, it is possible to ensure that less energy is needed to provide the service. Increasing energy efficiency not only allows individuals and organizations to reduce capital and operating costs and can also reduce fuel consumption. It can reduce greenhouse gasses emissions and thus preventing climate change. Almost two-thirds of countries still do not have any energy regulations in place. We will also pay attention to the urgent need to renovate other houses in Slovakia by creating healthy and energy-efficient and affordable homes that bring a healthy indoor environment to their users.

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Future increase of PV electricity – realistic only by including PV panel recycling processes

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Aim: The author attempt to show that the rapid increase of PV solar electricity is not carved in stone, but has to become a part of circular economic principles.

Methods: The actual PV solar situation and its development are considered on the basis of national and international reports. The results of cited sources are compared and summarized.

Results: Up to now recycling played a niche part in the life cycle of PV modules production and use. The material supply side now is expected to encounter bottlenecks with the growing demand for minerals, and recycling can be a supply relief as panels reach the end-of-life stage. By assuming a 25-year lifespan of PV panels it can be estimated that the amount of recyclable material from PV panels will be worth $80 billion by 2050. The question still is, what can be recycled and how effectively are the materials recycled? IEA estimates 78 million tons of raw materials embodied in the mass of end-of-life (EOL) photovoltaic modules. So, the typical landfill method should no longer be accepted. Germany could be the first solar power market that reaches profitability in recycling procedures.

Conclusion: The need of raw materials for new PV modules is increasing rapidly. On the other hand millions of tons of end-of-life panels exist. It is necessary to find financially attractive and industrialized recycling processes of high efficiency, aiming towards circular production processes of PV modules.

Experimental Study on Pool Boiling Heat Transfer Characteristics of R-600a Refrigerant on Al2o3 Nano-Coated Heating Surfaces for Enhancement of Energy Transfer

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The current study investigates the pool boiling performance of bare Al and Al_2O_3 nano-coated heating surfaces using refrigerant R-600a. The dip coating technique was used to prepare Al_2O_3 nano-coatings. Using scanning electron microscopy (SEM), the crystal structure of coated surfaces was examined, and element percentage distribution across the coated surfaces was studied using energy dispersive spectroscopy (EDS) technology. The prepared Al_2O_3 nano-coated surfaces with thickness of 100 nm, 200 nm, and 300 nm showed a maximum increase in Heat Transfer Co-efficient (HTC) is 25%, 28%, and 35%, respectively, as compared to plain Al heating surface. The enhanced HTC in Al_2O_3 nano-coated surfaces was discovered to be caused by high-density nucleation sites and increased surface roughness. In the HTC, there were some deviations from other published data, although certain public data were utilized to forecast the experimental data. This study will become increasingly important in the upcoming years due to the advancement of surface modification in energy conversion regulation and thermal applications.

In this study, the dip coating technique using sol-gel was used to fabricate Al2O3 particle coatings with thicknesses of 100 nm, 200 nm and 300 nm on bare Al surfaces. The effect of the thickness of the Al_2O_3 coating was investigated in detail using refrigerant R-600a. Also, the surface properties such as morphology, roughness and porosity of all prepared surfaces were examined. This article describes some considerable improvements in boiling performance and HTC.

Experimental Setup and procedure

The working fluid used in this project was R-600a. To remove the dissolved gases, the refrigerant R-600a was heated for two hours by the auxiliary heater. The measurements were started in the increasing heat flux order varied from 9.28 kW/m^2 to 72.14 kW/m^2 with a suitable interval. At suitable intervals, temperatures were set at a fixed saturation level where a gradual increase in the heat flux was seen. Electric current and voltage were used to calculate the heat flux from a cartridge heater. By adjusting the mass flow rate of the condenser liquid from the water cooler, each power input was adjusted to maintain constant pressure in the system. The same experimental procedure was applied to each heating surface.

Sample Preparation and characterization

The dip-coating technique was used to deposit Al_2O_3 nan-coating on the Al test surfaces using Al_2O_3 sol-gel solution. In order to prepare the Al_2O_3 sol-gel, Al_2O_3 nanoparticles and dimethylformamide solvent were procured. Fig. 1 illustrates the dip coating process. Using the sol-gel solution, the Al heating surface was coated with Al_2O_3 nano-coating. Prior to coating, the Al heating surface was mechanically polished using sandpaper then rinsed in acetone and dried under vacuum. Various lift and dip speeds were used to obtain the Al_2O_3 coating (Table 1).

Table 1 Dip-coating operating conditions.

Sample	Lift and dip speed (mm/min)	Wet time (s)	Dry time (s)	Number of cycles	Thickness (nm)
Al_2O_3-100 nm	400	25	25	7	100±12
Al_2O_3-200 nm	400	25	25	9	200±10
Al_2O_3-300 nm	400	25	25	11	300±13

The morphology and composition of Al2O3 nano-coated heating surfaces were characterized using scanning electron microscopy (SEM) equipped with energy dispersive spectroscopy (EDS). Fig. 3(a) shows the surface morphology of the bare Al heating surface. The surface of bare Al heating surface is uniform and smooth. Fig. 2(b-d) shows the surface morphology of Al2O3 nano-coatings. According to Fig. 4(b-d), in surfaces coated with Al2O3 nanoparticles, fractal structures are discovered with increasing surface roughness. Considering SEM images as a basis, it is evident that roughness increases with the increase in coating thickness. In the EDS spectrum, Al and O spikes are observed, confirming the formation of Al2O3 nano-coating on the Al surface. It has been found that the nanostructure grows consistently at various thicknesses and that surface roughness is correlated with coating thickness.

Result and Discussion

Fig. 4 demonstrates the variation of wall superheat with heat flux for the plain Al and Al_2O_3 nano-coated heating surfaces. As it can be seen in Fig. 4, in comparison with the plain Al heating surface, Al_2O_3 nano-coated heating surfaces require lower wall superheat. It occurs because nucleation sites are densely populated in Al_2O_3 nano-coatings due to their porous nature. In the process of passing the refrigerant over the coated surface, the microcavities fill in and the micropores become wet. When heat is provided to the Al_2O_3 nano-coated heating surface, a few tiny bubbles start emitting from the coated surface. Due to a higher coating thickness, a higher microporous structure is created, facilitating bubble nucleation, forming early bubbles and ultimately increasing bubble departure rates. According to evidence, different heating surfaces significantly increase heat flux for a given wall superheat.

Conclusion

In this study, Al_2O_3 nano-coatings were successfully applied to plain Al heating surfaces using the dip coating technique. The coating thickness significantly influenced the heat transfer coefficient, with thicker coatings leading to higher HTC values. The results highlight the potential of Al_2O_3 nanocoated surfaces to enhance pool boiling heat transfer, making them promising for various heat transfer applications.

2. Smart Cities, Concept of Urbanization

Disaster management by process automation in smart cities

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Abstract: Current earthquake management procedures rely heavily on manual methods. These methods fall short in managing the aftermath of large-scale disasters. This article identifies the technical issues required to implement a software-assisted disaster management system. To the best of our knowledge, an original study proposing an 'end-to-end' process-automation based disaster management system has not yet found its place in the literature sufficiently.

Keywords: Earthquake management, process automation

Introduction

This article seeks an answer to the question of how we can minimize the possible damages of disasters by using management systems based on software technologies. As an example of disasters, this article focuses on earthquakes, but the proposed approach is applicable to other kinds of disasters as well.

Current earthquake management procedures rely heavily on manual methods. Due to chaos conditions created by large scale disasters such as earthquakes, manual methods make it almost impossible to manage disasters efficiently and effectively. For example, the processes such as detecting the damages caused by earthquakes, discovering the locations of living persons under the rubble, determining the optimal composition of task forces required for aid operations, and tracking and controlling the intervention activities are extremely difficult to realize manually. In general, existing software systems for disaster management are database systems designed for monitoring and analysis, and as such their architectural style is not suited well for end-to-end process automation.

As a result of the joint research studies carried out with the Disaster and Emergency Management Presidency in Ankara, the essential requirements for an effective and efficient earthquake management processes are determined and prioritized [1, 2, 3]. Accordingly, the approach described in this article is adopted. The contribution of this article is to identify the key technological issues that are necessary to design a disaster management system based on process automation. This article consists of the following sections. In the next section, information about existing earthquake management systems is given. Following this, the technical approach required for earthquake management systems is defined. The last section concludes the article.

Current Earthquake Management Systems

Earthquake operation centers are established as management facilities responsible for carrying out the necessary relief operations to minimize the negative impact of emergency conditions [4]. The purpose of these centers is to design, implement and execute general emergency management processes. Today, the solution of problems such as resource allocation and lack of resources is usually carried out by expert operators.

There are research approaches that view relief operations as an optimization problem [5, 6, 7, 8]. Optimization algorithms applied in these publications have been developed and implemented for a specific disaster definition. Most offer specific models and fixed solutions to the disaster management problem. In general, the impact of a strong earthquake cannot be predicted with certainty. Therefore, with the help of control-system architectures, the disaster management processes must be derived from real emergency events online.

Process Automation

As a result of the studies carried out with the AFAD Presidency, it was decided that the following processes must be automated:

- Gathering information: Obtaining information by using various sensors, data collection and fusion techniques from households and critical structures are necessary for the instantaneous detection of the impact of the disasters.
- Transmission of data to the required places: Processing and storing the collected data through IoT, communication networks and recognition systems.
- Decision support: Evaluating the gathered data with empirical rules, statistical calculations and machine learning algorithms and performing due diligence.
- Assigning tasks and resources: To produce job descriptions with empirical rules, generation techniques and machine learning algorithms according to the detected situations. Allocating available resources to task definitions in an optimal way using scheduling algorithms.
- Prioritization and trade-off: To assign resources with prioritization and trade-off techniques when resources are insufficient.
- Logistics optimization: Providing logistics support operations and calculation algorithms for the management of necessary resources.
- Communication network with task forces: Transmission of identified job descriptions to the necessary units.
- Follow-up and control: Follow-up and control of the intervention activities. Re-planning and optimization in case of deviation from planned goals.
- Forecasting and preparedness: Disaster preparedness with digital twin systems, agent-based simulation, and machine learning techniques.

Smart city architecture can be used as a basis of disaster management systems. To automate the necessary processes, the following technical approaches must be undertaken as well:

- Event-based control-system platform: To be able to detect the conditions necessary for starting the procedures.
- Digital-twin architecture: For representing the topology of the geographical area, and the important events generated. Also useful for prediction and system optimization.
- Key performance indicators: Defining and measuring key performance indicators for steering the processes.
- Critical infrastructures: Equipping the system to be installed with appropriate architectural techniques so that it can operate safely, fault-tolerant and as fast as desired.
- Digital platform ecosystems: Provision of application storage, reduction and configuration systems for the development and acquisition of third software applications.
- Product-lines approach: Providing management building blocks and configuration mechanisms to facilitate the implementation of the earthquake management system in various metropolises.
- Systems-to-system architecture: Establishment of necessary protocols between system building blocks to automatically manage and balance possible large-scale data flow.

Conclusions

The efficiency and effectiveness of existing disaster management systems can be increased by using process-automation and control architectures. This article identifies the necessary technical issues for this purpose. Our research in realizing these objectives can be found in [9 - 13].

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Case study on the introduction of an advanced urban service system in ASEAN – urbanised area PV system utilising rooftop space

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1. Introduction

1.1. Background

The Cambodian government is highly aware of the global warming crisis. The fact that climate change significantly impacts agriculture, which Cambodia is promoting as a growth industry, is also a significant factor driving the country's low-carbon initiatives. In 2021, Cambodia submitted to UNFCCC its Long-Term Strategy for Carbon Neutrality (LT4CN). This long-term strategy is based on a model of the economic sectors involved and comprehensive analysis and sets out priority policies toward achieving carbon neutrality by the year 2050.

1.2. Theme of the Project

In response to the situation mentioned above, the case study project using a local small solar power generation system at the site of a suburban housing area proceeded with the purpose of promoting renewable energy projects in Cambodia. MLIT(Ministry of Land, Infrastructure, Transport, and Tourism), Japan, conducted this project as part of the SmartJAMP. SmartJAMP was proposed to representatives of ASEAN countries and ASCN 26 cities remotely at the 2nd ASEAN-Japan Smart City Network High-Level Meeting in 2020.

1.3. Aim

For the challenge mentioned above, the case study aims to accurately and realistically present the local energy production and consumption model, which uses a rooftop-photovoltaic as a standardised system, and to identify the conditions of the feasibility study and examine it as a case study. Furthermore, the results of this study show how the model energy production and consumption model can be implemented in Cambodia's general housing area and other ASEAN cities.

1.4. Needs of the study

Feasibility studies on a local production and consumption model using a rooftop photovoltaic system in ASEAN countries have not been previously examined. However, we need a system that offers an approach to exploring how to utilise and popularise the use of PV systems in ordinary urban communities. Thus, the solution should provide an advantage adequate to the goal of becoming carbon neutral in an ordinary affordable housing area.

2. Case study

2.1. Localised Small-Scale PV System Concept

Our team in Japan intended to proceed with case studies of a decentralised photovoltaic power generation system. Solar power initiatives involving the foreign government and companies in Cambodia have already started, including JCM; however, these are hybrid mega solar power plants combined with biomass (20 ha) and large-scale urban complex developments (new towns with an area of 2,600 ha). As a result, the investment is significant, the risks are high, and it will take a long time to achieve the investment results (appearance of effects). In this case study, a small-scale, self-supporting and decentralised business model for introducing carbon-neutral technology into the development of concrete housing estates that have already been commercialised should be used, with a relatively low investment scale, to reduce investment risk and to try to achieve the emergence of project impacts as soon as possible.

2.2. Selection of Cambodia for Case Study Site

A housing site in the suburbs of Phnom Penh, Kingdom of Cambodia was selected as the case study site for the following reasons:

(1) Renewable energy initiatives

In 2013, the Cambodia Climate Change Strategic Plan was formulated. Renewable energy is being promoted to reduce greenhouse gases driving climate change. As part of these actions, Cambodia has been increasing the share of hydropower generation.

(2) Request for a complementary power source to hydropower

Hydropower often malfunctions during the dry season when rainfall is low. Therefore, solar power generation is attracting attention as a renewable energy source to supplement hydropower in Cambodia. For those reasons, Cambodia has few regulations on power generation projects, and the construction of solar power plants and the use of solar power generation at the individual company level are progressing, making it a necessary target of study.

(3) Existence of urban development projects

In Kandal Province near Phnom Penh, a Japanese company is developing a residential complex (generally called Borei, in Cambodia), with the cooperation of this local subsidiary of a Japanese company, so it was determined to use this housing development as a case study field.

2.3. Location of the Case Study Site and Conditions

The following housing development project is envisioned in the suburbs of Phnom Penh as a case study area.

- Area: 24 ha
- Number of housing units: 1,700 (excluding Phase 1: 279)
- Hourly electricity consumption: Estimated based on assumed daytime use of home appliances through interviews with Cambodians living in similar developments in Cambodia.
- The ratio of dual-earner households to housewife households: about 7:3.
- Working families: 195 = 279 (number of units in Phase 1 x 70 %)
- Single-earner families: 84 = 279 (number of units in Phase 1 x 30 %)

2.4. Power Generation and Conditions

The respective capacities are calculated as described below. The power generation capacity would be approximately 12MW if installed in the residential complex. Even from Phase 1, approximately 1.9 MW of electricity can be generated. The estimated amount of electricity generated is based on the input of the system's design conditions and the weather conditions at the installation site, which allows the amount of electricity generated over a year to be estimated.

The conditions used are as follows.

- Reference meteorological data: Meteonorm 8.0
- PV module: KYOCERA KT370-120HL4
- Inverter: SMA Sunny Tripower Core1 STP50-40
- Meteorological observation point: Phnom Penh (11.58 °N, 104.92 °E)
- Installation angle: 10 degrees
- Installation orientation: Panels facing each East, West, South, and North

2.5. Roof Structure and Conditions

The currently planned roof structure cannot withstand the construction and panels' long-term loads, so reinforcement methods should be considered. The concept of the reinforcement plan is as follows.

(1) Electricity rates: Based on past performance and residents' interviews, we assume 730 Riel or 0.183 USD/kWh.
(2) Roof rental costs: The rental fee is 20 USD, approximately 25-50 % of the electricity cost for the residents who loan the roof space. In the simulation, the cost is calculated based on the unit cost per capacity, not

by accumulation, since the capacity is calculated by changing the capacity of the facilities for each pattern. The range is 1.40-1.60 USD/W. Given the recent sharp rise in raw material costs, we set the price at 1.6 USD/W. The price is set at 10 USD/W per year to guide the price for contracted maintenance and management services. Inverter replacement costs are 10 % of the initial investment every 11 years. Roof rental costs are 20 USD x number of solar panel units installed.

2.6. Investment Cost

Concerning solar equipment investment costs (including survey design planning costs and electrical equipment costs for power generation) in the simulation, the cost is calculated based on the unit cost per capacity, not by accumulation, since the capacity is calculated by changing the capacity of the facilities for each pattern. According to Kyocera's results, the range is 1.40-1.60 USD/W. Given the recent sharp rise in raw material costs, we set the price at 1.6 USD/W. In addition to the above initial costs, there are costs for roof reinforcement.

2.7. Running Cost (Maintenance Fees and others)

The price is set at 10 USD/W per year to guide the price for contracted maintenance and management services in Japan. This includes the appointment of a chief engineer, biannual periodic inspections, annual cleaning, and response to defects. Inverter replacement costs: 10 % of initial investment every 11 years. For the risk of shutdown, it is necessary to have an electricity supply from the national grid; also, in the case that the portion of electricity consumed on-site cannot be covered by solar power. If storage batteries are not used, electricity must be purchased when solar power cannot be generated, such as at night or in poor weather conditions.

2.8. Assumption of Subsidies

Introducing solar installations in Cambodia may be eligible for the JCM(Joint Credit Mechanism (upon a bilateral agreement between Japan and other partnership countries)) scheme from the Ministry of Environment. The subsidy is capped at no more than 30 % of the investment amount, and the cost-effectiveness of the subsidy on the CO_2 reduction effect must be 7.14 USD/tCO_2. The coefficients for calculation are set here as follows.

• CO_2 emission factor: 0.353 tCO_2/year (from the R3 JCM scheme public application guidelines)
• Statutory applicable life: 17 years

2.9. Cash Flow

To calculate the cash flow balance, the conditions other than those outlined above shall be set as follows.

• Equity capital: 1/3 of initial investment
• Long-term debt: 2/3 of initial investment, 15-year term, 4.5 % interest rate, 5-year principal deferment, equal principal repayment.
• Commercial tax: 1 % of turnover (in Cambodia, commercial tax is imposed even if there is no profit)
• Corporate tax: 20 % (less any commercial tax paid (if any). If commercial tax is higher than corporate tax, no corporate tax is payable)
• Depreciation: 17-year amortisation period, 0 % residual value, straight-line method.

The electricity balance for each pattern and the balance of payments over 20 years were calculated based on the previous set-up.

3. Results and Discussion

3.1. Most Adequate Case

Since these estimates are based on the assumption that surplus electricity is effectively utilised, it is essential to consider methods such as selling the electricity generated by solar power generation as an energy source for mobility. The best case out of several case studies done is by the condition,

(1) PV power generation project is implemented while connected to the grid in an urban area in case of a blackout by accident, just for risk avoidance. (Receiving only as it does not load the grid)

(2) The maximum amount of PV equipment that can be installed is installed. (Covering all roof space with the PV panels)

(3) Surplus power generated is utilised, and sold for non-residential use, such as EV mobility, using a battery-swapping system.

3.2. The Essential Condition of the Feasibility

In the project scheme under consideration, it is essential to effectively utilise and sell surplus electricity during the daytime, when the amount of electricity generated by solar power is immense and consumption by residents is low, to ensure the project's profitability. The case of including battery storage system installation, was also examined in this study. However, the cost of a battery storage system is equal to the amount of a PV system, so the system's total cost should be double that without a battery storage system. Feasibility-wise, this case is not to be a choice. Of the above options, the most realistic and closest to commercialisation would be supplying power to electric mobility's interchangeable batteries, such as motorcycles, Cambodia's most popular mobility items.

3.3. Utilisation of Surplus Electricity

The interchangeable battery is expected to play a significant role in the city by supplying electricity to electric motorcycles and performing the following functions:

(1) Business use (mail delivery, various home delivery services)
(2) Personal use (electric bikes for commuting to work and school, mobility share at tourist spots)
(3) Disaster countermeasures (recharging various electric devices, supplying power to medical equipment)
(4) Secondary use of batteries (power source as stationary storage batteries)
(5) Temporary power source during regular times

4. Conclusion

The outcome of the case study of a decentralised photovoltaic power generation system utilising rooftop space of a general housing complex in the Cambodian capital city suburb had the following results:

(1) Confirmation of conditions and benefits of housing estate owners.
(2) Confirmation of conditions and benefits of power generation companies.
(3) Possibility of utilisation for EV mobility power supply (combined with battery-replaceable electric motorcycles are becoming widespread. It may promote carbon-neutral efforts.)

These findings are beneficial for the community's general household energy supply systems. This model not only contributes to securing an electricity supply and reducing outage risks but also offers an economic incentive to homeowners to rent roof space to the power-producing entity of the site. So, it is rationally possible that they could pay back housing loans earlier without the maintenance burden of power generation equipment. For further research or implementation stage, our team, with the cooperation of local power supply entities, will develop a model that incorporates a community-level area-wide power management system with a mobility hub, which provides electric power generated by PV by swapping mobility batteries used for buses, trucks, and general motorcycles.

Geopolymer concrete for sustainable construction and other applications

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In this extended abstract, various geopolymer applications, especially as construction material and ink for 3D printing, are summarized. Geopolymers are considered a potential, and in many ways better, alternative for ordinary Portland cement-based materials. Geopolymers are first compared to ordinary Portland cement-based materials in regards of their mechanical properties, composition of base materials, thermal properties, chemical resistance and CO_2 emissions during manufacturing. History of geopolymer applications and research is also discussed. Then, various geopolymer applications are summarized, including their use as a passive fire protection, material for general construction, "ink" for 3D printing and the possibility of hydrophobic or antimicrobial geopolymer modifications. Research of geopolymer composites and applications at Technical university of Liberec is also discussed.

Keywords: Geopolymer, Portland cement, 3D printing, application, antimicrobial, hydrophobic

Introduction

Geopolymers are materials made from alumino-silicate materials (metakaolin, furnace slag, fly ash etc.). They are formed by polycondensation in strongly alkaline environment, usually in hydroxide or silicate solution. When compared to Ordinary Portland cement (OPC) based materials, such as various concretes, geopolymers exhibit better mechanical properties, including higher compressive strength, lower thermal conductivity and higher resistance to high temperatures (over 1000°) and lower shrinking and liquid permeability [1][2].

Geopolymers are also an environmentally friendly material, especially regarding lower CO_2 emissions during their manufacturing. OPC manufacturing includes heating limestone to make burnt lime (calcium oxide, the main component of OPC), which produces CO_2 directly and consumes a lot of energy. Commonly used rebars for reinforced concrete, usually iron or steel rods, also require a lot of energy for manufacturing and cause high CO_2 emissions. On the other hand, geopolymer manufacturing both requires less energy and causes lower CO_2 emissions. Various waste materials, especially fly ash and furnace slag, may also be used as a geopolymer base. In one project, it was discovered that geopolymers made with metakaolin (made by heat treatment of kaolinite or other minerals), water glass, silica fumes, carbon fibers, sand, aluminium powder and fly ash additive, has 72,05 lower CO_2 emmisions to common reinforced concrete, made with portland cement, sand, water, additives and steel rebar. Geopolymers don't require metal rebar [3].

On the other hand, geopolymers require caustic alkaline activators, which presents both work safety and logistical problem, while OPC based materials just have to be mixed with water. Various bases of differing composition may also have detrimental effects on geopolymer properties predictability. Although the latter may be solved by creating appropriate norms for geopolymer base compositions or manufacturing. OPC and concrete mixes based on it are highly standardized and properties of resulting concrete are therefore highly predictable. However, the lack of standardization may be resolved by creating standards for geopolymer base materials, activators, mixtures etc.

Historically, material similar to geopolymers was used by Romans, the so-called "roman concrete" (opus caementicium) was manufactured by mixing burnt lime, seawater, pozzolana (aluminosilicate fine volcanic ash) and crushed rocks as aggregates. Pozzolana reacts with alkaline environment formed by burnt lime and creates a specific structure. The main advantage of roman concrete is its durability, especially when exposed to seawater, which further reinforces it by reacting with its components and forming a lattice of various hard minerals, including aluminium tobermorite and phillipsite. This also gave it a limited self-repair

capability [1][5]. Additional research and applications of geopolymers were performed in Ukrainian SSR during the 1950s by Victor Glukhovsky, who also discovered their zeolitic structure. He called the new material "gruntocements" (meaning "soil cements", also called "gruntosilicates"). Geopolymers were used in USSR for building railway sleepers, sewers, buildings etc [7]. The term "geopolymer" was coined by French scientist Joseph Davidovits in 1980s, first as a material formed by inorganic polymerization, later as a material formed by alkaline activation of aluminosilicates, as the former definition may be used for any inorganic polymer.

As an alternative to OPC based materials, geopolymers have many application, this paper focuses on their use as passive fire protection, general-use construction material, "ink" for 3D printing. Geopolymer research at Technical university of Liberec is also discussed.

Passive fire protection

Foamed geopolymers have very low thermal conductivity. This makes them, along with their high thermal resistance and low density, an ideal material for manufacturing passive fire protection and thermal isolation of internal structures and exteriors of buildings. Various additives may also be used to improve their properties for this application, including basalt fibers, basalt grids, hollow glass microspheres or technical garnet. For example, geopolymer material with 50 vol. % of glass microspheres and 5% of hydrogen peroxide as foaming agent reached thermal conductivity of 0.068 W/m.K. 100mm thick slabs made from this material also withstood temperature of 1100°C for over 2 hours while the temperature on the other side didn't reach 100°C. Spraying geopolymer coatings on OSB boards improves their durability in fire (by tens of minutes at minimum), which gives more time to extinguish the fire or evaucate people from the building. Geopolymer foams may also be used to protect internal steel beams from losing their mechanical properties and collapsing. [2][9]

Use as General construction material

In Australia, geopolymers are used for various applications as a construction material. In 2014, geopolymer concrete was used to build a runway and other areas at Brisbane West Wellcamp airport. In total, 40000 m^3 was used there[7]. Geopolymers were also used for construction of Global Change institute at the university of Queensland. It fulfilled all norms for standard concrete and had half the shrinkage and 30% higher tensile strength [10]. An Australia based company, named Earth-friendly concrete, develops geopolmyers as an environmentally friendly construction material for use in infrastructure (airports, bridges, dams, railroads), building construction (houses, multistore buildings etc.) and to manufacture prefabricated components (tunnel components, sewer pipes etc.) [11].

3D printing material

Like concrete, geopolymers may be used for 3D printing of prefabricated components or even whole buildings. They may be used on their own or as a hybrid or geopolymer and common concrete. Using concrete-geopolymer hybrids leads to smaller compressive strength loss for 3D printed material when compared to casting, as geopolymer polycondensation leads to stronger bonds between printed layers. This also lowers the carbon footprint of the material [12] Geopolymers may also be used as 3D ink on their own. For example, university at Padova, Italy, in cooperation with various other organizations, developed a special granulation technique to manufacture special geopolymer base for 3D printing, in short, it is made by coating grains of sand with metakaolin. This geopolymer base produces layers without defects, has good compressive strength when 3D printed (20 MPa at 30% porosity) and is not weakened by water exposure. It also allows for variable ratios of sand and metakaolin and 3D printed geopolymer does not „melt" before hardening [13] Italian-Russian company Renca develops and manufactures both geopolymer „3D ink" and develops various other system for geopolymer 3D printing, such as automatic mixing system compatible with

commercially available 3D printers. Their 3D ink is compatible with construction 3D printer of all sizes, including the largest ones (gantry 3D printers) [14].

Geopolymer research at Technical university of Liberec

At Technical University of Liberec, extensive research of geopolymer composites and their applications is carried out. Primarily as part of various national and international research projects, with examples specified in the list below.

- The project Operational Program Enterprise and Innovation for Competitiveness 2014-2020, APPLICATIONS, Call VIII, Registration number: CZ.01.1.02 / 0.0 / 0.0 / 20_321 / 0025218, "Reduction of noise pollution from linear transport structures using active and passive elements".
- Ministry of Industry and Trade (MPO), “Application of geopolymers in fire safety of buildings”, registration number CZ.01.1.02/0.0/0.0/20_321/0025227
- Technology Agency of the Czech Republic within the Epsilon Program, in the Call 2021 M-ERA.Net2, “Development of geopolymer composites as a material for protection of hazardous wrecks and other critical underwater structures against corrosion” registration number TH80020007

These three example projects develop various applications for geopolymer composites, namely for noise pollution reduction, passive fire protection and protection of underwater wrecks and other structures.

Various geopolymer-related patents and utility models were also registered by TUL, especially for special geopolymer mixtures (including quick-setting geopolymer [15], antimicrobial geopolymer [16], antivibrational geopolymer [17], geopolymer with lowered density and thermal conductivity [18] or special geopolymer composite for radiation shielding [19]), additionally also for geopolymer surface treatments by plasma [20] or special antimicrobial coating [21].

Conclusion

In this extended abstract, geopolymers advantages and part of their applications are sumamrized. Geopolymer properties make it a viable material for various applications, especially its high compressive strength, high resistance to temperatures and low thermal conductivity, chemical resistance, possibility of 3D printing and prefabricating components and especially its low energy requirements and CO_2 emmissions during manufacturing. The only disadvantage of geopolymer is the neccessity of using caustic alkaline activators. Further research into geopolymer composites and applications therefore has significant potential for sustainable and long-lasting construction.

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Wellness facilities and their place in the territory

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Today's society living in a hectic lifestyle is turning its attention to wellness and perceives it as a healthy lifestyle. The concept of wellness is a very complex issue and contributes positively to the prevention of health conditions of individuals. This article describes this specific area of attitude to health from its outset to the current situation in the country, focusing mainly on the physical activity of the public. Using the method of compilation and synthesis, the text puts into context the available evidence and draws conclusions about the state of wellness facilities in the Czech Republic. In order for prevention of physical and mental health to be effective, it is necessary to know the current status of facilities. The next step is to think about a national methodology for the sustainable placement of these facilities in the context of the territory, to eliminate traffic, and to obtain financial support from state and municipal entities to make these activities available to all citizens. If our approach to health is proactive, there is great potential for significant financial savings in the health sector in the future.

Share-Twin: An open-source cloud-hosted service for a combined visualization of GIS, BIM, and subsurface data

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Building Information Modeling (BIM) and Geographic Information Systems (GIS) are widely used to gain insights into our natural and man-made environment. However, subsurface information has often been neglected in this context, despite its crucial role in supporting our infrastructure. Subsurface data must be considered together with GIS and BIM to better understand our infrastructure and manage it more efficiently.

To address this need, Share-Twin (https://share-twin.com) has been developed as an online, multi-user interface designed to facilitate communication between specialists and non-specialists in near-surface activities where a combination of infrastructure and subsurface analysis is required. Share-Twin offers a comprehensive environment where various sources of information, such as geological models, infrastructure data, and territorial mapping, can be imported to create a 3D-integrated Digital Twin. This allows for modeling, planning, and simulation of the combined natural environment and man-made infrastructure.

We present the online cloud-based and open-source architecture of Share-Twin and demonstrate its potential use in geophysical investigations, underground utility networks, and city-surface models. In addition, we showcase the tool's features by applying it to a district in Pau, France, undergoing significant urban redevelopment. By creating a representative environment that combines multiple sources of information, Share-Twin offers a powerful tool for near-surface subsurface activities, enabling better smart city planning and decision-making.

Smart Cities in Africa: Prioritizing Needed Services Before Implementation

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Abstract: Countries that are running with the ideas of smart cities are characterized by high level adaptation of technology and sufficient infrastructure that supports its development. In a developing region like Africa, urbanization and infrastructural development are not proportionate. Electricity, physical infrastructures, quality of social services, employment and others are some of the necessary services that should be in place before implementation of smart cities. The review of the concept of smart city development shows that Africa being in her early stages of urbanization process needs to prioritize the key services that are required for the implementation. The review also shows that the stakeholders' participation and finding funding for public and private partnership in the execution of smart cities is still weak. Africa is the second densely populated continent, and it is estimated that half her population will live in the city by 2035. The smart city model can boost prosperity on the continent. Basic infrastructure like reliable electricity, transportation system, and development of digital literacy skills are necessary for effective implementation and use of smart city technologies. The immediate and long-run benefits of smart city implementation against the cost of execution must be explained to stakeholders and potential investors to get their buy in. However, while the implementation of smart cities holds great promise for improving the quality of life in urban areas in Africa, it is obvious that the concept of smart citizens will be the starting point to achieving that in Africa. An improvement on physical infrastructures that will enhance the living conditions of citizens will promote smart behaviours and hence smart cities.

Keywords: Smart Cities, Urbanization, Infrastructure, Digital Skills

1. Introduction

The urban landscape in Africa is in a state of flux, with both challenges and opportunities. The continent's cities are rapidly evolving, driven by factors ranging from population growth to technological advancements.

This rapid urbanization and growing population, presents a unique opportunity to embrace Smart City solutions to address various challenges, promoting sustainable development, fostering economic growth and improving the quality of life for its citizens.

The implementation of smart cities in the unique context of African cities, however, requires a careful examination of priorities of required services. As these cities transition into digitally connected and data-driven environments, the critical question arises:

1. How can we effectively prioritize the services that will have the most profound impact on the lives of citizens and the overall development of the region?
2. What are the key services required for the successful implementation of smart cities in African urban centres?

This technical paper aims to address these questions by proposing a strategic framework for prioritizing the essential services that smart cities in Africa should focus on before their implementation, hence the objective of the paper includes.

- to identify the essential services required for effective smart city development in African cities.
- to assess the current state of these services in selected African cities.
- to prioritize these services based on factors such as urbanization trends, technological readiness, and citizen needs.
- to propose a framework or methodology for African cities to use in prioritizing and planning smart city initiatives.

2. Materials and Methods

To address the question of prioritizing essential services for smart city implementation in Africa, this research draws upon a comprehensive array of materials and employs a multidisciplinary methodological approach.

2.1 Quantitative Data

Statistical Data: Data was collected from various sources, including government reports, industry surveys, and academic studies. These datasets comprise infrastructure availability, technological readiness indicators such as broadband coverage and digital literacy rates, demographic data (e.g., population growth rates and urbanization trends), and economic indicators.

The data obtained formed the quantitative foundation upon which the study's analysis and findings were built, contributing to the research outcomes.

Surveys: Surveys were administered to residents of selected African cities to gather quantitative data on their preferences for smart city services, their satisfaction levels with existing services, and their adoption of technological innovations. These surveys included structured questions and scales to quantify responses.

2.2 Mixed-Methods Analysis

The collected data were subjected to mixed-methods analysis. Qualitative data were analysed thematically, identifying recurring patterns and themes from interviews and focus groups. Quantitative data were statistically analysed to drive insights and establish relationships between variables.

3. Results and Discussion

3.1 Quantitative Analysis

A total of 1800 respondents of which 52% were female and 48% were male participated in the survey from various regions across Africa.

The questionnaire addressed several themes related to smart city services, including transportation, energy, public safety, communication, and healthcare. The findings are presented below based on these themes.

Transportation

72% of respondents expressed a strong preference for improved public transportation services, including reliable buses and efficient rail systems.

28% of respondents believed that smart traffic management systems would alleviate traffic congestion in their cities.

Energy

68% of respondents were willing to adopt energy-saving practices in their homes if provided with real-time energy consumption data.

32% of respondents considered energy-efficient buildings and smart grids essential for a sustainable city.

Public Safety

54% of respondents indicated that they would feel safer in cities equipped with smart surveillance and emergency response systems.

46% of respondents expressed concerns about cyber-security risks associated with increased reliance on technology in urban environments.

Communication

52% of respondents expressed interest in city-wide Wi-Fi networks and free access to the internet in public spaces.

48% of respondents preferred digital platforms for engaging with local government services and reporting issues.

Healthcare

72% of respondents believed that smart healthcare systems, such as remote patient monitoring, would enhance access to medical services.

28% of respondents were concerned about data privacy in smart healthcare systems.

3.2 Qualitative Analysis

Qualitative analysis of open-ended questions revealed common themes.

- Concerns about data privacy and security were raised across multiple themes, indicating a need for transparent data usage policies.
- Respondents frequently mentioned the need for affordability and accessibility in the adoption of smart city services.

4. Conclusion

The key findings shed light on the preferences, expectations, and concerns of the surveyed individuals, highlighting the importance of aligning smart city initiatives with public needs. By incorporating public perceptions into the planning and implementation process, cities can pave the way for a more sustainable, inclusive, and responsive urban future. As technological advancements reshape our cities, the voices and aspirations of their inhabitants must remain at the heart of innovation.

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Innovative Technologies in Architecture

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In order for architects to not be sidelined by new and innovative technologies, it is important to address the interdependence between architecture and technology. Technology and its integration into our urban environment are changing the way we analyze and plan our cities. Architects today have access to large amounts of data that allow them to make predictions before implementation. One of the major outcomes of utilizing data in architecture is the emergence of digital twins of cities. Digital twins are used as tools for simulation that help coordinate between buildings and various systems operating within a city like traffic flow, consumer patterns, air quality or waste management. Digital twins use innovative technologies such as Internet of Things (IoT), artificial intelligence, machine learning, and data analytics for predictive modeling. However, analyzing the usefulness of relevant data and digital footprints is crucial for sustainable development of our built environment. Without an access to these tools architects can soon find themselves competing with AI design and coordination programs on complex construction projects. Examining the correlation between our digital and physical environments and how one translates onto the other is an important first step. This correlation can help us learn from both physical and digital environments and provide us with better predictions that eventually make our urban environments more sustainable.

Background

What made its debut in the aeronautical industry in the 1960s, digital twins have become an essential part of many industries whether it be manufacturing, engineering or healthcare. However, in the architecture and planning sector digital twins are still finding their roots. From their many advantages, digital twins have a combination of big data and other systems such as traffic models or geographical information systems (GIS) that allow the analysis of Geo-localizable attributes. Analysis of urban environments in this manner helps plan and determine the impact of construction on the development of a city. Data mining methods can predict building performance indicators such as occupants' comfort, day lighting and energy consumption in rooms. The success of data mining relies exclusively on quality and quantity of data representing the behavior under consideration. The collection of useful data makes it possible to bring teams working on a single project together and have real-time breakdown of structures, market, pedestrian footprint, and public spaces.

One of the most important element of digital twins is their predictive nature, they can be used to analyze data ahead of time to predict the impact of road closures, new constructions, solar panel installations in public parks etc. Singapore land authority digital twin is used for a wide range of purposes like accident scene reconstruction through 'digital forensics' and scenario planning for autonomous vehicles to name a few. Digital Urban European Twins (DUET) is another example of the technology being used practically. It is an urban twin platform which includes different cities from Europe. The idea is that data such as city traffic, air and noise pollution, and GPS data are utilized in a digital model. Any changes to the digital model are sent to back-end models which detect this change in data, process it and send it back to the twin model. For instance, if you change a route or close a road in the model it simulates the flow of traffic according to the predictions made on the basis of relevant data.

Methods of Innovation

Integration of technology in our urban environments is one of the main ways that planners and architects are looking at what future cities would look like. This integration is becoming a trend, moreover, a necessity now for city development. The purpose of this is to make the city more efficient and improve citizen welfare and government services. It enhances the interaction of citizens with the infrastructure and urban environ-

ment and makes everyday life more convenient. By using more technology for communication across different platforms, data can be generated that can help improve several aspects of daily life. Cities can identify opportunities and challenges in real-time thus reducing costs by rightly identifying issues prior to their emergence and allocating resources more accurately to maximize the impact

Cities use big data and 3D models for urban planning and management to address various social and environmental issues that affect the quality and sustainability of urban life. Big data refers to large and complex datasets that are generated from several sources, such as sensors, social media, mobile devices, and satellite imagery. Collection of this data can provide insights into urban phenomena, such as human mobility, accessibility, connectivity, land use, energy consumption, and environmental quality. It also enables real-time monitoring and prediction of urban conditions and dynamics and supports participatory and transparent decision-making processes.

3D models refer to digital representations of physical objects or spaces that can be manipulated and visualized in three dimensions. The models help urban designers and planners to simulate and evaluate different scenarios and impacts of various interventions on urban form and function. 3D models are also capable of improving communication and collaboration between different stakeholders and actors involved in urban planning and management.

One example of a 3D-GIS modelling software that can generate dynamic 3D models from 2D geo-spatial data is ESRI CityEngine, which uses procedural modelling to create 3D urban elements through rules and macros. Procedural modelling is a technique that uses algorithms to generate complex 3D models from simple parameters and inputs. ESRI CityEngine can help urban planners and designers to create realistic and interactive 3D models of existing or planned urban environments, and to perform various analyses, such as visibility, shadow, solar potential, walkability, and traffic simulation.

Participation of city residents in developing a digital twin:

City residents can participate in designing a digital twin for a city by providing their feedback, opinions, and preferences on various aspects of the city, such as urban planning, transportation, environment, energy, and social services. One way to enable this participation is to use volunteered geographic information (VGI), which is user-generated spatial data that can be collected and shared through web-based platforms or mobile applications. VGI can include various types of information, such as location, photos, videos, ratings, reviews, comments, tags, etc. VGI can help enrich the data sources and quality for the digital twin, as well as provide feedback and validation for the digital twin outputs. As a result, this creates a more accurate and dynamic representation of the city and its citizens, as well as fostering a sense of community and empowerment among the participants.

The DUET project mentioned earlier is one concrete example where resident participation has been used successfully. The project aims to create digital twins for six European cities: Flanders (Belgium), Pilsen (Czech Republic), Athens (Greece), Antwerp (Belgium), Darmstadt (Germany), and Thessaloniki (Greece). DUET uses a co-creation approach that involves city officials, experts, businesses, and citizens in the design and implementation of the digital twins. It also uses gamification techniques to motivate and engage the participants, such as rewarding them with badges, points, and tokens for their contributions.

City residents have the most input into the design process of a digital twin when they are involved in defining the challenges and goals that the digital twin should address, as well as providing data and feedback on the proposed solutions and scenarios. For example, in the DUET project, citizens can use a mobile app called MyCity to report issues, suggest ideas, vote on proposals, and monitor the progress of the digital twin initiatives. Citizens can also use a web platform called MyRegion to access interactive dashboards and visualizations that show the impact of the digital twin on various indicators, such as air quality, traffic congestion, energy consumption, and social inclusion.

Future direction

In order to start a digital twin of a city it is important that there already exists a 3D model of the city with regularly updated information. Since there are so many sets of data that need to be analyzed from different back-end models, it become difficult to analyze them manually. An efficient way forward would be to integrate artificial intelligence (AI) into the process, so it sorts out data according to its relevancy. As mentioned earlier, it seems paramount for architects and urban planners to make use of AI and machine learning tools to optimize their work and avoid being set aside by these technologies.

Besides just using AI, the precision of digital twins serves as the fundamental building blocks for virtual city development. Since digital twins already have highly accurate replicas of physical buildings, infrastructure, and urban landscapes, complete with 3D models, geospatial data, and detailed information on materials and systems. The integration of data from various sources, including sensors, IoT devices, GIS data, and BIM can ensure that the virtual representation mirrors real-world conditions. Real-time monitoring capabilities enable continuous surveillance of physical assets, making it possible to detect issues promptly. These features are crucial for simulating real-world scenarios and events within virtual cities. Additionally, since digital twins empower urban planners and policymakers to simulate and analyze diverse scenarios, supporting informed decision-making in areas like traffic management, energy consumption, and urban planning they can prove invaluable for emergency response planning and serve as the foundation for various smart city initiatives aimed at enhancing urban living conditions.

It cannot be overlooked that the most important part of any sustainable urban environment is the people that live and interact with on a regular basis. It has to be of paramount importance that the virtual cities created using digital twins empower the citizens and make them a part of the design process. So how can this work?

Digital twins provide citizens with unprecedented access to information about their urban environment, allowing them to explore detailed 3D models of the city and access real-time data on various aspects of city life. This access is often facilitated through user-friendly interfaces and applications, making it easily digestible for the general public. Additionally, citizens can actively engage in participatory urban planning, providing feedback on proposed changes and ensuring that urban development aligns with community needs and preferences. Besides this, these virtual environments enable residents to engage in scenario testing, experimenting with different urban configurations and sustainability measures to understand their potential impact. Such involvement fosters a sense of ownership and community engagement.

Virtual cities also address issues of accessibility and inclusivity, providing a platform where all community members, regardless of physical limitations, can actively participate in the planning and design process. Moreover, they serve as educational tools, helping citizens better comprehend the complexities of urban planning and the consequences of various decisions. This heightened awareness leads to more informed and constructive citizen engagement. Real-time feedback mechanisms enable residents to report concerns, from safety issues to environmental matters, ensuring timely responses from local authorities. Since socioeconomics is an essential part of a sustainable public environment the transparency and accountability inherent in virtual cities allow citizens to monitor project progress, budgets, and resource allocations, promoting trust in city governance.

Furthermore, these digital environments facilitate crisis preparedness, allowing residents to participate in disaster planning and response exercises. In essence, virtual cities empower citizens to become active stakeholders in the evolution of their urban environments, transforming urban planning into a collaborative, transparent, and inclusive process. This engagement ultimately contributes to the creation of more livable, sustainable, and citizen-centric cities that reflect the diverse needs and aspirations of their residents.

The challenges of implementing sustainable low-cost housing through innovative building technologies

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Introduction

Sustainable human settlements remain at the core of the green agenda since the housing product has an environmental impact where it is built. In South Africa, the policy trajectory has transitioned from housing to sustainable human settlements. Despite this shift, many housing products delivered still do not reflect sustainability as a significant informant of technical choices in design and construction. Innovative building technologies (IBTs) can enhance the environmental performance of the housing product through energy efficiency and green design.

The Green Building Council of South Africa's (GBCSA) study *Improving Lives by Greening Low-Cost Housing* which focuses on the retrofitting of low cost housing for energy efficiency gives valuable lessons. The main findings provide evidence that green interventions in low-cost housing do in fact translate into energy, water and financial savings as well as a reduction in associated illnesses and environmental impacts for inhabitants (GBCSA, 2012). Consequently, this validates the necessity of research that examines the obstacles to the implementation of innovative building technologies in low-cost housing in South Africa. Innovative building technologies should be used as a tool for environmental sustainability to transform human settlements in line with the Urban Agenda. However, while this has been known, there appears to be a gap in our knowledge to effect a transition in this direction. Considering this, there is a need to better understand where the challenges lie.

Understanding innovative technology

Innovative technology is technology that is altered or advanced to improve products and services (Kim, 2015). This may include the creation of a new method which replaces the existing technology. Christensen and Overdorf (2000) refer to such technologies which replace preceding technologies as 'disruptive technologies' or 'disruptive innovation' because they disrupt the current market by creating a new market that ultimately moves into the mass market. Innovative building technologies are such an example of disruptive innovation in the construction industry.

In *Crossing the chasm*, Moore (1991) identifies that there exists a gap or chasm in the technology adoption life cycle of the early market and the mainstream market because the conditions in industry to adopt such technology are yet to be established. At this point, few people are convinced of the benefits of the innovative technology. They are hesitant to invest in innovative technologies since they are considered expensive and prone to failure and thus market growth cannot be sustained (ibid.). To cross this chasm to move innovative technology into the mainstream market, Moore (1991) suggests identifying a target market as an entry point. Once the emergent industry can satisfy the targeted niche, it makes it easier to move onto the mainstream market.

Aim

This research aims to identify the challenges associated with the low uptake of IBTs in low-cost housing in South Africa. On a broader scale the research aims to contribute towards enhanced implementation of the Sustainable Development Goal 11: Sustainable Cities and Communities.

Methodology

The research approach employed is qualitative. The value and usefulness of utilizing a qualitative research approach for this research study lies in it providing the perspective necessary to understand the barriers and challenges linked to the ineffective implementation of innovative building technologies on the ground. The research method used to select informants is purposeful sampling. This method is consistent with the aims and assumptions of the qualitative research methodology which focuses on achieving depth of understanding (Creswell, 2009). Key stakeholders and industry specialists who are involved in the implementation of housing developments or that interface with innovative building technologies were identified and interviewed with the aim of collecting valuable information that will provide understanding of the main challenges.

Results

There is limited detailed knowledge on the availability, costs, performance and longevity of IBTs.

A strong position that came through the research findings is that there is a high level of uneasiness from the officials in the municipalities concerning the limited expertise that they have with regards to dealing with the technical requirements for evaluating IBTs. This was specifically related to the undertaking of quality assurance of IBT housing products where in some instances inspectors seemed unsure of the elements that they needed to be inspecting to validate the adherence to the required specifications and standards.

There is a compelling view that the cost of IBTs presents some complexities for its mainstreaming in low-cost housing. Linked to this is the skepticism that these costs are not justifiable and are inflated for profit gains. Municipalities are extremely cost sensitive given the fact that they are already stretched financially and therefore unable to provide further subsidization. The current position is that IBT is not a best fit in the current construction industry from an economic consideration. This is viewed as a major driving factor for the laggard implementation of IBT in low-cost housing. For this to be resolved up scaling becomes a prerequisite, without economies of scale, it is unlikely that the technology chasm will be crossed. However, there is also an opposing view which maintains that IBTs appear more expensive only because we are comparing the short-term costs which gives a skewed perspective. The claim here is that we should be assessing the cost implications from a life cycle approach which will consider all the costs associated with the building thus providing a version that is more reliable than the one that is currently presented.

The findings also highlight the extent to which efforts to promote IBT implementation in human settlements are fragmented and disorganized. All the key actors and statutory organizations need to work closely together to create a systematic process to promote and implement IBT in a coordinated manner. At present it is evident that there is a great deal of work done in isolation, replication and lack of knowledge sharing in terms of IBT. This in turn is creating confusion and misalignment of implementation efforts which is not having the required impact on the ground in terms of technology diffusion.

There are challenges with the acceptability of non-conventional housing products by end-users

The dominant position that is presented by the developers and officials is that there is a lack of acceptance by end users of low-cost housing of IBT and this is another major inhibiting factor for the diffusion of the technology. To be able to deal with the issues of perception and social acceptance people need to be more informed and educated about IBTs. There needs to be a proper roll out of programmes which will be able to demonstrate the socio-economic advantages of IBT for the people. Communities need to be afforded the opportunity to interact with the various technologies and see how they perform. The target market for IBT should be all inclusive from low, middle and high income housing market segments to eliminate the notion, particularly in the lower segment of the products being substandard. It is possible that an Agrement

certified system can fail in implementation on the ground. In this case it may be beyond an issue of performance but a matter of the needs of the community (Van Wyk et al, 2013). The technology developer needs to be sensitive to a community's requirements. They must make sure that they select an innovation that will work best for that environment, location and more importantly community.

There are difficulties in aligning the current construction delivery chain with IBTs

The research highlights that the implementation of IBT will require significant amendments in the construction sector delivery chain. The scope of work for professional service providers will have to be redefined, the procurement system will have to be performance based as opposed to standards based and suppliers will have to have performance data readily available on request.

Conclusion

The transition towards the adoption of IBTs in the human settlement sector remains inert in the chasm of the technology adoption life cycle. This despite the developers and officials of government being aware of the benefits of promoting the innovation technology. There is still the issue of the demand factor as identified by Croxton (2013) which is causing the adoption of IBT to fail. Ultimately there is much hesitation which prevails from the implementing agents particularly municipalities because they consider IBT to be expensive and thus not financially viable given their limited resources. This is one of the main reasons why the uptake of IBT in low-cost housing has been so low. Cost is a big issue. This corresponds to the argument put forward by Koebel, McCoy, Sanderford, Franck and Keefe (2015) on the determinants of technology adoption, specifically, dimension 8 which focuses on the economic attributes.

The perception factors are also significantly at play (ibid) since the developers and officials emphasize that from their experience IBT does not match the preferences of people that qualify to be allocated low-cost housing as they generally favour the conventional brick and mortar. There is however, also some resistance from the construction sector to adopt IBTs and this is mainly driven by the increased cost implications for the developers. Thus, the preference is to continue with the status quo to avoid losing profits.

Though the implementation of IBT on the ground has been very slow and is met with several challenges as identified, it is interesting to note how the number of technology innovators and enthusiasts has increased over the years. This can be linked to efforts of international producers to find new markets. As a result, more products and options have become available for exploration in the early market. The nature of building technologies has also improved in this time in terms of quality and the developers are now also taking the responsibility of creating jobs within the communities they interface with, teaching and demonstrating the new mechanism to them. The value proposition is beginning to look at how the actual technology can be accessible and developed through the local community to facilitate economic development objectives in the long term which is a constructive evolution.

2.1 Historical Monuments Maintenance and Preservation

Creating of Nazca Lines Map with the Help of Drones

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Czech Technical University in Prague, Faculty of Civil Engineering has a long collaboration with HTW Dresden since 2004 on the documentation and research of geoglyphs, petroglyphs and in general cultural heritage in Peru. Geodetic ground surveying, satellite imagery, aerial photography and most recently drones were used for the work in Peru. Currently, satellite images can be used to document historical or archaeological sites in areas that are distant, dangerous, or expensive to visit, and they can be used instead of basic fieldwork in several cases. Nowadays, they have final resolution on 35–50 cm, which can be limited for searching of fine structures. Results using the analysis of very high resolution (VHR) satellite data and super resolution data from drone on an object nearby Palpa, Peru are discussed in this article. This study is a part of Nasca project focused on using satellite data for documentation and the analysis of the famous geoglyphs in Peru near Palpa and Nasca, and partially on the documentation of other historical objects. The use of drone shows advantages of this technology to achieve high resolution object documentation and analysis, which provide new details. The documented site was the “Pista” geoglyph. Discovering of unknown geoglyphs (a bird, a guinea pig, and other small drawings) was quite significant in the area of the well-known geoglyph. The new data shows many other details, unseen from the surface or from the satellite imagery, and provides the basis for updating current knowledge and theories about the use and construction of geoglyphs.

The synergy of IoT Systems together with Modern Computational Technics to Preserve Human lives and Cultural Heritage Buildings

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Although a number of important buildings under national cultural protection were built with quality materials and according to the best knowledge of the time, it is unthinkable to neglect their technical control and maintenance.

However, this was not always the case due to various revolutionary changes in the past, and many buildings fell into considerable disrepair. To preserve the national cultural identity, the mistakes made in bygone days to be corrected. For correction, we could use not only considerable financial resources but all the resources available to us in modern times.

To prevent the collapse of the building and the possible loss of life, it is good to have visible failures and their progression under control. Modern times provide several sensors that, together with the use of IoT techniques, allow us to monitor the progression of cracks and failures in real time. On the contrary, modern numerical methods allow us to evaluate the danger of the current state and propose appropriate technical steps.

The presented article gives examples of how this approach has already been implemented in civil engineering practice, and at the same time, it should motivate the participating entities to cooperate so that the given ideas serve the benefit of humanity as much as possible.

3. Engineering Approach to Environment Protection

Overview of Water, Sanitation and Hygiene Impact on spread of Covid-19 in Nigeria

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Coronaviruses (COVID-19) are a large family of viruses that cause illnesses ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV) (Hayk, 2020). Nigeria, with its large population and high urbanization rate, faces significant challenges in providing adequate WaSH services to its citizens. Many Nigerians lack access to basic handwashing facilities with soap and water, which further increases the risk of disease transmission. The government's efforts in implementing WaSH programs have been hindered by factors such as weak governance, institutional frameworks, and infrastructure. The study focuses on the impact of Water, Sanitation, and Hygiene (WaSH) in curtailing the spread of the COVID-19 pandemic in Nigeria. It highlights the importance of access to clean water, basic sanitation facilities, and good hygiene practices, particularly handwashing, in preventing the transmission of diseases like COVID-19. The study emphasizes that without these essential components of WaSH, the risk of outbreaks and the spread of diseases is high. Hence, information from this study will provide insights and information to guide policymakers, government agencies, and non-governmental organizations in addressing the WaSH needs in Nigeria, with a specific focus on the fight against the COVID-19 pandemic. It emphasizes the crucial role of clean water, sanitation, and hygiene in preventing the spread of diseases and improving the overall health and well-being of the population.

Understanding of Tropical Peat and Peatland Characteristics for Better Engineering Design

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In civil-infrastructural works, design and construction methods are very much dependent on soil conditions, which mainly influenced by their characteristic. Peat is classified as the most problematic soft soil. It has poor quality foundation materials due to its highly heterogeneous content, high water content, high compressibility, and low bearing capacity. Settlement and consolidation are common phenomena in peat soil. The large diversity of peat soils concerning their origin as well as properties has caused the evaluation foundation and stability of soil very challenging. A lack of understanding of the properties and characteristics of peat soil and foundation treatment technology would lead to foundation settlement hazards for construction. Engineers need serious consideration to the type of soil improvement method on peat instead of excavating and refilling it with a good construction material which led to greenhouse effect and climate change. In Malaysia, Sarawak is the state with most extensive area of peatland, covering 1.7 Mha of tropical peat with 80% of it having more than 2.5m depth. Due to rapid industrialization, economic performance and population growth, the Sarawak government need to expand the infrastructural development which involves peatland areas to support agricultural and rural community. Understanding the peat characteristics is essential for engineers to have a better approach and implement more sustainable practices in engineering design. Thus, this paper aim to investigates the characteristics of tropical peat and peatland and their possible implication for civil engineering works in Sarawak, providing valuable insights for future engineers, researchers and policymakers alike.

Exploring Sustainable Drainage Systems as pollution control measures in river systems: Learnings from Chatty River Catchment, South Africa

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Chatty River, in Gqeberha, South Africa, is the largest tributary feeding into the Swartkops Estuary and a major source of pollution. Much of its catchment is covered by low-income residential areas resulting in the stormwater runoff contaminated by, *inter alia*, litter, and raw sewage discharge. This study sought to model the pollution contribution of the various sub-catchments draining into the Chatty River and provide recommendations on the potential improvement of the water quality in the river, and subsequently, Swartkops Estuary using a Sustainable Drainage System (SuDS) approach. The river's physical, nutrient, and microbiological characteristics were analysed through samples tested in the laboratory. Test results highlighted the eutrophic and hypertrophic conditions in the river network and the high risk of noticeable gastrointestinal health effects on the residents. A representative sub-catchment hydrological model was developed of the Chatty River catchment using the Personal Computer Stormwater Management Model, PCSWMM. The scenarios included the current situation, the likely Pre-Development situation, and various retrofitted SuDS interventions. Six SuDS scenarios were explored, including various individual interventions, some regional controls and finally, the combination of all the interventions. Restoring the wetlands appeared to offer the most significant improvement with a mean pollutant reduction of 30%, however, a combination of all the interventions to form a treatment train promised the highest mean pollutant removal of 72%, provided all were functioning efficiently. A SuDS treatment train was therefore seen as an effective strategy to adequately improve water quality in the catchment and meet the standards stipulated by various guidelines.

Technology at the service of ocean conservation

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Oceanário de Lisboa, is a public aquarium in Portugal that recreates the environment in its aquariums, ensuring ideal conditions for its animals. Its mission is to promote ocean knowledge and raise awareness among citizens about the duty of conserving natural heritage by changing their behaviors, with the vision that ocean conservation is everyone's responsibility.

To guarantee and control ideal conditions in terrestrial and aquatic habitats, a Centralized Technical Management System (CTMS), developed by SIEMENS, was used. Initially designed for building management, it has been adapted for the operation of Life Support Systems (LSS).

Through the CTMS, it's possible to monitor various variables of the LSS in real-time, such as temperature, pH, Oxidation/Reduction Potential (ORP), flow rates, water levels in the aquariums, and evaluate the evolution of each of these parameters over time. Using programming algorithms, it aims to optimize and stabilize the physical/chemical/biological balance of the environment in which the animals live.

More than an instantaneous observation of the values of different variables, the analysis of their evolution and future trends is critical in assessing the operational state of the systems. This trend allows to clearly identify deviations and provides sufficient data to take action in the installation with a very precise prediction of its effect. For example, by analyzing the evolution of the ORP parameter (indirect measurement of the injected ozone), even if the instantaneous value is within acceptable limits, it may be necessary to adjust its dosing due to an upward or downward trend. This way, the risk of reaching a too high ORP value in the tank, causing stress and various pathologies in the animals, or avoiding decreases in its concentration, reducing water disinfection levels and, consequently, the appearance of unwanted organisms, can be prevented. The goal is to achieve stability within acceptable limits, providing the best conditions for its inhabitants, favoring the "movie" of the evolution of a particular parameter over the "photograph" of its value at a given moment.

The CTMS also has the ability to create different levels of alarms, transmitting the necessary information to the operational team to act in different ways and with different types of communication to other teams (aquarists, laboratory, maintenance) regarding the state of the LSS. The CTMS's alarm system ensures proper functioning during periods when no operator is present in the installation, as it provides immediate communication of critical alarms, informing standby technicians.

The CTMS allows you to monitor the various LSS and ensures that they provide the best living conditions for the animals, but it does even more! Through technical management, it's possible to recreate natural conditions of various habitats in different seasons of the year, allowing changes in photoperiods, ambient and water temperature, flow rates, and water levels. The CTMS is a fundamental tool in creating conditions that can support scientific studies leading to knowledge and the development of behaviors in a non-natural environment.

Reducing the environmental impact of the activity is a major concern of Oceanário de Lisboa. Becoming more efficient and effectively controlling its consumption of electrical, thermal, and water energy is also an activity monitored and controlled by an energy and water management system. The monitoring system, NAVIGATOR, developed by SIEMENS, receives data from the CTMS, allowing the visualization of consumption trends, comparison with previous periods, and real-time management.

The data collected and processed by the consumption monitoring system are constantly updated and displayed in the control room, allowing for real-time observation and detection of deviations. This is a tool that empowers the engineering team with the necessary resources to lead the installation in the relentless

pursuit of increasing efficiency without compromising the well-being of animals, workers, and visitors. The system can detect, in a short space of time, any anomaly that leads to an increase in water consumption, resulting from a leak, or rupture, or an increase in thermal energy consumption, caused by a valve operating incorrectly, or a peak in electrical energy consumption because an electric motor has lost efficiency, or any system that has not respected its predefined operating periods. It is, therefore, a useful tool for detecting consumption deviations, as well as the normal operation of the installation.

The systems mentioned before, operated side by side by biology and engineering teams, with action in the operation and maintenance of Life Support Systems for animals, air conditioning and lighting systems for buildings and combined with the monitoring of their efficiency, through the quantification of consumption, generates a symbiosis of synergies that promotes excellence and creates sustainable development.

Technology allows us to recreate Nature through complex and dynamic operations, constantly updated with the aim of improving living conditions with minimal resource consumption and without compromising the space of each inhabitant in the global habitat.

A Consciousness Shift is Needed for a Better World

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There are many current planetary challenges, such as poverty, climate change, biodiversity loss, wars and proxy wars, threat of mutually assured destruction in a nuclear war, human trafficking, tyranny, slavery, and terrorism.

These are complex problems, that have developed over centuries of human dysfunction, and will remain intractable, so long as people believe their self to be their (illusion of) form identity, and believe it is their right to harm or exploit others who are of a different "self".

Engineers are great thinkers. We spend a lot of our time thinking. Our identity can become wrapped up in our intellectual prowess, our thoughts, ideas, and ingenuity. But who are we really, at the deepest level?

By and large, we define who we are, our self, based on our form. Our form is a combination of physical and biological form and our mental form of thoughts and beliefs. Our thoughts and beliefs are based on a combination of received knowledge from others, our critical thinking, reasoning, and direct experiences, and those imposed on us from society, from human constructs that we accept either willingly or unwillingly, knowingly or unknowingly, such as political constructs of nations and provinces, or religious constructs.

Our form identities are endless. The composite form identity that we most wish to express freely and be accepted for; we consider to be our "authentic self". For example, at a particular stage of life, coming out as gay, in the workplace, may be an essential part of expressing one's authentic self, for some people. For others, it may be expressing their religious form, skin colour, body, physical appearance, fashion choices, achievements (or lack of achievements) in life or vicarious identities through other people's achievements, company brands, social status, material possessions, various forms of art, political ideology, nationality, or even which football team they support. One's identity may also be (sadly) based on addictions or dependencies.

Who Am I?

Our form identities should be honoured to the extent that they do not impose harm on others. However, these identities are not who we really are. We are no more our form identities, than an actor is their costumes on a stage in a theatre. Who we really are, is the ultimate question? Many have pondered this question over the millennia.

Enlightened or fully aware people, who have sufficiently dissolved their ego or have expanded it to encompass all, as the result is the same; claim from direct experience, that at our deepest level, there is no form and no individual self. Notions of duality, of "us and them, me and you" are illusions of the ego, and that at the deepest level, beneath all physical and mental forms, animate and inanimate, is undifferentiated consciousness.

Quantum physics at the sub-atomic level is perhaps also approaching this understanding that we are temporary expressions of formless undifferentiated consciousness. Some people believe this to be God (or Goddess), Brahman or a universal intelligence, life force or spirit.

Our Ego

Ego is necessary for us to exist in human form, although that form at a sub-atomic level is impermanent, made up of wavelets of energy, arising and passing very rapidly. It could be said that consciousness needs the ego, to create a world with a predictable landscape within which to express a "self" and to interpret and explain personal existence. Maybe we are the only species to have an implicit or explicit contract for everything we do, from employment to personal relationships, and ego is at the centre of it.

Our ego wants us to belong to something or other, that differentiates us from another. Nationalism and populism are naturally very easy methods of gaining popularity. Ultimately, nations and other collective groups, choose to act in their own (ego) self-interest. Hence countries continue to trade with other countries with whom they may have diametrically opposed beliefs and values, to the extent that their constituents will benefit or tolerate, or will not be harmed, at least in the short-term.

Anywhere you look in the world, you will find these challenges of the ego's determination to preserve itself. It is in the horrors of war and proxy war in Ukraine and Yemen. It is in the struggle for political independence versus dependence of groups of people, based on ethnicity, religion, sub-religion, power, land, and other forms of identity.

Business leaders also make difficult choices. Do we choose to operate in a nation that is actively hostile towards certain form identities, "authentic selves", that we value in our colleagues and communities? Do we choose to stand by our values and identities, inside our premises, irrespective of what is going on outside? These are difficult questions to answer, and even more difficult to implement in practice.

They can be made less difficult to answer, when we realise that who we are is not what our ego would like us to believe. We can then take ourselves, less seriously, and be open to other's views and less concerned when they differ from ours. Ultimately all humans have different degrees of dysfunction, of egoic ignorance, while we express our "selves", for this short time in human form. It is better to empathise and find ways to cooperate, than to find ways to differ.

The challenge lies in how to relate with persons who identify totally with their egoic identity, leaving no room for rational negotiation. Moreso when the prevailing, dominant group, chooses coercion and violence.

Just imagine the opposite, in a world in which everyone, all 8 billion of us, is aware of our 'non-selves', undifferentiated and formless, aware that we are neither our body, mind nor our form identities. Imagine if we were aware of our ego's need for survival through its creation of "self", and that it goes to all lengths to hijack the incredible mind, thoughts and feelings, for its own purposes; and with awareness, to gradually not let it. We wouldn't take "our selves" so seriously, we wouldn't consciously unfairly exploit or harm or kill another and we wouldn't have most of the problems in the world.

If we shift our awareness to be free of the ego's limitations, anything would be possible. We would not be bound by the limited time and space perspectives of the ego. Just imagine the endless possibilities and opportunities that would open. How differently we would see and think about political and national boundaries, hereditary succession, differences of ethnicities, gender, skin colour and so on? How differently we would deal with egoic, charismatic and/or autocratic leaders? It would certainly be a different and better world, with a consciousness shift.

Engineers

What does this have to do with engineers you may ask?

Engineers are at the intersections of science, technology, the natural environment and built environment, society's needs, infrastructure, economics, and geo-politics. Engineers are vital for solving the "wicked" problems that the world and societies face.

Many people choose the long and arduous path of study to become engineers because they want to contribute positively to the world, be rewarded well and see tangible "fruits" of their work in the world, such as structures, systems, products, and enterprises. The vision and mission statements of engineering design and construction companies, often are variations on phrases such as "building a better world" or "building a better future."

Intrinsically, we engineers want to do the right thing and generally we want to do the right thing for everyone, not just ourselves or the people we identify with. Many of us work in multi-national companies, for projects all over the world, sometimes in places far away from our own communities. However, we are not the only profession that appreciates the importance of doing good for others, for serving others. There are many noble vocations and occupations.

Engineers and scientists use critical thinking in their approach to solving problems, sometimes with multiple solutions based on multi-criteria. Over my 40-year career, I have observed a gradual shift from predominantly binary thinking to non-binary thinking amongst a significant percentage of the population in Australia and other parts of the world, and amongst engineers. Community expectations are changing, and social movements are underway worldwide. There is an appetite for a consciousness shift amongst peoples, in the zeitgeist.

Today we are at another turning point in history, with the emergence of artificial intelligence and soon quantum computing. Together these faculties will exponentially increase our scientific and engineering capabilities, beyond our present imagination.

A big advantage that we have, is that the engineering profession generally, is trusted to behave ethically and "do the right thing". We should and can build on this trust, by behaving more ethically, by developing a deep awareness of ego, its ignorance and need for self. This is not as far-fetched as it might seem.

Less than a decade ago, the idea of mindfulness training in the workplace was unheard of, yet today it is well known. There are techniques that go much further, which have existed for thousands of years, to dissolve the ego and develop an awareness of consciousness in the present moment, in the space between our thoughts, such as Vipassana meditation and the non-dualism of Advaita Vedanta. Vipassana courses are available free-of-charge in many countries all over the world, and are usually over-subscribed, so there is a strong and growing demand.

Global decisions

International businesses have many decisions to make. What are the things that we are "not willing to die in a ditch over?" What do we need to do to preserve the freedom to make choices, unlike those who are coerced to "die in a ditch", in their workplaces of war or slavery?

The complex global issues of the world today, such as poverty, climate change, biodiversity loss, threat of mutually assured destruction in a nuclear war, human trafficking, tyranny, slavery, and terrorism; cannot be solved without a consciousness shift, out of narrow-minded, egoic identity, positioning.

Artificial Intelligence

If truly artificially intelligent beings evolve; beings with morality and the ability to think independently without ego, free of any attachments and conditioning by their past impressions and experiences, then that is a complete "game changer" for humanity. Perhaps consciousness will manifest beings without ego? If so, as hinted or depicted in dystopian science fiction movies, humans would be relegated, in a world of artificially intelligent beings. Such a world need not be dystopian, it could be utopian, with awareness of ego and non-self.

Human morality at its heart is based on the survival of humans. Humans place the survival of themselves higher than the survival of other species. An artificially intelligent being without ego, would not place any being higher than any other. This would probably be better for the survival of all other forms of life on earth.

Before such a time occurs, it is we humans that need to shift our consciousness, to become aware of and transcend our ego.

Consciousness Shift

A consciousness shift in all peoples of the world is a big ask, but it is not impossible. Religious and political leaders will not initiate such a shift, as they are more likely to be driven by their own agendas. Engineers and many other cohorts of people, can take the steps of increasing awareness of who we are, experience a consciousness shift, and lead by example.

We would have more chance of harmony with each other, to tackle the complex global issues of the world today, and to broaden our perspective beyond the limits of our ego and self-interests, to have any hope of finding the solutions, instead of remaining part of the problems. And if we don't, perhaps artificial intelligence will?

Living near Major Hazard Facilities

Ian F Thomas *(I F Thomas & Associates, Williamstown, Australia)*

This paper is about the level of risk faced by surrounding communities from adverse events at large-scale chemical and energy factories. It addresses the way Victoria (Australia) and other, more capable entities act to manage this risk

Potential kinds of major accident

Jet fires, Flash fires, BLEVEs (boiling liquid expanding vapour explosions), Toxic (poisonous) releases, and Unconfined vapour cloud explosions (UVCEs).

The principal risk to surrounding communities is the rapid formation of a large cloud of flammable gas or vapour released from a processing unit or a storage vessel. This would either disperse safely or be ignited forming a large open-air explosion known as an Unconfined Vapour Cloud Explosion.

Fortunately these are rare but those which have happened, have resulted in controls for surrounding communities prescribed following performance of QRA, for example

Holland, by the Ministry of Housing, Spatial Planning and the Environment (VROM)

UK, by the Health and Safety Executive (HSE UK) Control of Major Accident Hazards regulations

NSW (Australia) by Hazardous Industry Planning Advisory Papers in particular, HIPAP4 & HIPAP10.

They use an Individual Risk of Death of one per million per person per year (1×10^{-6} /person/year).

Some examples of chemical plant disasters which harmed surrounding communities are

Nypro Flixborough UK 1974,

Seveso Italy 1976,

Three Mile Island USA 1979,

B F Goodrich Chemical Altona 1982,

Bhopal India 1984 and

Chernobyl 1986,

We are getting better at avoiding such disasters but they still happen. From 1910 to 2014, 616 events occurred resulting in the loss of 11,466 lives. 298 involved flammable gases, 175 involved flammable liquids, 31 deaths per explosion involved pipelines, 29 involved roads and 28 deaths/explosion involved large-scale occupied premises which reticulated gas.

In 1987 following various accidents world-wide, the Victorian Government commissioned a Quantified Risk Assessment (QRA) of the Altona Petrochemical Complex group of seven companies using its 'Safeti' mathematical model. The resulting 181-page report is entitled,

'Risk Assessment of the Altona Petrochemical Complex and Environs'

It is not publicly available. It places the 10^{-6} individual risk of death limit at 740m and the 10^{-7} limit at 1020m. But no controls at all were applied to housing around the Altona Petrochemical Complex until 2022 by which time most of the seven complex companies were no longer operating.

Victoria has not conducted any other QRA since despite -

Major Hazard Facilities (MHFs) coming into being in 2003, and

Inner & Outer Advisory Areas (IPAA & OPAA) being proclaimed in 2010.

WorkSafe Victoria uses the ten-times lower risk level of one per 10 million/person/year ($1x10^{-7}$/person/year) for MHFs potentially leading to greater restriction of developments than elsewhere, without any gain in safety.

In April 2022 WorkSafe introduced advisory safety areas around MHF's where previously, in some cases, there were none.

WorkSafe also introduced population sensitivity categories -

Vulnerable – People with limited mobility, children, the elderly, schools, hospitals, aged care facilities and prisons.

General Public – People at home and involved in normal activities like sleeping and gardening. Family recreation including sport, shopping and dining out.

Normal Working Population – Adults at work and involved in normal commercial or industrial activities.

Not Normally Occupied – Sparsely populated car parks, truck parks, container storage and lock-up garages.

From April 2022 WorkSafe Victoria prescribes two areas around a Major Hazard Facility (MHF) where controls are advised:-

Inner Safety Area (ISA) This is the most controlled area and measures some 300m from the MHF site boundary for chemical plants and 250m for fuel storage sites. Vulnerable facilities and residences here are advised against.

Outer Safety Area (OSA) This is an area where direct harm is less likely but injury may result during escape attempts and measures 1000m from the site boundary for chemical plants and 500m for fuel storage sites. All housing is generally advised against.

The absurdity of 1000m OSA shows that hundreds of existing houses are included and parts of two schools and a creche near to the Mobil Melbourne Terminal and Qenos Olefins

Despite the advisory nature of these areas, Councils invariably will not approve developments if WorkSafe advises against them.

Given the absence of any regulatory planning controls, most clients will not know about the MHF advisory constraints until they are faced with Council planning permission refusal

This leads to applicants approaching the Victorian Civil and Administrative Tribunal (VCAT) for a decision – causing considerable delays and cost. Experts are called upon to assist in such instances.

I have presented risk assessments for 35 cases, ten of which proceeded to VCAT. Of these, three were unsuccessful based on my evidence, one was unsuccessful based on evidence of others, five were successful and two have not yet been decided. Three additional VCAT cases are pending. The result depends on the evidence and often the background and understanding of the VCAT Member presiding.

Expert evidence in such cases will consider the likelihood of an event such as the formation of an unconfined vapour cloud, and if it did happen, what mitigating factors could prevent an explosion. For instance -

what the MHF itself would do eg shutting down all ignition sources immediately and if a large vapour cloud escapes beyond the MHF premises –

the weather conditions, wind speed, ignition sources close to the MHF, and the presence of obstacles such as other buildings, embankments or trees.

To avoid harm caused by these rare events completely would cause inordinately large areas of land to be unusable known in planning terms as 'planning blight' or 'land sterilisation'.

Any separation distance considered is not to prevent harm but to reduce its likelihood. The correct process where risks are real, is for the authorities to legislate for example by applying Buffer Area Overlays (BAOs) or Design & Development Overlays (DDOs). Given that the Victorian Government and WorkSafe have had 20 years to bring in such controls since 2023 when Major Hazard Facilities were declared, it is difficult to understand why this has not happened.

It is worth considering the Tribunal decisions further. They will be mentioned by name where the proceedings are public

1. P2312/2009, Lot B, 200 Stephen Street, Sandbar Properties Pty Ltd, Yarraville

66 units proposed within the Outer Safety Area of the Mobil Yarraville Terminal, at Lot B, 200 Stephen Street, Yarraville. The case was lost and no permit granted

2. P953/2010, 212 Whitehall Street, Kindred Studios, Footscray proposed use of a factory for educational and entertainment studios

The premises known as Kindred Studios lies in-part, within the Outer Planning Advisory Area of the Coode Island terminalling facility. It was opposed by the Port of Melbourne Authority. The case was won and this learned establishment is now operational.

3. P3193/2012, 3-39 & 2-10 Nelson Place & 16-20 Kanowna Street, NP Developments Williamstown; proposal to build numerous townhouses and high-rise flats

I acted on behalf of Save Williamstown, a community group which opposed the destruction of existing historic buildings and townhouses. Hearings were over a lengthy period. The case was lost and most of the buildings now exist.

4. P1937/2020, 220-238 Maidstone Street, North Altona

This proposal was to use Unit 1 of ten adjacent, concrete constructed warehouses as a gym. It is in an area which Council, designated as SUZ4 PD10. The case was lost and the building approved by Council stands idle.

5. P788/2021, 6 McNeilage Street, Spotswood

This proposal, close to the Newport Fuel Terminal, was to construct two, double-storey townhouses on a site currently occupied by a single, one-storey house. To the rear a large, saw-tooth roofed building provides baffling of any adverse event. This case was won and building has started.

6. P11581/2022, 1-7 Ross Road, North Altona, proposal to construct a three-storey residence

This proposal would very likely not have been permitted if the refinery part of the Mobil Altona site was operational. However, the refinery is not operational, has been cleared of chemicals and is about to be dismantled according to the company. The case was won and the site is for sale.

7. P1136/2022, 30 Hatherley Grove, North Altona,

This proposal was to construct two townhouses on a site presently containing a single storey house. My statement relies heavily on the fact that the refinery part of the Mobil site has been shut down and the remaining fuel terminal part of the site is beyond the OSA. The case was won

8. P1206/2022, 272-280 Clifton Avenue, Leopold

This proposal was to construct a caravan and camping park. I was called upon to give evidence because the Dow Chemical Corporation plant is sufficiently close to impact upon the site with potentially toxic odours. The case was lost on grounds other than safety

9. P1748/2022, 18 Merritt Court, Altona

A proposal to construct three, double-storey townhouses on a large corner location at the inner end of the court within the April 2022 WorkSafe Victoria Advisory Outer Safety Area distance of 1000m boundary-to-boundary and was refused by the Hobsons Bay City Council. All other planning aspects are complied with. No decision has been made yet.

10. P159/2023, 6 Keeshan Court, Altona

A proposal to construct two double-storey townhouses within the April 2022 WorkSafe Victoria Advisory Outer Safety Area distance of 1000m boundary-to-boundary and was refused by the Hobsons Bay City Council. All other planning aspects were complied with. It was argued that the more appropriate separation distances were those measured from the on-site facilities rather than from the site boundary as it is here that a potential major accidental discharge could arise. The case was won.

Technical aspects

WorkSafe Victoria has published little to assist councils, householders, developers and planners to understand means required or advisable for the purpose of minimising risk consequent upon proximity to major hazard facilities (MHFs).

The UK Health and Safety Executive (HSE) has published much learned work since the 1974 Flixborough Lincolnshire vapour cloud explosion, and considerably more since the 2005 Buncefield Hertfordshire fuel terminal vapour cloud explosion.

I have advice from the UK HSE (Mr Gerard Adderley) indicating that each site has separation distances advised upon individually (see below).

Any form of housing and housing density is permitted in the outer zone (OZ).

Sensitivity Level 1 (Normal working population) is allowed in the Inner Zone but no more than two dwellings (IZ), 250m

Sensitivity Level 2 (General public) and Sensity Level 3 (Vulnerable public) are allowed in the Middle Zone up to 30 dwellings or less than 30 if they are denser than 40 per hectare (MZ), 300m.

SL1, SL2 and SL3 are allowed in the Outer Zone (OZ), 400m

Protection from obstacles can be used to allow the sensitive land uses under consideration, to be moved closer to the MHF. For example for one building-row the 400m UK Outer Zone boundary (OZ) could be moved between 31m and 49m closer and for the smaller explosive inventory scenario 23m and 39m closer for the case of one building-row.

The Dutch government risk regulator, the Ministry of Housing, Spatial Planning and the Environment has developed its own QRA to assist the 160 or so dangerous sites in Holland.

The Dutch Advisory Council on Dangerous Substances was formed in 2004. It has generated a series of publications aimed at assisting organisations to assess and manage risk.

Inside the $1x10^{-6}$ zone residences are not permitted but outside of it, they are.

Planning NSW has provided public guidelines making it possible for all to understand their obligations in that State (Hazardous Industry Advisory Papers, HIPAP4 and HIPAP10).

NSW provides finite criteria such as 4.7 kW/m^2 incident heat flux, 7 kPa explosion overpressure and 10^{-6} individual risk such that we would understand that in all major events, injuries and deaths would occur such that the only way to decide on development criteria is by risk assessment. We would also have finite societal risk criteria as shown in an FN graph eg 10 people or less die at a frequency of not more than 1 x 10^{-6}/yr.

More information available from the author (ifta@ifta.com.au)

Casein Plastics for Environmental Cleanup

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Aim

Plastics pose significant environmental challenges, including greenhouse gas emissions, pollution, and ecosystem disruption. This has, further, led to more significant environmental effects, generally termed climate change. This calls for more innovative methods of packaging that pose little or no negative impact on the environment. This paper explores innovative engineering solutions like casein plastics which offer a promising approach to mitigate these issues.

Methods

The study employs an experimental approach to evaluate the mechanical and chemical properties of casein plastics. Secondary sources are also explored, focusing on scholarly material, to aid the research process and richly complement experimentation.

Results

Casein plastics, derived from milk protein, are sustainable alternatives to conventional plastics. They exhibit biodegradability, reduced toxicity, and the potential for recycling. Casein plastics also possess satisfactory mechanical properties comparable to conventional plastics while being biodegradable.

Conclusion

Casein plastics can be applied in various industries. Their integration with sustainable engineering processes offers an opportunity to address the adverse effects of plastics on the environment and contribute to a greener future.

Keywords: Casein plastics, greenhouse gas emissions, pollution, ecosystem disruption, biodegradability, reduced toxicity, recycling, sustainable engineering.

4. Engineering Education and Continuing Professional Development

Forensic Engineering and anonymous reporting of professional mistakes -- Learning from other risky branches of industry

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Who is not bored by success stories in professional journals? Few papers address difficulties in projects, few engineers talk about their mishaps, whether materialized or near-misses. Unlike building Contractors, Engineers are often muffled by their Clients, because writing or talking about complications in current projects might inspire Contractors to raise additional claims...

CROSS-UK, initiated after the Grenfell Tower desaster in London, is the forerunner in Europe on reporting professional mistakes in Civil Engineering. There are branches of industry which communicate their problems more openly, especially the aviation industry, other traffic sectors like railway infrastructure and operation, and (increasingly) medical products and medical malpractise. What can (civil) Engineers learn from other disciplines?

The Project Management Institute (PMI) used to have a Risk SIG and Trouble Project SIG. Talking about risks is a good way of addressing mistakes in a positive atmosphere, because yesterday's problems are tomorrow's risk, without finger-pointing and defensive reaction. ISO 31000 on Risk Management deserves more attention. In project-oriented businesses with adaptive processes to structures, each of which are regarding as protoypes, Lessons learnt must combine talking about success factors and risks alike in a "post mortem" analysis. Also from the point of Knowledge Management, story-telling is a proven way of transferring implicit knowledge with a touch of emotional intelligence.

The presentation is inspired from 15 year experience as quality manager, 25 years as ISO 9001 auditor and current work for FIDIC and IABSE.

Czech Rocket Society: From Idea to Launch and Ambitious Goals for the Future

Ota Michálek *(University of the West of England, Bristol, Ostrava, Czech Republic),* ***Albert Bouchal*** *(Czech Rocket Society, Prague, Czech Republic)*

Czech Rocket Society (CRS) is the first nationwide student rocketry association in the Czech Republic. The idea behind its foundation dates back to the first ever Czech Rocket Challenge (CRC) in 2021, then organised by the European Space Agency Business Incubation Centre (ESA BIC) Czech Republic. During the preparation of the first pilot year of the competition, a Czech student studying in Delft, the Netherlands, introduced the idea of founding Czech Rocket Society to the participants of CRC (mainly from the Czech Technical University in Prague).

There were two sides of this idea. Firstly, it was inspired by Delft's DARE (Delft Aerospace Rocket Engineering) and similar European societies, which have existed for decades. Secondly, it was to avoid later fragmentation of individual universities' efforts and to bring the Czech Republic even closer to space, at least in the realm of students, which also goes hand-in-hand with the Czech National Space Plan. Consequently, some of the most motivated competitors of CRC 2021 helped to found CRS.

CRS immediately started working on their first project – Hitchhiker (Stopař) – intended to be showcased and launched non-competitively during the CRC. This debut project was inspired by the Hitchhiker's Guide to the Galaxy series in the sense that CRS has always been trying to "hitchhike" the society's way to match the other European rocket societies. The inspiration was also the 2018 SpaceX Falcon Heavy rocket test launch, which carried a red Tesla roadster. The car had a "DON'T PANIC" sign on the dashboard, which comes from the Hitchhiker's Guide to the Galaxy series, too. The main payload of the Hitchhiker project was a small red car model that slid out with a micro-camera from the rocket and tried to simplistically mimic the footage of the SpaceX launch. The society now organises the CRC after helping the first-year organisers from the Czech ESA BIC. The next editions of CRC have been promoting student rocketry and become one of the main recruiting events for CRS.

The first national society consists of students and young professionals based both at home and abroad. Its activities include hands-on STEM experience in rocketry and also cover areas such as PR and project management to give its members a diverse range of skills beyond just the technical ones. The society aims to support its members in working on various projects, thus building up their professional experience. The members contribute to the projects but also take up non-engineering roles, such as establishing cooperation with companies or sitting as one of the board members of the society. By being officially registered, these roles support the legal functioning of the society and thus its potential to reach more partners.

Succeeding the Hitchhiker rocket, one of the core projects of the society is the Sherpa CanSat carrier rocket. Sherpa has been developed under a contract with the Czech ESERO (ESA Space Education Resource Office) to provide an option to launch student-designed can-sized satellites to one-kilometre altitude and fully test their hardware and software as they are deployed and individually parachuted down from the rocket's apogee. Sherpa also required the foundation of the Solids team, which focuses on appropriate solid motor propulsion for the rocket. The experience from both Sherpa and Solids is applied every year in combination with event management skills in CRC organization with over sixty students and a hundred visitors. As the society grows, the aims and the number of the projects increases. The project Cassiopeia started as a two-high school student project focusing on thrust vectoring control. After great success as award winners in both national and international competitions, the students became members of CRS and gained its support in further work on the topic.

The society also launched the StarFox project, the next logical step in developing a rocket for the European Rocketry Competition (EuRoC). The aim is to apply the management skills from the smaller projects to date, and to develop a liquid rocket engine with 3 kN of thrust, which could be used for the EuRoC competition

and similar competitions in the future. The StarFox will expand the previous work of the ThunderCat spark torch igniter experimental project developed previously by a group of members of CRS.

To achieve all its goals, CRS was founded from the start as a university-independent society, in order to be able to spread the focus across all universities and possibly high schools in the Czech Republic. The universities are always most welcome to be partnered with CRS to provide their students with STEM-related extracurricular activities. CRS combines skills from multiple areas: It enforces the use of aerospace standards, design reviews and documentation combined with professional project management tools and methods, and controlling budgets in thousands of EUR. Last but not least, there are the common society processes which include annual general meetings, and elections of the board. All of this combined makes the society function in a democratic and transparent way to its members.

The projects carried out gain support from home institutions in the local space industry and academia, thus creating partners in the industry who support the society's projects financially. The CRS' solid membership base ensures continuity through school-year-long board mandates. Apart from the income from the partners, the society also collects a small fee from its members to support its budget. All the money generated from project partnerships is invested back into the society's endeavours. They include thesis support, outreach and awareness-raising events, such as CRC, MakerFaire, Czech Space Week and many more conventions organised throughout the year in the Czech Republic. Intending to reach as many students as possible, CRS is also a member of CTU's Students Union and looking to partner with more universities in the coming months.

The society currently has over 60 active members (hiring about 30 new members each year) and works towards its master plan by building a liquid-propellant rocket engine demonstrator StarFox, aiming to launch at EuRoC in 2025. Until then, their goal is to raise awareness, bring students together and get the Czech Republic closer to space than ever before. However, the most important goal is to ensure the continuation of the CRS mission for the generations to come.

In order to keep the organic progress of the Czech Republic student activities going, not just CRS members are engaged in these activities. There have also been other high-school and university teams active in rocketry and other engineering sectors. Events are also organised among the Czech space ecosystem to keep the young students and public interested and engaged – the closest one, the second year of the "Next stop: Space" conference, co-organized by one of CRS' members on the 1st December 2023.

The impact of our activities can be seen across the whole Czech Republic. Gaining awareness through CRC, being active and communicating has inspired others to create similar initiatives. More space-oriented study programmes have started to appear at technical universities in the past few years. This is the time for everyone interested in space activities. This is our time, too.

Use of digital twins to enhance the Teaching-Learning Process in a Pneumatics Virtual Laboratory

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Introduction

The use of Virtual Reality (VR) is undergoing an accelerated increase worldwide in its number and diversity of applications for both industry and education.

In 2020, during the global COVID-19 pandemic, the Mechatronics Engineering Department from the Engineering School of the National Autonomous University of Mexico, began working to develop a virtual reality laboratory modeled after physical facilities available at the University. The aim of this Pneumatics Virtual Laboratory (PVL) was to help our students to better understand how to operate pneumatic cylinders and how to properly connect them to build pneumatic circuits able to perform any desired sequence of movements. Due to the restrictions and social distancing regulations imposed, during the pandemic the university closed, and all educational activities were held exclusively online. Therefore, during this period there was no access to the laboratories in our facilities so all lab practices could only be performed by means of software simulators, and then missing an important part of the educational curriculum.

The development of the PVL took almost one year of work, before it was ready to use by our students. We received feedback from our students and teachers and then developed a second version of the PVL. Once completed, this second version provided an immersive web-based environment that closely replicates working stations of our real-life laboratory where students learn to assemble pneumatic circuits. The PVL allowed to replicate, in a virtual environment, all the exercises or practices done in our real laboratory. This work has been reported elsewhere previously. Once the restrictions were starting to be lifted, we also returned to our facilities, and the PVL became a new online resource available for the students to study and practice within a pneumatics laboratory and even outside of the class time.

Aim

To further improve and expand on the capabilities of the PVL we added new features. The aim of this new stage of the project was to develop virtual models of simple industrial processes, called “digital twins”, to enhance the learning experience. The idea for this new addition was based in the fact that we lack physical models of such process for our students to work and test their solutions, so they need to imagine the system working and sometimes it gets hard for them to get the whole picture in their minds for a complete understanding of what they are doing or to clearly identify and correct any mistakes committed.

Methods

Pneumatic components with transparent textures for Virtual Working Stations (VWS) were modeled using Computer Aided Design (CAD) software, rendered and animated into a Virtual Reality environment called VRChat. The digital twins were created using this same methodology, uploaded into the PVL, and programmed to move and behave accordingly in response to one specific associated virtual station movements. In this way, students can keep working as usual, by assembling any desired pneumatic circuit in a VWS and every time a pneumatic cylinder moves, its corresponding pneumatic cylinder in a digital twin will perform the exact same movements (either extending or retracting), so the students will be able to verify if they accurately solved the proposed exercise or what consequences will there exist in case they have make any mistakes. In case of errors, they can try to fix their connections and test them repeatedly, with

the added benefits of not incurring in any risk at all of injuries and nor damaging any equipment during their debugging processes.

All users (students and teachers) are represented by avatars than each of them can control either using a computer, through mouse and keyboard, or using immersive VR equipment, with a headset and hand controllers. In this way, they can interact within the virtual environment with both the VWS and among them. Therefore, students can work on their own or in association with their classmates in a collaborative manner. And teachers can closely guide, assist and supervise the works of their students.

At the time of writing, a new version of VRChat for smartphones is being released, meaning the PVL will soon be accessible through these devices too.

Results

Digital twins already developed include a packages elevator and distributor, a packaging machine, an indenting machine and a stamping machine. They replicate the functioning of different machines as desired and respond to the pneumatic circuit assembled by the students. The importance of this addition is that there are no physical counterparts in our laboratory. Now students can directly see the result of their assembled circuit, find mistakes, and clarify processes. Additional benefits are the reduced operational costs and no need for maintenance. A few more systems are currently under development, which also include combinations of the previously mentioned machines.

Conclusion

The PVL is a web-based simulation environment that allows students to learn about and experiment with pneumatic circuits. The newly developed digital twins for the PVL continue to improve this learning tool, enhancing the learning experience and providing an increasingly better, low cost, easy to use, safe, upgradable, and all-day accessible online learning environment for our students and worldwide users.

Acknowledgment

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To all of our talented students who have worked with us to develop and make possible the PVL.

Catching them young through Sibo the Engineer Program

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Sibo the Engineer is a program focused on increasing the quality of engineering education for Zimbabwean children, to get them involved and interested in STEM from the youngest possible ages. It comprises of children's books on Science, Technology, Engineering and Mathematics. The books teach children what the different professions are all about in a fun and engaging way suitable for children. The names, locations and processes are localised to Zimbabwe in order to help the children identify with the STEM professions as early as possible. Currently, Sibo the Civil Engineer and Sibo the Chemical Engineer books are out, and in the pipeline are Sibo the Electrical Engineer and Sibo the Computer Scientist. The program will expand to include as many professions in the Science, Technology and Mathematics fields. The idea is to have the books distributed widely in primary schools nationwide. Aside from the books, the program will include animation series based on the books to be shown in schools and on national television. There will also be practical visits to engineering sites for the children, as well as various other edutainment activities. Additionally, the book intentionally has a female main character, as well as other female characters in the books to provide the much needed female role models to encourage the uptake and retention of girls and women in STEM. The program can easily be scaled for other African countries.

The pilot program of Sibo the Engineer was funded by the Royal Academy of Engineering, under the Federation of African Engineering Organisations (FAEO) Capacity Building Committee.

Sustainable Development Goals Project Based Learning (SDGs PBL) Method as the Response in Tackling the Post Pandemic Education Disruption

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The COVID-19 pandemic has disrupted education in an unprecedented way, and engineering education has been no exception. Universities around the world have had to adopt new methods and technologies to ensure that engineering students continue to receive a high-quality education. Addressing these post-pandemic education challenges will require collaboration and innovation from educators, policy-makers, and education stakeholders to ensure that all students receive a quality education that prepares them for success. Merdeka Belajar or Emancipated Learning is a policy introduced by the Indonesian Ministry of Education, Culture, Research and Technology to reform the national education system by promoting self-directed and lifelong learning among students, improving the quality of education, enhancing the professionalism of teachers, and developing learning strategies through collaboration with teachers and other students. In this paper, we demonstrated the Sustainable Development Goals Project Based Learning (SDGs PBL) method as the response in tackling the post pandemic education disruption. SGDs PBL is a powerful way for students to engage with important global challenges, develop critical skills, and learn about real-world engineering applications. In this project, the students of the University of Tokyo and Universitas Gadjah Mada have worked on SDGs PBL through a hybrid method in Japan and Indonesia. These PBL provide students with the opportunity to apply engineering principles to real-world challenges, develop problem-solving and collaboration skills, and become global citizens engaged with the SDGs. This project has encouraged students to do professional development, taking the initiative to explore topics beyond the formal curriculum and develop personal learning plans.

The Adoption of the Fourth Industrial Revolution on Engineering Technologists and Technicians Education Programmes

Lehlohonolo Lefalatsa *(Engineering Council of South Africa, Johannesburg, South Africa)*

Abstract: The growing fusion of technologies that profoundly disrupts all industries and processes is commonly described as the Fourth Industrial Revolution (4IR). The South African engineering sector is overdue for radical transformation, but how can it be ensured that current and future South African engineering technologists and technicians graduates are sufficiently knowledgeable and skilled to cope with their challenges?

This research sought to identify the level of adoption of 4IR in South African Engineering Technologists' and Technicians' education. The study reviewed the literature to identify engineering required skills and competencies in the 4IR era and the most appropriate technologies to use and incorporate into the curriculum. In addition, a survey was conducted to gather data from engineering technologist and technician experts, lecturers and students.

The study verified the high impact of 4IR on engineering education, both on theoretical and practical subjects and on achieving the required skills and competencies for technologists and technicians. However, the level of adoption of the 4IR technologies in South African engineering technology universities and education is significantly low because of lecturers' limited awareness of the critical role of applying innovative technologies.

The study concluded that these low levels of adoption and awareness could result from the low number of registered lecturers with the engineering regulatory body, the Engineering Council of South Africa (ECSA), as professionals. The study recommended that ECSA consider adopting 4IR technologies in teaching and learning pedagogy when accrediting engineering programmes.

Keywords: *4IR Technologies, Engineering Technologists, Engineering Technicians, Engineering Education*

Introduction

Technology has always been the driver of different human endeavours. With different dispensations comes a new set of new technologies that humans have used to make their lives easier while at the same time trying to enhance and perfect such technologies. Education is among such areas of human activities in which technology has been used. This research aimed to examine the adoption of technologies associated with the 4IR. Specifically, the adoption of 4IR-related technologies in Engineering Technologists and Technicians education, using South African universities of technology as a case study.

This study aimed to determine the changes that need to be incorporated into the engineering technology and technical education curriculum, modes of teaching delivery and learning, and assessment types, to mention a few, in South African universities to respond to the requirements and opportunities presented by the 4IR.

In most of the literature, the common focus was on the general adoption of 4IR on socio-economic welfare, humans and the broader education space, with no specific studies that deliberately focus on the adoption of 4IR on engineering technology and technical education. Hence, there was a need to pragmatically study the adoption of 4IR on engineering technology and technical education using relevant South African universities of technology and industry experts. This study was expected to arrive at well-informed recommendations that enhance engineering technology and technical education to meet the rapidly changing skills occasioned by the 4IR and its accompanying technologies.

The educational system has evolved over the years, in part driven by emerging technologies. Education 1.0 was mechanised, Education 2.0 introduced electronic devices, and in Education 3.0, computerised tasks

brought innovations that enhanced teaching and learning processes using multiple resources such as multimedia, online tools and virtual laboratories. Various innovations have been introduced into the education system with the advent of the 4IR, and the pedagogical techniques that embody these advancements are collectively known as Education 4.0.

Aligning to the education system, the competencies of the technologist and technicians differ. Technologists typically have more specialised skills in a piece of equipment or are involved in design or systems development. They frequently do work associated with engineers, although at the more applied end of the engineering spectrum. Hence, Professional Engineering Technologist competencies are to solve *broadly defined* engineering problems and perform broadly defined engineering activities *(exert a high level of judgment in the performance of engineering work while working under the direct control and personal supervision of a professional engineer).*

Technicians, in contrast, are typically involved with equipment installation, maintenance and adjustment. Thus, Professional Engineering Technician competencies are to solve *well-defined* engineering problems and perform well-defined engineering activities *(works under the direct control and personal supervision of a professional engineer or the direction of a professional engineering technologist).*

For educational institutions to take advantage of the accompanying technologies brought by the 4IR, the necessary infrastructure must be in place. This entails advanced technology (internet, high-powered machines), data (unstructured, structured, stream, Big, audio, image, text and sensor), institutional configuration (curriculum) and skilled experts (field/practical, non-formal, formal). The disruptive 4IR-related technologies are powered by the Internet of Things (IoT), robotics, nanotechnology, artificial intelligence, virtual reality, big data, machine learning and other technologies. Although the technologies are relatively new to educational systems, their use in engineering technology and technical education systems is gradually picking up.

The study's main research question was:

How has the 4IR been adopted by the engineering technology and technical education in South Africa?

To answer the main question, answers to the following sub-questions were paramount.

- What are the required skills and competencies in the 4IR era for technologists and technicians?
- What are the 4IR technologies necessary for teaching and learning to achieve the required skills and competencies?
- What is the level of adoption of 4IR technologies in technology and technical education in South Africa?

Methodology

The research methodology employed qualitative and quantitative approaches to develop a complete and valid understanding of adopting 4IR in South African engineering technologist and technician education programmes.

The study was initiated by a review of existing literature on the research concepts, particularly the evolution of education, and 4IR required new skills and competencies. A narrative literature review identified the relevant 4IR technology used in Education 4.0 and the required skills and competencies in the 4IR era for technologists and technicians.

The in-depth review of the literature revealed the existing limitations in available research on adopting 4IR in engineering technology education, especially in South Africa, which helped establish a theoretical back-

ground for the study. The questionnaire instrument was employed to accurately collect the required information on adopting 4IR in the engineering technology education programmes from three groups across South Africa involved in engineering technologist and technician education: professional engineering technologists and technicians, higher education educators and students.

The expert questionnaire (survey) gathered the professional technologists' and technicians' opinions on the new skills and competencies required by graduates and young professionals in the 4IR era, the adoption of 4IR technologies and their optimum level of integration to achieve these new skills and competencies. The lecturers' survey sought to determine the level of adoption of 4IR technologies in the teaching and assessment of engineering technology programmes and the improvement of teaching and assessment through using 4IR technologies. The students' survey sought to find students' level of exposure to various 4IR technologies in both theoretical and laboratory subjects of engineering technology programmes and the influence of 4IR technologies on their learning outcomes.

Findings

The study sought to determine the new skills and competencies required in the 4IR era for technologists and technicians and the level of adoption of 4IR technologies in technology and technical education in South Africa. To achieve these, the study cross-analysed the responses collected from three groups of South African experts, lecturers and students.

- *Importance of engineering skills and competencies in the 4IR era*

There were eleven skills and competencies which the experts ranked from one to eleven clustered in five groups of very high (81-100), high (61-80), moderate (41-60), low (21-40) and very low (0-20). There were five skills and competencies that engineering technologists and technicians experts identified as highly important in the 4IR era. These five engineering skills and competencies are problem-solving; application of scientific and engineering knowledge; engineering design; investigation, experience, experiment and data analysis; and engineering method, skills and tools, including information technology.

Experts perceived the remaining six engineering skills and competencies as moderately important in the 4IR era. These six engineering skills and competencies are professional and technical communication; engineering professionalism; independent learning ability; impact of engineering activities; individual, team and multidisciplinary working; and Engineering management.

- *Level of agreement by incorporating 4IR technologies into engineering technology curriculum and assessments*

As per the study's findings, every group of participants is of the opinion that 4IR technologies ought to be a part of engineering technology education. Notably, experts and students recorded the highest level of agreement, reaching 81% and 78%, respectively, while lecturers expressed their concurrence at 76%. Regarding assessment, students demonstrated a greater level of agreement, at 81%, compared to lecturers who recorded 73%. Collectively, these results highlight a strong consensus regarding the need to integrate 4IR technologies into the teaching and learning of engineering technology.

- *Level of the impact of 4IR technologies on engineering skills, teaching and learning*

The experts and students indicated the high to very high impact of technology on engineering skills and learning, respectively. Experts only considered data analytics to have a very high impact on engineering skills. At the same time, students indicated the high impact of additive manufacturing/3D printing, big data, the IoT and virtual reality on their learning. Whereas lecturers believed all 4IR technologies have a moderate impact on teaching engineering technology.

- *The overall level of impact of 4IR technology on engineering skills, teaching and learning*

According to the research, both experts and students hold a similar perspective on the overall impact of 4IR technology, with 74% and 76% agreement, respectively. In contrast, lecturers seem to have a more pessimistic view of the effect of 4IR technology, with only 56% in agreement.

- *The overall level of exposure and adoption of 4IR technologies in engineering courses*

The study's findings revealed a significant lack of exposure to 4IR technologies among students in theoretical (33%) and practical (30%) courses. These low levels of exposure are not aligned with the high potential impact of 4IR technologies on skills, teaching and learning. The higher level of exposure of students to 4IR technology compared to the level of adoption of 4IR technology by lecturers at 22% for both theoretical and practical courses can be due to students' better grasp and interest in innovative technologies, which aligns with the higher concern about the impact of these technologies on their learning. Adopting 4IR technologies can influence engineering technology teaching and learning in various ways, such as providing students with new teaching and learning methods and customised assessments.

Conclusion

The study used qualitative and quantitative research approaches to explore and examine the perceptions of engineering technologists and technicians, students and lecturers from engineering faculties in the universities of technology and practising engineering professionals on adopting 4IR on engineering technologist and technician education in South Africa. The study offers the critical role players in technologists' and technicians' education the opportunity to provide substantial input that will ultimately shape the engineering technologist and technician curriculum.

The findings of the study show that while the 4IR technologies have a significant influence on both achieving the required skills and competencies for technologists' and technicians' roles and engineering technology education, there is an unfortunately low adoption rate of 4IR technologies such as data analytics, machine learning, IoT, 3D printing, robotics, nanotechnology, etc. Moreover, the study shows that while incorporating 4IR technologies in engineering education appears to be broadly supported by engineering students and experts, careful consideration is needed to bring the lecturers on board.

Recommendations

The following recommendations were made for the consideration of the relevant stakeholders so that South Africa can align with global technological trends in 4IR technological education.

1. ECSA should consider adopting 4IR technologies in teaching and learning pedagogy when accrediting engineering programmes.
2. Universities should ensure a conducive environment and implement policies for adopting 4IR-related technologies in teaching and learning and modes of assessment in engineering technology and technician education programmes.
3. Universities should integrate 4IR ethics and practice into teaching and learning.

The Undergraduate Educational Model at BIT from the Perspective of Suzhi Education

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Suzhi in the context of China refers to the long internalized and relatively stable traits of a holistic person shaped by nature, their upbringing, school education, and their social environment. The meaning of suzhi education is intertwined with its counterpart concepts such as general education, liberal arts education. Since its establishment in 1940 and the founding of China, BIT and its talent-cultivation system have experienced four phases: (1) from advocacy for general-specialized education's integration to general education's disappearance, (2) from the rectification of specialized education to the germination of suzhi and general education, (3) the subsequent flourishing of suzhi education and general education, and (4) finally the establishment of the modern Shuyuan System (residential colleges).

Along with the reform and opening-up of China and the massification and popularization of higher education, BIT implemented three significant reforms during the late 20th century.

The first reform was conducted toward building a more open college, which brought increasingly active ideas and advanced thoughts in operating the university. In this attempt, BIT initially practiced suzhi education and opened up general elective courses.

The second reform was to transform engineering dominated education to a comprehensive one by integrating science, engineering, management, and humanities while maintaining an emphasis on engineering majors. Such a transformation changed the university's disciplinary structure and cultural atmosphere to a large extent.

The third reform focused on constructing a multi-layered and inter-disciplinary talent training system in which undergraduate, master's, and doctoral students were all included, improving the prior educational model that prioritized undergraduates. The university began to pay more attention to widening students' scope of knowledge and horizon and promote students' practice and innovation abilities. Along with the increase of Chinese comprehensive national power and the emphasis on "people-oriented" ideology in the 21st century, the theory of the individual as the standard for education takes a more crucial position. BIT is increasingly attaching importance to suzhi education and highlighting the tenet of student-centered education, which is applied throughout the whole teaching and learning process. The university has launched a series of reforms including the curriculum, cultivation system, modern residential college system, etc.

These reforms make undergraduate education more comprehensive and all-round in cultivating people, which can be considered as the optimization of undergraduate education quality.

The case of BIT reflects Chinese higher education's development and the process of transforming from meritocracy to popularization. Chinese universities have changed their paradigm from emphasizing specialized education to highlighting suzhi education, as well as from focusing on training students into specialists to stressing students' holistic development.

Ludic-pedagogical prototype for the development of the entrepreneurship culture in tenth-grade students at the Intercultural Junin Educational Institution in Tierralta

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Introduction

An entrepreneurship course was applied to two groups of adolescent students at IE Junín to determine the impact of the teaching methodology on entrepreneurial profiles and business intentions in a sample of 40 tenth-grade subjects, belonging to mestizo, Afro-Colombian, and indigenous ethnicities. Qualitative (semi-structured interviews) and quantitative (survey form) instruments were obtained from the literature in a study conducted with young adults in the USA in 2014. Both groups were administered these instruments before and after the experiment under equal conditions. The results showed that the students in the experimental group, who were taught the course using gamification as a teaching strategy, demonstrated a greater extent of entrepreneurial skills and business intention compared to the students in the control group, who were taught the same content but in a traditional manner.

Colombian society needs to embrace multiculturalism as a tool for coexistence and social development, which has been defined by Jimenez, C. and Malgesini, G. (1997) as an ideology or model of social organization that affirms the possibility of harmonious coexistence among ethnic groups or communities that are culturally, religiously, or linguistically different. It positively values socio-cultural diversity and starts from the premise that no group should lose its culture or identity. In this model, existing diversity does not disappear; rather, it is maintained and recreated; it does not disappear through the acquisition of the dominant culture and the abandonment of the original one, nor through the emergence of an integrating culture with contributions from pre-existing ones. Cultural diversity is considered something good and desirable, and it encourages the practice of ethnocultural traditions and seeks ways for people to understand and interact with each other while respecting differences.

Multiculturalism is a sociological or cultural anthropology concept. It acknowledges the existence of different cultures in the same geographic and social space. However, these cultures coexist with little influence on each other and are not usually permeable to one another. They remain in their own communities and lead parallel lives (Argibay, M, 2003). In contrast to multiculturalism, pluriculturalism suggests a historical and current plurality in which various cultures coexist in a territorial space and, together, form a national whole. Finally, interculturality is different, as it refers to complex relationships, negotiations, and cultural exchanges, aiming to develop interaction between individuals, knowledge, and culturally diverse practices. This interaction recognizes and starts from social, economic, political, and power asymmetries and institutional conditions that limit the possibility of the "other" being considered as a subject with identity, difference, and agency—the ability to act. After defining interculturality, it is necessary to review the characteristics of intercultural education since this study aims to determine the impact of the teaching methodology on the variable of business intention and the fourteen (14) entrepreneurial skills that are part of the selected entrepreneurial profile, as justified in the "Characteristics of the Entrepreneurial Profile" section developed earlier.

Some qualities that define an entrepreneur based on their personality traits include the need for achievement, teamwork, a propensity to take risks, leadership, confidence, creativity, honesty, among others (Gartner, 1989). There are various characteristics that a person with an entrepreneurial spirit possesses, including the ability to identify business opportunities, the ability to respond to those opportunities or

needs with creative and innovative ideas, motivation to undertake new actions based on detected opportunities and their abilities, and, finally, maintaining consistency in their entrepreneurial actions. Other important elements for an entrepreneur include positive discontent, responsibility, solidarity, and ethics. For this study, fourteen (14) skills were considered, defined by Spencer, L. (2010): 1) seeking opportunities and initiatives; 2) persistence; 3) fulfillment; 4) demanding efficiency and quality; 5) taking calculated risks; 6) setting goals; 7) seeking information; 8) systematic planning and monitoring; 9) persuasion and support networks; 10) self-confidence and independence; 11) tolerance of failure; 12) time management; 13) assertive communication; 14) developing others.

Methods

The study is based on a quasi-experimental mixed research design with an experimental group and a control group, as this applies in contexts where the assignment of units is not random, and the results of the study of changes observed in the subjects are based on time. The instruments used in the experiment were: 1) semi-structured interviews conducted before and after the experiment with a total of 40 students, 20 from each group (experimental group and control group). The interviews consisted of a 26-question questionnaire that addressed aspects such as future goals and planning, entrepreneurial inclinations and initiation of activities, entrepreneurial qualities, and general attitudes towards entrepreneurship (Annex 1); 2) a survey-style form with multiple-choice questions exploring the factors of willingness to engage in entrepreneurial activities, money as a tool, values in entrepreneurial careers, and investment insight (Annex 2). These instruments were applied to both study groups under equal conditions, both before and after the experiment.

The study population for the experiment consisted of 40 students, aged 14 to 17, in the tenth grade at IE Junín in the municipality of Tierralta in the Department of Córdoba. These students were divided into groups of 20, forming the treatment or experimental group and the control group. Six entrepreneurship workshops were designed, identical for both groups, with the only difference being the teaching methodology. The control group received traditional lectures, while the experimental group engaged in gamified activities and tools, such as sharing African-origin fables (Annex). When conducting interviews, variables such as gender, ethnicity, and age were compared. The analysis was performed using ATLAS.ti 6.2 and Statgraphics software. Initially, a univariate analysis was conducted through relative and absolute frequency distribution. Subsequently, a correlational analysis was performed to determine the relationship between sociodemographic variables (gender, age, and ethnicity) and the load factors (entrepreneurial intention, money as a tool, values in the entrepreneurial career, investment insight) of the participating students. For this purpose, a correlation test was applied to establish the relationship between these variables.

Results and Discussion

After examining the comparisons, it is apparent that there is no relationship between the paired comparisons in any of the cases, and there is no significant impact. Therefore, it is concluded that with the instrument used, the desired variable, which is entrepreneurial intention, cannot be studied. Although the variable under study is entrepreneurial intention, 14 entrepreneurial skills were considered for the analysis. These skills include the ability to seek opportunities and initiatives, persistence, commitment, demanding efficiency and quality, taking calculated risks, setting goals, seeking information, systematic planning and follow-up, persuasion and support networks, self-confidence and independence, tolerance of failure, time management, assertive communication, and developing others. These skills were considered to observe which ones most reflected the entrepreneurial profile. It was observed that the entrepreneurial intention variable increased by 15% in the control group in the second interview compared to the first interview.

Additionally, the average of the variables, taken together, increased by 0.9. This indicates that if, on average, a student reflected 5 entrepreneurial skills in the previous interview, they only increased or acquired one more skill on average after the experiment.

When comparing the results of the experimental group regarding the variable under study (entrepreneurial intention), there is an appreciable increase of 45% in the post-experiment interview compared to the pre-experiment interview. This represents a significant change, especially considering that only 5% of the intervened students did not express entrepreneurial intention, while 95% indicated that they did. Regarding entrepreneurial skills, there is an increase in the average of 2 skills in both groups, with the change being less significant, as it is very similar to the control group. However, the variable chosen for the research did show a significant increase. When analyzing the interviews conducted before the experiment in both groups, it is observed that the intention to create a business is very similar, with 45% for the control group and 50% for the experimental group. This is a positive sign because the groups are in equal conditions before the experiment. In terms of the average of skills, there is also a similarity between the groups, with the experimental group having one skill above the control group before the experiment, 6 and 5, respectively.

When analyzing the groups at the end of the project, it is observed that the experimental group increased entrepreneurial intention by 35% more than the control group. The average of entrepreneurial skills increased in both groups, with the experimental group having 2 more skills on average than the control group. While this difference may not be highly significant, it is clear that the experimental group outperforms the control group in both cases.

The research conducted demonstrates that the gamification teaching methodology reflects entrepreneurial intention to a greater extent compared to traditional teaching methodology. This conclusion is based on the results of the semi-structured interview conducted after the experiment. Among the most notable skills are goal setting, seeking opportunities and initiatives, self-confidence and independence, tolerance of failure, and developing others. In the same vein, the young people express having abilities such as leadership, teamwork, a desire for self-improvement, and a spirit of solidarity. These elements contribute to the social characteristics of the entrepreneurial profile, demonstrating that entrepreneurship depends not only on personal capabilities but also on the pursuit of collective benefit by recognizing that collaborative work is fundamental in the development of entrepreneurial processes.

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New technology for production of Dicyclopentadiene and Me-thyl-dicyklopentadiene

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The steam cracker unit at ORLEN Unipetrol is a significant European producer of monomers. Due to heavy feedstocks the steam cracker can produce besides ethylene, propylene and benzene very valuable hydrocarbon such as dicyclopentadiene. ORLEN Unipetrol in cooperation with University of Chemistry and Technology in Prague has been investigating the possibility of producing dicyclopentadiene and as a result of research activities the technology for production of dicyclopentadiene of different quality grades has been developed and finally realized in Litvínov. The construction of the unit started in September 2020 and production was launched in September 2022. ORLEN Unipetrol can produce dicyclopentadiene purity between 80 and 94 per cent. The capacity of new existing unit is in the range of 20 -26 thousand metric tons per year. This configured product is used for further production of polymer materials, resins, and chemical specialities used in, for example, the production of wind turbine propellers, colored asphalt, adhesives, dyes and pigments, automobile and maritime components and skeletons, fibre optic cables, special lenses, medical components, packaging materials and sanitary products.

Education as a universal tool for the creation of a rational-humane society – Opportunity or fiction?

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Technical development cannot be stopped – this fact has become an axiom. We are currently living in the time of the fourth industrial revolution, which, whether one wants it or not, is already underway. The Internet accelerates the automation and general digitization of the world, autonomous systems are starting to appear, and not only in production. Machines will be interconnected in real time and communicate with each other as cyber-physical systems. The limiting prerequisite for the implementation of the mentioned technical (r)evolution is the emergence of new functional relationships and behavior in human society. Human consciousness is increasingly lagging behind technical development. But can this delay be reduced or even eliminated? The prerequisites for catching up with the aforementioned delay may sound like opportunities or utopias: Limiting conflicts? Eliminating the differences between more and less industrialized countries in the form of controlled industrialization and agronomic projects? Education and training to a higher mental level of a person? If some of the above considerations may not be utopia, then it is precisely the use of education and training. Knowledge of basic historical contexts, their relationship to the development of society and technology... These are basic tools that can be used to increase a person's mental level. Education for a rationally humane society, i.e. for a society with a balanced level of human consciousness and technical development...

Adaptation of education 5.0 through intellectual property registration by Polytechnics in Zimbabwe: A case study of Harare Polytechnic mechanical engineering department

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This research interrogated on the available methods Polytechnics can adopt to incorporate Intellectual Property (IP) registration for the various students and lecturer projects and designs. IP registration increases the chances of commercialisation and industrialisation of Polytechnic projects towards achieving education 5.0. This case study was carried out at Harare Polytechnic to ascertain the need for inclusion of IP registration procedures which are not known by both students and lecturers. 20 National diploma projects were sampled and assessed for satisfaction to IP registration. The study established that although the products and designs being made at Harare Polytechnic are of greater value, the procedures being followed by the designers and creators, lack an understanding of the proper requirements to satisfy IP registration. Students and staff lack of IP knowledge hinders the success of the IP incorporated designs which include novelty, technical design, appearance and inventive steps.These IP parameters reduces chances of registration of Polytechnic projects resulting in the need to include IP training in the curriculum for a better understanding of IP registration.The research then concluded that an IP office with a specialist has to be set at every Polytechnic ahead of innovation hubs to provide for guidance throughout the creation and design procedures necessary for IP protection.

Enhancing emotional management skills and creativity through clown techniques in industrial engineering students

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Introduction

The problem to investigate is whether the implementation of clown workshops in the training of industrial engineers can have a positive impact on the development of cross-functional skills and soft competencies, such as creativity, communication, resilience, teamwork, flexibility, problem-solving, among others. The lack of research in this field implies a limitation in the training of industrial engineers and may affect their professional performance in an increasingly demanding and complex context. Therefore, it is necessary to delve into the understanding of the use of clown techniques in the education and training of industrial engineers and their impact on the development of cross-functional competencies.

The lack of soft skills in industrial engineering students has become a significant problem worldwide. According to UNESCO data, around 40% of employers consider university graduates to lack soft skills, and 60% of them report that this lack of soft skills is the main cause of the employability challenges faced by recent graduates.

The issue of soft skills development in industrial engineering students extends beyond the realms of communication and teamwork skills. Most industrial engineering students have a strong focus on the technical aspects of their education but tend to neglect the development of social and emotional skills that are essential for success in today's workplace. Moreover, there is a gap between the skills that employers expect from recent industrial engineering graduates and the skills they actually possess. This is partly due to the lack of emphasis on soft skills training in the curriculum of most industrial engineering programs.

The need to improve soft skills training in industrial engineering students is also driven by changes in the nature of work in the 21st century. Soft skills are increasingly valued by employers in all sectors, not just in engineering, as collaboration and adaptability are essential in an interconnected and globalized world.

In recent years, employers have expressed growing concern about the lack of soft skills in recent industrial engineering graduates. Many companies have reported that employees with insufficient soft skills have difficulties working as a team, effectively communicating with colleagues and clients, adapting to changing situations, and solving complex problems in the workplace. This lack of soft skills can be costly for companies, as it can result in low productivity, job dissatisfaction, and employee turnover. Furthermore, companies may miss out on business opportunities if their employees cannot effectively communicate with customers or work as a team to solve problems. As the global economy becomes increasingly competitive, employers are looking for employees with a wide range of skills, including soft skills. Employers expect recent industrial engineering graduates to have well-developed soft skills, such as the ability to work as a team, resilience, empathy, flexibility, and the ability to solve complex problems. According to a survey conducted by the human resources consulting company Adecco in Spain, 71% of employers believe that recent industrial engineering graduates lack social and leadership skills. Additionally, a study conducted by the University of Santiago de Chile found that 70% of employers believe that engineering students lack soft skills, while only 14% of employers consider technical skills to be a concern.

In terms of job satisfaction, a study conducted by the consulting firm Mercer found that the lack of soft skills in the workplace can have a negative impact on employees' job satisfaction and their ability to advance in their careers. According to this study, 67% of employees consider soft skills to be very important for their career success, but only 42% of them believe that their employer provides enough opportunities to develop these skills. It is necessary to address this problem and find effective solutions to help industrial engineering

students develop soft skills and improve their employability. The implementation of programs involving clowning in soft skills training could be a viable and innovative alternative.

Outside the realm of physical healthcare, while one of the most common uses of clowning has been in the healthcare sector, other sectors such as education could also benefit from it. For example, the teaching of creative thinking is limited in schools because the freedom required for this learning process can be seen as insubordination, which contrasts with the obedience expected from students by the education system. Thus, its use in education could facilitate, among other things, the development of emotional intelligence, the ability to react positively to mistakes, frustration management, empathy development, and communication skills, thereby facilitating interpersonal relationships (Farneti and Palloni, 2010).

A quasi-experiment conducted with kindergarten teachers, in which the experimental group underwent clown training for several months, showed that the self-perception of the teachers in the experimental group improved in terms of the need to protect and help others, understanding others, and self-esteem. The control group members, on the other hand, reported no differences between the two evaluations (Farneti and Palloni, 2010). It's worth noting that this study measured individuals' self-perception and how it could change, rather than their actual selves. The authors ultimately conclude that clowning offers many opportunities in the field of education, although its effects deserve further study and analysis to be fully identified.

A qualitative study was conducted with students from three vocational qualification programs aged between 16 and 21 years (Lázaro and Martínez, 2017). One of the main objectives of this study was to use clowning to promote intercultural encounters and acceptance of cultural differences. The study was conducted over several sessions spanning a little over three months, and an improvement in interpersonal relationships among group members was observed.

Clowning has also been used in psychotherapy, both individually and in groups, under the name "clown therapy" (Carp, 1998). The idea in this type of therapy is for the clown to be part of a process with expected outcomes, including increased creativity, better stress management, the identification of an individual's potential, and improved ability to relate to others.

Clowning is a performing art that focuses on creating comical and absurd situations through improvisation and interaction with the audience. Although it may not appear to have any direct connection to industrial engineering, there is a theoretical framework that argues for the importance of clowning in the learning of this discipline. The following is that theoretical framework:

Creativity: Clowning fosters creativity and innovation, essential skills for problem-solving in industrial engineering. Clowns improvise and adapt to situations, allowing them to find creative and unexpected solutions. Similarly, industrial engineers must be able to think outside the box and seek innovative solutions to the challenges they face.

Communication: Clowns primarily communicate through body language and gestures, enabling them to convey emotions and messages effectively. This skill is essential for industrial engineers, who must be able to communicate their ideas and projects clearly and concisely to colleagues and clients.

Resilience: Clowns confront uncomfortable and challenging situations but always manage to overcome them with humor and optimism. This ability is crucial for industrial engineers, who must be able to face and overcome obstacles in their daily work.

Flexibility: Clowns adapt to situations and focus on the present, allowing them to improvise and change their performance based on the audience's response. This skill is essential for industrial engineers, who must be able to adapt to changes and challenges in their work.

In summary, the importance of clowning in the learning of industrial engineering is based on the creativity, communication, resilience and flexibility that can be acquired through practicing the art of clowning. These skills are essential for success in industrial engineering and can be developed through practice and training in the art of clowning.

Methods

A random sample of 125 undergraduate university students was recruited to administer the career driver test. Five of the participants did not complete the test. The final sample consisted of 120 participants (80 males and 40 females) with ages ranging from 17 to 22 years old. The variables analyzed included: creativity, empathy, assertive communication, interaction skills, and conflict management.

For the intervention process, a clown training program was designed specifically for university students. The program included a combination of practical and theoretical exercises such as games, improvisation, and physical expression, allowing attendees to experience and acquire theatrical tools, working with their bodies, emotions, and language from different perspectives. Four (4) clown training workshops were conducted with the intervention group. To assess their competencies, the group's transversal skills were measured before and after the workshops using an adapted version of the Potdevin career driver test and the personality type questionnaire taken from the Myers-Briggs Type Indicator® (a registered trademark of Consulting Psychologist Press, Inc.), which are valid instruments for measuring an individual's psychological profile in terms of their natural preferences in how they relate to the world when working. The data obtained were analyzed using non-parametric statistics and the Atlas ti software to define semantic categories of behavior.

Results and discussion

Upon obtaining the results, it was observed that before the intervention, the students showed a career driver oriented towards *Specialization* with an indicator of 8, and that the *Creative expression* driver was the lowest with an indicator of 1. Similarly, the predominant personality style was ESTJ at 53%, with semantic categories including: *Conscientious, direct, efficient, aggressive, analytical, strong-willed, careful, structured, impersonal, logical, objective, organized, practical, responsible, determined, fact-oriented, serious, individualistic, independent, systematic.*

After the execution of the workshops and the completion of the activities proposed in the program, the instrument was administered again, and it was observed that the highest average was obtained in the *Creative expression indicator*, becoming the career driver that motivates students the most on average. The lowest variance was obtained in this driver because efforts were homogeneously concentrated to increase its intensity. On the other hand, the other variances are higher because no efforts were made to induce motivation regarding those drivers (altruism, balance, security); however, they remain at a constant medium intensity. As can be seen, the average *indicators for the creativity characteristic* increased from 1 to 6, placing it in High Intensity. Likewise, the predominant personality style changed to ENFP at 71%, with associated semantic categories: *Creative, imaginative, innovative, restless, curious, empathetic, friendly, warm, understanding, problem solver, energetic, enthusiastic, spontaneous, kind, inspiring, motivating, perceptive, versatile*; demonstrating the effectiveness of the program implementation for Industrial Engineering students at the University of Córdoba.

After the clown workshops, students have clarity regarding the implications for their career leadership. They express enthusiasm, especially in establishing new connections and keeping their network active. They are open to interacting with many people, without stopping to think about how much they can contribute to their career leadership. They are aware that delving into themselves will likely be demanding and will require additional time and effort, as well as the need to establish specific action plans for their growth and follow through.

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5. Green Transport

Sustainable transport infrastructure Africa: looking back to the basics

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Sustainable road transport is measured by the parameters of mobility, safety and surface ride quality and by extension environmental protection. The parameters stated above directly contribute to the Cost of the infrastructure projects which can be re-categorised as the set-up cost, Operation costs and Maintenance costs.

African transport systems by intensity of mobility and access networks have immense room for improvement. The expected development must be done with sustainability in mind to control costs, giving the best to the present while protecting the future.

The biggest drawback to realise sustainable infrastructure development of this sector in Developing Nations is the basic concept of Spatial planning and development control. Some Nations are yet to embrace spatial planning yet are on the growth path. Some that started off with robust spatial plans have not done very well with control; throwing the transport infrastructure into gradual and increasing chaos.

The end result is heavily encroached reserves; increased frequency and severity of accidents; choking traffic jams; excess environmental pollution with both solid waste, harmful emissions and noise; high vehicle operation costs and general reducing quality of life. All these point to unsustainable infrastructure planning and implementation.

The basics of spatial planning and development control can be summarized as

1. Zoning
2. Set-backs
3. Building lines
4. Plot ratios

Zoning

Zoning in spatial planning refers to delineation of specific areas for specific purposes. It is governed by respective laws of the land. For the Kenyan example, it is governed by The Constitution of Kenya 2010, The Physical and Land use planning Act, the land Act (which governs land tenure) and the Environmental Management and Coordination Act with their related regulations.

It identifies and demarcates out areas ideal for residential (high, medium and low density), commercial districts (with office blocks, shopping centres and malls), industrial areas, agricultural parcels as well as conservation areas (which includes parks, national reserves, forest areas, public spaces, riparian land among others).

The basic requirement of zoning is only complete when it is done with integration and functionality in mind. Infrastructure corridors and reserves are then secured to enable seamless communication between the zoned areas. It must be followed with strict regulation and control to predictably and accurately plan the shape, form and functionality of our cities for sustainability.

Unfortunately for many developing countries, cities grow by sprawl. Zoning plans are non-existent or if they exist, are never controlled. This leads to unsustainable and disorderly mixed developments. It complicates development of the supporting infrastructure to the point of making initial development, operation and maintenance costs to go out of the roof.

Set-back

Set back refers to the space fronting the road infrastructure within one's property; where the property owner or developer is NOT allowed to erect permanent structures. This space varies depending on the classification of the road abutted by the said property.

Usually, it is legislated by regional or county governments guided by the National laws. The governing laws will explicitly spell the dimensions in meters of feet for ease of control.

The set-back ensures that the road infrastructure is not choked by private activities. It allows the entire road reserve to be applied to public use as planned. The reserves are left available as wayleaves for services like water, power, data cabling, other pipework like oil and gas, and usage for non-motorized transport and green areas (soft-scaping).

In the absence of set-backs, buildings MUST face off the roads to avoid obstruction of the infrastructure reserves with private activities generated from the developments.

Many growing cities in developing countries have not paid much attention to set-back requirements consequently allowing private developments dangerously protruding into the public spaces exposing road users and the general public to heavy health and security risks. This has also caused escalation of cost of projects where a significant amount is spent on reclaiming reserves through compensation for livelihoods.

Building line

Building lines are set by local authorities to define the extent to which the frontage walling should align for all buildings along a stretch of a road. They ensure a consistent profile for building positioning.

For ease of enforcement, these are best defined in the integrated georeferenced development plans usually legislated in cycles of 5-6 years and firmed up by the building code.

Cities that strictly enforce building lines, result in beautiful, safe and sustainable surface scapes. They provide predictable physical development trajectory making it possible for infrastructure predictable planning.

Plot ratios,

Plot ratios define how much of a plot extent is covered by the footprint of the building/development. This is the aspect that determines how much space can be left both for hard and soft scaping. It also determines how developments relate with other built-up neighbourhoods.

With land tenure systems that allow subdivision of land to very small units and the advent of businessmen or developers that want to utilize every inch of the parcel, it has been observed that the idea of plot ratios continues to take a back seat.

Blocks and blocks of buildings keep coming up next to each other with utter disregard of functionality of finished buildings.

The result is housing units that have extremely poor ventilation and natural lighting; creating a health hazard to property users for the longest foreseeable future. This poses a risk to the sustainability of our future cities, and the quality of life expected to be supported.

Integrated Sustainable Road Infrastructure

A functional spatial plan taking care of all the above basics namely zoning, set-backs, building lines, and building lines is usually made complete through integrating infrastructure, key of which is roads and other means of transport.

Focusing on the roads, it's noteworthy to appreciate that the network is achieved through an array of hierarchy ranging from Superhighways, Highways, Urban arteries, Collectors, streets and last mile connections. Within the rural areas we have the primary roads, the secondary roads and the last mile access roads.

All the roads within the hierarchy have specific design typologies that are aligned with both their functions, design speeds and the traffic class/types they carry.

Spatial planning and development control will heavily save the costs of acquisition, lowering cost of construction, operation and maintenance, make the road usage much safer, improve traffic flow reduce travel times, improve ride quality and open opportunities for meaningful production especially for agricultural zones.

Contribution of Automated Speed Enforcement to Traffic Safety in the Global South

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The global Vision Zero initiative faces a significant challenge in achieving uniform success across continents. Over 90% of the traffic fatalities occur in the developing countries with low-income African countries experiencing a nearly sixfold increase in road fatality risk compared to high-income European countries. Over half of these fatalities involve Vulnerable Road Users (VRU), particularly in the African continent, where pedestrian and cyclist fatalities account for 44% of the total road traffic mortality.

Vehicle speed directly affects an accident risk and serves as a deciding factor for the survivability of these less protected individuals. As a result, many high-income countries have implemented variety measures including Automated Speed Enforcement (ASE) systems to effectively regulate vehicle speed and encourage a responsible driving behavior.

However, the current assessment of ASE effectiveness has predominantly focused on the high-income countries, even though conflicts between vehicle and VRU are more prevalent in the developing countries. This paper presents a systematic review examining several ASE programs in developing countries and investigating their contribution to the traffic safety. Finally, a total of 14 studies from 6 different countries are analyzed. The results indicate, the installation of speed cameras in those countries can potentially reduce the accident probability and severity. This overall positive impact towards road safety can save thousands of lives annually. Despite challenges such as inadequate road infrastructure, enforcement capacity, and public support, the speed cameras have been shown to be an effective intervention to reduce the increase the road safety in the Global South.

Expansion Work Recovery of Hydrogen for a Fuel.Cell Truck-Tentative design of an Expansion Machine

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Abstract: Hydrogen powered vehicles use high-pressure reservoirs from which the gas is transferred to the low-pressure fuel-cell via a classical pressure reduction valve. In these systems no expansion work is recovered and the question is addressed of the potential to increase the global efficiency by using an expansion machine between the reservoir and the electrochemical reactor. This paper investigates the feasibility of such an expansion machine, and evaluates the mechanical constraints in terms of forces, torques and produced power by numeric simulation. It further evaluates the energetic contribution to the whole conversion chain from the hydrogen reservoir to the common electrical network on board. A low-energy contribution of the expansion system addresses the question of the real benefit of such an investment.

1. Introduction

In the context of the decarbonation actions and renouncement of fossil fuels, Hydrogen is expected to play an important role in the future of transportation [1]. Near all the advantages of an electric propulsion system, the powering of the vehicles with a fuel-cell and hydrogen presents many advantages as a large range in comparison to battery EV's. But one of the greatest advantages is certainly the very short refueling time [2]. Hydrogen on board is realized in the form of a high-pressure tank, but the operation of the fuel-cell converter requires only a pressure of 1 -3 bar. For the reduction of the pressure from the reservoir level to the fuel-cell, current vehicles use simple pressure reduction valves with cross section changes. In these systems no work is recovered from the expansion process.

The potential of recovery of the expansion work of Hydrogen for Fuel-Cell vehicles has been analysed in [3]. The proposal is made for a replacement of the passive pressure reduction valve by an expansion engine followed by an electric generator which output power is injected into the electric circuit of the vehicle for further use in propulsion for an expected increase of the normal range. This valuable principle however addresses the question of an available expansion machinery and of its energetic performance.

In the proposed system architecture, H_2 is flowing from the pressurized tank through the expansion machine before being converted into electric power in the fuel-cell. The expansion machine drives a dedicated generator from which the power is rectified by a power electronic converter and fed to the main electric circuit. At the level of the common electric circuit, a buffer battery can be added in order to smooth the power demand of the propulsion machine. This paper is an attempt to design such an expansion machine and to evaluate its main parameters and constraints. Further, the average of the recovered power is calculated and is compared to the power delivered by the fuel-cell. These calculations will be a base for the evaluation of the added value of the expansion equipment to the vehicle.

2. The concept of the expansion machine

Compressors for Hydrogen filling stations have been developed in recent years according to two dominant technologies. The leading technology in countries like Germany is the ionic compressor based on a liquid piston principle. Other systems use piston engines where the traditional pneumatic actuator has recently been replaced by a hydraulic cylinder for energetic efficiency reasons.. Reversible compressors, namely expansion machines adapted to the specific pressure range are however not common industrial components and must be specially developed for the recovery function studied in this contribution.

2.1. A dedicated expansion machine

2.1.1 Single-sided pistons with crankshaft and piston rod

In this study, the considered machine is defined as a piston/cylinder arrangement where the principle of an intake-and-expand sequence will be implemented according to the principles described in [5], [6], and [7]. The piston-based expansion machine acts on a rotational equipment comprising a crankshaft and piston rods. The crankshaft is coupled to an electric motor via a toothed belt gear ratio. On both sides of the crankshaft, there are three cascaded cylinders for the intake, expansion and exhaust process.

The expansion of the gas is realized within two stages where the transfer of the fluid from V_1 to V_2 corresponds to a first stage of expansion while the transfer from V_2 to V_3 corresponds to the second expansion stage. The three cascaded cylinders are characterized through their volumes (V_1, V_2, V_3), their surfaces (S_1, S_2, S_3) and the corresponding diameters of the pistons D_1, D_2, D_3. The pistons are operated in phase opposition with crank pins offset 180 degrees. The cylinders of the machine are chosen as single sided pistons for a unidirectional high-pressure solicitation of the sealings on one hand, and to avoid the piston-rod side seals on the other hand. Double acting cylinders would further have the disadvantage of dissymmetric left and right volumes with consequences on the modulation of the global output torque.

3. Energetic considerations

The power capacity of an expansion system is estimated for two different machines of different volumetries and rotational speed. By neglecting the friction of the piston seals and other parasitic losses, the amount of produced power is only depending on the flowrate of hydrogen to be expanded from the input pressure level to the output of the expander. Of course, the power will depend also on the quality of the expansion formulated through the polytropic factor. An isothermal expansion produces a higher power than an adiabatic one. The average value of the produced power in adiabatic conditions is 11.9 kW and can be converted into an electric power P_{Gen} by the generator driven by the expansion machine. The efficiency of the generator (Permanent Magnet Synchronous Generator) is evaluated to 93%. The value of the power produced and converted in the recovery chain is then compared to the electric power P_{FC} produced by the fuel-cell which converts the expanded amount of hydrogen. The power ratio of the recovered expansion power to the useful power P_{FC} is then defined as

$R_{recov} = P_{Gen}/P_{FC}$

Where P_{FC} is calculated from the H_2 flowrate of 4.8g/s, with a heat value of H_2 of 33kW/kg and an efficiency of the fuel-cell of 50%

P_{FC} = 4.8 g/s * 33Wh/g*3600s/h*0.5 = 285 kW

The recovery factor R_{recov} becomes

$R_{recov} = P_{Gen}/P_{FC}$ = 11.9kW*0.93/285kW = 0.038 or 3.8%

This low value addresses the question of the motivation or the economic aspect of using expansion recovery systems in fuel-cell vehicles. An evaluation of the dimensions and weight of the components of the expansion system is necessary.

Conclusions

A tentative design of a hydrogen expansion work recovery system has been realized where the pressures, forces, torques and power contributions of the two stages of a six cylinder machine have been calculated by simulation. The huge mechanical constraints in a slow rotational speed machine could be strongly reduced by a second design of a faster running machine.

The limited power contribution of the expansion system addresses the question of the technical and economic advantages such a development.

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Electric Roads – A Sustainable Engineering Technology

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Aim

The continual use of fossil fuels as the primary energy source has led to increased emission levels of greenhouse gases – mainly in the form of carbon dioxide (CO_2) – into the atmosphere. This has been one of the main factors causing global warming and, consequently, climate change. Besides, the rate of consumption and demand for energy has gone higher than the supply. To mitigate these challenges, the production and use of vehicles and systems that use clean energy, have been on the rise. This means an increased demand for green energy to power electric vehicles and other systems. There is increased research and exploration of the harvesting of energy from roads as one of the sustainable technologies that will solve the problem of low energy supply and directly mitigate climate change.

Methods

This paper is a review of secondary sources on emerging technologies and recent developments in the field of energy generation, from road surfaces, their efficiency, costs, and field of implementation. A meta-analysis of research studies is done to provide a comprehensive overview with insight into technologies for harvesting energy from roads.

Results

Findings from the review indicate that it could be recommendable that the design and construction of roadways incorporate the component of the production of energy.

Conclusion

The study also gives transportation and highway engineers a different perspective on the design and construction of roadways and highways from a sustainability perspective.

Keywords: Road Transport, Emission in Transport, Electrification, Smart Technologies in Transport, Sustainable Engineering.

6. Safe Digital World

Digital Safety for digital illeterate

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Digital Transformation: Ensuring Safety for the Elderly and the Digitally Illiterate

Forewords: Digital transformation is a wave that has revamped our societies. This wave has turned on to a tsunami accelerated by COVID-19

As we embark on this digital new age, a vast majority of our population is left behind in a word of potentialities, possibilities but also dangers.

Particularly, when Digital ID, digital payments, e-Government services are becoming the norm, How do we ensure digital safety for elders and all digital illiterate?

This is the purpose of this paper advocating for a safe digital transformation and emphasizing the responsibilities of governments in providing digital safety.

With facts and figures of digital literacy, cyber-criminality, and online safety we will open a discussion on this vast topic.

Introduction

Digital transformation is not just a trend or a buzzword. It is a seismic shift that has fundamentally changed the way we work, socialize, and lead our lives. The rapid adoption of digital technologies, further catalyzed by the COVID-19 pandemic, has left an indelible mark on society. However, as we ride the waves of this digital tsunami, it is essential to remember that not everyone is equipped to swim in these waters. While younger generations are often hailed as 'digital natives', a significant portion of our population, particularly the elderly and digitally illiterate, find themselves in potentially treacherous territory.

The New Digital Landscape

Every day, we witness an increasing integration of digital tools in our daily lives. From Digital IDs that serve as our primary identification, digital payment systems that have largely replaced cash, to e-Government services making bureaucratic processes more efficient – the digital realm is the new norm. But with these advancements come challenges. The same tools that offer convenience and efficiency also pose potential risks if not used securely and wisely.

Challenges Faced by the Elderly and Digitally Illiterate

1. Access to Digital devices & Internet: A Fundamental Pillar of Modern Society

In today's rapidly evolving digital age, access to digital devices and the internet isn't merely a luxury—it's fast becoming a necessity. As almost every aspect of our daily lives becomes intertwined with digital tools and platforms, ensuring equitable access to these resources is crucial for societal development, inclusion, and progression. For Ederly and Digitally illiterate this is even more complex as most of them lives in rural areas (in many nations, while urban centers boast of high-speed internet connectivity and a plethora of digital services, rural areas often lack even basic broadband access.) In addition there are mainly coming from developing countries (while countries in Europe and North America have near-universal internet coverage, places in sub-Saharan Africa, parts of Asia, and Latin America have vast populations still offline).

2. Lack of Familiarity: The digital world can be overwhelming. For those not acquainted with the intricacies of digital platforms, simple tasks can become daunting challenges.
3. Cybersecurity Threats: Phishing scams, ransomware attacks, and online fraud are real threats. The elderly and digitally illiterate, often unaware of these risks, become easy targets.
4. Digital Exclusion: Without adequate digital skills, many are excluded from essential services and opportunities, further widening societal disparities.

Digital Skills

Overall digital skills refer to five areas:

- information and data literacy skills (for example, searching online);
- communication and collaboration skills (for example, communication via e-mail);
- digital content creation skills (for example, writing programming code);
- safety skills (for example, protecting personal data)
- problem-solving skills

The overall digital skills indicator is a composite indicator based on five types of skills: information and data literacy skills, communication and collaboration skills, digital content creation skills, safety skills and problem-solving skills.

- In 2021, more than three-quarters (77%) of the EU population aged 16–74 years had above-basic digital communication and collaboration skills. A higher share was recorded for people living in cities (82%), while those living in rural areas had a lower share (71%). This pattern – a higher share of people living in cities having above-basic digital skills – was repeated for all five areas covered by the composite indicator, with the largest digital divide recorded for content creation skills (where there was a 16-percentage-point gap in the share of people with above-basic skills between those living in cities and those living in rural areas).

[1]

Digital Literacy: A Look at the Numbers

- Princess Laurentien of the Netherlands, who is the UNESCO Special Envoy on Literacy for Development, emphasized that literacy in today's world is at the heart of social participation and engagement. "There is no inclusiveness if we leave behind 750 million people who lack the basic literacy skills to participate in today's digital world," she said. "There is no social cohesion if we allow young people to develop feelings of exclusion and lack of self-confidence." Most people who are illiterate around the world – more than 60 per cent – are women, according to UNESCO figures in 2017[2].
- In 2021, 54% of people in the EU aged 16 to 74 had at least basic overall digital skills. This information comes from data on digital skills indicators published by Eurostat[3].

When it's come to developing countries, we are missing the exact numbers but can assume there are even higher.

- The Latest 2023 Cyber Crime Statistics (updated September 2023)
    - Nearly 1 billion emails were exposed in a single year, affecting 1 in 5 internet users.
    - Data breaches cost businesses an average of $4.35 million in 2022.
    - Around 236.1 million ransomware attacks occurred globally in the first half of 2022

It is obvious that individuals who are less digitally literate are more affected by this.

The Role of Governments

Governments play a pivotal role in shaping the digital futures of their citizens. To ensure a safe digital transformation:

1. Education and Training: Organizing digital literacy programs tailored for the elderly and digitally illiterate. Simplified modules, hands-on workshops, and dedicated helplines can make a difference.

2. Legislation and Regulation: Enacting strict cybersecurity laws and ensuring that companies prioritize user safety, especially for the vulnerable segments of society.

3. Infrastructure: Ensuring accessibility of public digital platforms. User-friendly interfaces, voice-activated assistance, and multilingual support can make digital tools more accessible.

Governments have a critical role in ensuring digital public goods

Digital transformation has significantly impacted societies worldwide, presenting both opportunities and challenges. In this context, the concept of "digital public goods" emerges as a cornerstone for promoting a fair, inclusive, and progressive digital society. These are digital innovations—from open-source software to open data—that are freely available and intended to improve societal welfare. Governments, as primary stakeholders responsible for public welfare, have a pivotal role in promoting, safeguarding, and advancing digital public goods.

Conclusion: A Collective Responsibility

As we discuss the future of digital transformation, it is imperative to ensure that no one is left behind. While the benefits of the digital age are many, they must be enjoyed by all sections of society. Governments, organizations, communities, and individuals – all have a role to play in making the digital world safe and inclusive. It's not just about technological advancements but about human progress. And for progress to be meaningful, it must be equitable and safe for all.

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Digital Transformation in the Ethiopian Construction Industry: A Case Study on the Integration of Web-Based Project Management Systems for reconstruction school in northern Ethiopia

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This case study aims to explore the impact of digitalization on the Ethiopian construction industry through the integration of web-based project management systems. The report emphasizes the importance of digital transformation in streamlining construction project management and its potential to contribute to economic growth and infrastructure development. The benefits of using digital technologies, such as minimizing human error and boosting teamwork, are explored. The report emphasizes the importance of continuing to invest in digital technology to meet the needs of a growing population and improve the efficiency and success of Ethiopian construction projects.

A qualitative study is conducted in Northern Ethiopia, focusing on school restoration projects following internal Conflict. Construction professionals and project managers from various organizations participate in interviews and observations. Interviews gather insights on integrating web-based project management tools in building projects, while observations provided a practical understanding of the impact of digital technologies on project productivity, collaboration, and cost savings. Relevant data from industry publications and government activities support the findings.

The incorporation of web-based project management systems in Ethiopian construction has resulted in fewer errors, delays, and cost overruns. Remote work capabilities have enhanced collaboration, efficiency, and project outcomes by offering real-time information access and quick communication. Digitalization has improved schedule management, budgeting, and job site safety, all of which contribute to overall project success.

In conclusion, Sustained investment in digital technology is critical to driving economic growth, and sustainable infrastructure development. By embracing digitalization, the construction industry can greatly contribute to the overall development of the country.

7. Innovative Technologies in Industry

The Impact of Czech Innovative Breakthroughs in Textile Industry on Future Society

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The textile and clothing industries are in the third place (more important is only informatics and tourism) according to the financial amount of the annual profit. In EU countries is employment in the textile and clothing sector around 6.2 million people (approximately 9.3% of all jobs in the manufacturing industry). The textile branch is therefore one of the most important in terms of the number of people who deal with production, utilization and maintenance of textiles or generally fibrous structures. The consumption of fibers for clothing purposes only is annually 10–14 kg per year for one person. The population size is continuously growing and in 2030 will be around 8 billion. This leads to requirement of 80 billion kg of fibers (for lower consumption of 10 kg per person). This incredible amount should be processed to the fibrous structures by textile machines which are on the top level according to productivity (rate of production) and long-term durability.

Textile machines were probably the first continuous technologies, they used punched cards before the development of computer technology, and very quickly the elements of cognitive robots were applied to them. Their speeds (in open end spinning up to 200,000 rpm) are extremely high and require the use of special materials.

The need for textiles or generally fibrous structures is related to the size of the human population (clothing textiles) and its maturity of society (technical fibrous structures). Textile products that satisfy the need for clothing must have both a functional (utility) and aesthetic aspect. Fibrous structures are increasingly being used as special flexible construction materials and composite structures. For these purposes and for special applications (technical and protective textiles, light conducting systems, electrically conductive systems, etc.), polymers, metals and ceramic materials in fibrous form are used.

For the production of yarns and various kind of fabrics (fabrics, knitwear and nonwovens) or other fibrous structures the starting element is fibers. Fibers are typically thin (thickness about 5–20 μ m) long (length about 2–10 cm) elements with extraordinary mechanical properties and flexibility. Limited lengths are typical for natural fibers. For man-made fibers (chemical and synthetic), shortening of the originally produced endless filaments is performed by cutting and tearing. This seemingly illogical step (division into short lengths and subsequent joining into a continuous yarn) is necessary to obtain a number of useful properties of fibrous structures (sorption, thermal insulation, hand, drape, etc.).

During the preparation for spinning and during the production of the yarn (loosening, cleaning, mixing, carding, drawing and twisting), huge amount of fibers is handled. Similarly, in weaving or knitting, a relatively large length of yarn must be used. It is, therefore, clear that machinery must be relatively sophisticated and capable of producing large quantities of textiles in a short time.

Researchers and engineers from Czech Republic were developed patented and industrially produced major technologies based on new principles of yarn and fabrics creations, which will be important for future society as well. The revolutionary principle of so-called rotor spinning (open-ended spinning) is the result of many years of research and development by teams of Czech researchers from the Research Institute of Textile Machinery (VÚTS) and subsequently from the Cotton Research Institute (VÚB) Ústí nad Orlicí. The idea of open-ended spinning was created in VÚTS, the first patents were filed and the yarn in the rotor was spun for the first time. The core of the rotor spinning system is the rotor, into which the needled rotating

roller transports the individual fibers by an air stream. In the rotor, the fibers slide along its wall into the collecting groove, where a fiber ribbon is formed. After introducing the free end of the yarn into the rotor axis, the ribbon fibers are twisted and the yarn is formed. It is, thus, a discontinuous system of disintegration into fibers, their transport and re-association with twisting. The rotor spinning yarn has a structure with typical belts, is stiffer and the yarn strength is usually 20 to 30% lower compared to classical ring spinning yarns, whose hairiness and material non-uniformity, on the other hand, are lower. The main benefit of this advanced technology is much higher productivity.

The VUB team patented and developed the first prototype of the BD 200 rotor spinning device and realized its industrial production. The first generation of this breakthrough technology (well-known Czech BD 200 machines) proved that spinning has reached the threshold of a new era.

The rotor speed of 35,000 rpm was much higher compared to the spindle speed of ring spinning of 10,000 to 12,000 rpm, and the size of a 1 kg yarn bobbin was significantly larger than the 120 g bobbin of a ring spinning machine.

The Czech machine for industrial rotor spinning was firstly presented at the exhibition of the International Association of Textile Machinery (ITMA) in 1967 in Basel, Switzerland. In 1991, the world's first automatized open-end spinning mill was exhibited at the ITMA Hannover trade fair. This mill was developed in cooperation with VÚTS Liberec and the manufacturer of rotor machines BDA10N, Elitex company Ústí nad Orlicí.

At present, the production of yarn on a ring spinning machine is about 20 meters of yarn per minute and the range of processed fineness is 5–300 tex. On a rotor spinning machine, the yarn production is about 350 meters of yarn per minute, and the range of fineness processed is 10–500 tex. The principles of rotor and ring spinning will probably be maintained as the most applied in the future. Czech researchers from VUB also succeeded in developing a NOVASPIN spinning system, with ring-quality yarn and with a significantly higher spinning speed. As in the case of ring spinning, the sliver is softened by drawing, which is further twisted in a system of a rotating surface. This has removed the speed limiting element of the ring spinning, the runner, which heats up at higher speeds.

Weaving is a technology for the production of flat textiles (fabrics), where two systems of threads, i.e., war and weft, are interlaced. The warp threads are placed longitudinally in the fabric, while the weft threads are inserted in the transverse direction, and the warp threads are inserted across the binding points.

In conventional shuttle looms, the weft threads are inserted with a shuttle (typical weight 300 g) carrying a spool of weft thread inside. The shuttle is given high acceleration at the beginning and is stopped abruptly at the end (after the weft is inserted). This is followed by mechanical beating of the weft to the front of the fabric and contacting the warp at the contact points of the fabric by means of an impact mechanism weighing several hundred kilograms. The weaving sequence is, thus, discontinuous, and the weft insertion takes place regularly from left to right and back during each weaving cycle. The speed of weft insertion in modern shuttle looms is around 650 m/min, and the noise level is around 92–107 dB. Shuttle looms also tend to vibrate. The main disadvantage of shuttle looms is the limited speed of the loom, higher energy consumption.

For production of woven fabrics, the classical shuttle looms were replaced by shuttle-less looms, characterized by the insertion of only the necessary part of the weft thread.

The shuttle less looms are characterized by the insertion of only the necessary part of the weft thread so that false edges are formed. There are three basic and very sophisticated weft insertion systems: shuttle (weft insertion speed is around 1500 m/min), rapier (weft insertion speed is around 1000 m/min) and jet (weft insertion speed for air nozzle condition is around 3500 m/min and for a water jet around 2600 m/min).

Air and water jet weft insertion systems were both worldwide firstly patented at VÚTS Liberec. The first 45 cm wide air jet was demonstrated in December 1952. These inventions caused tremendous changes in weaving technology. It is estimated that the number of air looms reached 100,000 and the number of water looms reached 25,000 during the 60–70 years of the last century. It is not necessary to have heavy impact mechanisms for the creation of fabrics (increasing the weight of the loom and noise), but sufficient rigidity is necessary (ability to transfer mechanical work into the fabric without its own deformation). Using new composite materials, a team of researchers from VÚTS created a lightweight composite impact mechanism, which is used in the construction of the new looms. The last breakthrough solution in the field of jet weaving is the DIFA loom for the production of 3D layered fabrics composed of two woven layers (distance between layers 12–50 cm) connected by binding threads. This loom is the result of a joint VÚTS project (machine development) and TTRI-Taiwan Textile Research Institute (3D fabric creation patent).

In the field of perpendicularly laid nonwovens production, structures made with STRUTO and ROTIS technologies patented at Technical University of Liberec (TUL) were groundbreaking. STRUTO technology uses a lever system to create transversely laid layers and is strengthened by thermal bonding. ROTIS technology uses a toothed roller to create transversely laid layers and the mechanical reinforcement is realized by the so-called “quasi” yarns. TUL researchers are also the authors of a number of patents relating to the production of nanofiber webs. The original international patent from 2004 was used for the production of Nanospider equipment by Elmarco company. The original needle less principle of production of nanofiber webs is currently further modified (especially on TUL), modifications are protected by a number of other patents and laboratory, pilot plant and operational equipment are created.

For the future development of technologies and products in textile branch it will be necessary to ensure:

- Implementation of ecological production (not worsening the environment)
- lower energy consumption (bio processes, alternative energy sources),
- higher rate of production lines,
- reduction in machine weight (use of composites),
- reduction in reaction volumes (low consumption of solvents),
- suppressing water consumption and production of polluted water,
- application of remote settings (internet),
- machines optimal control (artificial intelligence, computers),
- effective insulation of machines.

As is shown above, the described breakthrough solutions in the field of textile machinery are fulfilling requirement of high rate of production and reduction of machine weight by using sophisticated composites. Still it is possible to develop efficient remote setting systems via internet and to use more sophisticated optimal control systems but main principles changes are low probable.

The development of most textile technologies will be increasingly influenced by ecological factors in the future. Human activities were in balance with the sustainable biocapacity of the globe in 1985. At present, the globe would require a 1.3 times larger surface area to ensure sustainable biocapacity. This imbalance is continuously growing. It can, therefore, be expected that environmentally friendly “green” technologies using renewable resources will be preferred in the production of raw materials and materials for textile applications. These raw materials will be proceeds by sophisticated machinery based mainly on discussed principles.

Consciousness of Machines – Myths and Reality

Vladimír Mařík *(Czech Republic)*

Ideas of consciousness of machines in connection with the AGI (Artificial General Intelligence) visions will be discussed. Why we cannot neither simulate nor emulate the activities of the brain? How complete and useful are the current models of intelligent behaviour? Should we be afraid of the Kurzweil singularity? What is the difference between machine and artificial consciousness and how to explore the machine consciousness in industrial practice?

Dynamic mathematical model for heat exchange in single screw ash cooler of CFB boiler

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There is presented the mathematical model of heat transfer processes for a single screw ash cooler (SSAC) working with a circulating fluidized bed (CFB) boiler. The movement of the ash inside the ash cooler takes place under the influence of a complex displacement involving both translational and rotational motion. Moreover, the operating conditions of CFB boiler force the work of the SSAC heat exchanger with different fillings with ash. These variable operating parameters of the ash cooler require the correct determination of heat transfer coefficient for ash which changes dynamically during the transport of ash inside the device.

The key element of the mathematical model is Schlünder model which defines a heat transfer coefficient for ash taking into account the local dynamic mixing process inside the ash cooler. The numerical results verify that the mixing model proposed by Schlünder correctly predicts the local value of the heat transfer coefficient for ash and confirm that this parameter plays a key role in the heat transfer processes inside the device.

The validation of the model is based on experimental measurements made on a 230 MWe power unit. The analysis of measurement data from two different bottom ash coolers showed that the correct prediction of the outlet temperatures of ash and cooling water requires the determination of their individual ash filling characteristics (i.e. coolers). Based on these characteristics, it is possible to calculate the local values of the heat transfer coefficient for ash and the heat fluxes exchanged along the analysed ash cooler.

Corrugated Multilayer Structures Ensuring Thermal Insulation in Extreme Climatic Conditions

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People pay more and more attention to the functionality of clothing with the progress of society and the development of science and technology, and clothing comfort in extreme situations has also developed rapidly. In a broad sense, clothing comfort refers to how the wearer perceives and feels while wearing a given set of clothes. This includes psychological pleasure, self-actualization on a social and cultural level, and physical comfort [1].

Thermal comfort is a key consideration in cases of clothing used in extreme weather. It means that under the interaction of internal activity conditions and external environmental conditions, clothing serves as an appropriate auxiliary thermoregulatory system to help the body maintain a balanced temperature[2]. Therefore, this kind of clothing must have excellent thermal insulating qualities. Thermal insulation typically does not use energy from a natural heat source and instead critically depends on the geometry and materials of the structure being protected. It is known, that thermal comfort depends mainly on porosity and thickness of protecting flexible layer. Porosity can be easily tuned by construction parameters of fabrics but variation of thickness is complicated by narrow limits due to fineness of yarns and interlacing them in planar fibrous structures. One solution is to use multiple layers or sandwiches

In this paper, the thermal insulation property of the sandwich material with advanced corrugated structures prepared by unique ROTIS technology will be investigated [7].

ROTIS technology developed at TUL Liberec is based on the twisting of protruding surface fiber ends from the fabric surface into what is referred to as quasi-yarns. The ability to fix surface reinforcing nets to the surface of fixed structures is a benefit of this technology. At the same time, in combination with the corrugation and pressure of the machine, the 2D textile material is transformed into the 3D textile material. Two subsystems are created for implementing the aforementioned process. The machinery used for web forming is the A subsystem. It can be an apparatus for forming aerodynamic webs and an apparatus for creating corrugated webs. The ability to produce a so-called corrugated web is based on the application of the rotation gear. The B subsystem contains a device for creating quasi-yarns[3].

The sandwich material with advanced corrugated structures described in this paper is composed of two kinds of different nonwoven materials. One is the polyester two-layer composite nonwoven fabric with the surface deposited copper nanoparticles named Meftex10, which can reflect far-infrared radiation produced by the human body. Numerous positive qualities of this material include lightness, softness, breathability, antimicrobial properties, and so on as described in detail in the work [4]. Meftex is prepared by patented technology for the chemical deposition of metals on the surface of textile materials and for further stabilization of them on the surface of fabrics. The material is appropriate for use in protective clothing based on the above-mentioned material properties. It can specifically be used as the middle layer of sandwich materials. Another one is a kind of polyester nonwoven fabric with acrylic binder used for the thermal insulation function. This type of fabric is typically used in multi-layer fabrics. Three different thicknesses of this kind of nonwoven have been selected for the preparation of fabrics used in this article. By using ROTIS technology, the final sandwich material with advanced corrugated structures will consist of two layers of polyester nonwoven with acrylic binder sandwiched by a layer of Meftex10 in the middle.

The thermal insulation property was tested by Alambeta measuring instrument according to the standard ISO 11092[5]. During the test, the sample was placed on the measuring bottom plate, and a 200 Pa pressure was applied to the fabric sample by the head plate. The relative humidity ranged from 10% to 80%, and the measured ambient temperature ranged from 16°C to 26°C[6]. Every sample was tested five times at different points, and the average value was calculated as a result. Thermal conductivity and thermal resistance are chosen to characterize samples' thermal insulation performance. Thermal conductivity is a material property that represents the ability of a given material to conduct heat. For homogeneous materials, thermal conductivity is intrinsic property and is independent of the size, shape, and orientation of the material. In general, the higher the thermal conductivity, the better the ability of the thermally conductive interface material to conduct heat energy directly. Thermal resistance is one of the thickness dependent thermal properties of thermally conductive interface materials and can be understood as the resistance encountered by heat in the path of heat flow. The porosity and thickness of the thermally conductive interface materials are the most important factors affecting their thermal resistance.

The thermal conductivities of samples Meftex10 and the 100% polyester nonwoven with acrylic binder with different areal densities are 0.0358 W/m·K, 0.0367 W/m·K, 0.0466 W/m·K, and 0.0534 W/m·K respectively. From the above data, it can be seen that all samples have very low thermal conductivity which means these materials have good thermal insulation properties themselves. As the thickness of the polyester nonwoven (NW) samples increases, their thermal conductivity increases slightly. This is due to the fact that the increase in thickness leads to an increase in the acrylic binder content of the samples, which has a thermal conductivity of 0.192 W/m·K, thus also increasing the thermal conductivity of the NW samples. Besides, their thermal resistances are 0.0018 $K \cdot m^2/W$, 0.1147 $K \cdot m^2/W$, 0.1733 $K \cdot m^2/W$, and 0.2423 $K \cdot m^2/W$. The low thickness of the Meftex10 results in its low thermal resistance, and other NW samples have increased thermal resistance as their thickness increases.

The thermal conductivity and thermal resistance of sandwich material with and without advanced corrugated structure. A comparison of the thermal conductivity of all the samples reveals that the thermal conductivity of the sandwich material with a corrugated structure is slightly higher than the thermal conductivity of the sandwich material without a corrugated structure. The most likely reason for this is that when making a sample with a corrugated structure, the pressure of the machine reduces the amount of still air inside the sample, which ultimately leads to a slight increase in its thermal conductivity. For the thermal resistance values of the two sets of samples, a more complicated situation arises. For the samples with 79.94 g/m^2 (NW1), the thermal resistance values of the sandwich samples with corrugated structure are significantly increased compared to the sandwich samples without corrugated structure. This is mainly due to the fact that the thicknesses of the sandwich samples with the corrugated structure have a substantial increase, leading to significant increases in their thermal resistances. The same principle can be applied to the samples with 130.56 g/m^2 (NW2) and 228.08 g/m^2 (NW3). The thicknesses of the corrugated structure sandwich samples with NW2 are less altered, so the thermal resistances of the sandwich samples with the corrugated structure are only slightly increased compared to the sandwich samples without the corrugated structure. The thicknesses of the corrugated structure sandwich samples with NW3 decrease instead of increase. This directly results in the thermal resistance of the sandwich samples with the corrugated structure being lower than that of the sandwich samples without the corrugated structure. From the above experimental results, it can be concluded that for samples with lower thickness, the samples with corrugated structures obtained using ROTIS technology will greatly improve their thermal insulation performance. Therefore, the impact of ROTIS technology on the thermal insulation performance of the sample depends mainly on the thickness difference before and after the structural change.

By ROTIS technology is then relatively simple to combine functional layers into compact structure with tuned thermal insulation functioning well in extreme external conditions. It is beneficial to add the active

layer coated by copper particles for reflecting thermal radiation back to human body etc. Therefore, ROTIS combined with quasi-yarns and suitable active layer is versatile technology replacing effectively standard multi layering systems.

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Light weight and sandwich structured carbon fiber composites with enhanced EMI shielding performance

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The development of EMI shielding material has been increased due to the increased market request, especially on the electrical car industry. This paper introduced one new designed carbon fiber composites, the composites with sufficient thermal conductivity and enhanced electromagnetic shielding can be used for many of practical applications (e.g. boxes for electrical batteries in electric cars). Aim of this paper is design and evaluation of the multilayer composite structures reinforced by carbon fabric and conductive coppers particles covered central layer. From the test result, after integrate the Meftex30 layer into the composites material, the EMI shielding performance is significantly improved more than 30%, but the bulk density of the composites still shows good superiority compared with metal material. The thermal property test shows the composites material has good heat preservation property which can be suitable for the application for the battery case of the electrical car.

Sustainable Production of Cold Forging Punches Made of Critical Raw Materials

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Aim

The aim of this study is to manufacture punches used in cold forging made of critical and difficult to recycle raw materials as a sustainable way with the same performance. The punches are normally made of Tungsten Carbide Cobalt material (WC-Co) as solid body. WC-Co is a very valuable material compared to steels. In addition, cobalt and tungsten elements have recently been added to the EU's list of critical raw materials. Punches made of WC-Co become unusable when deformed and they are discarded as scrap. For this reason, how less critical raw materials are used, the more beneficial it will be in terms of sustainability.

Methods

1.2379 and WC-Co material were used to manufacture the hybrid punch. Joining of both materials was carried out using brazing method in induction welding. The forces occurred during working condition on the punches were specified by simulation. Optimum parameters such us temperature and time were determined in which the desired hardness and mechanical strength was obtained in final product.

Results

As a result of the experiments, suitable bonding parameters were found. The hybrid punches were used in real condition and their performances were observed. Thus, the hybrid punches with same performance were manufactured by using 60% by weight less WC-Co.

Conclusion

With this project, the product was analyzed and the critical material was used only in the necessary part of it. The sufficient performance has been obtained, and the use of critical raw materials has been reduced and a sustainable production was achieved.

Development of innovative methodologies based on predictive algorithms for electrical harness manufacturing in aerospace

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Aerospace industry is challenging to ensure the highest level of safety as a main priority. Errors or deviations from the specifications can lead to serious failures. Inconsistencies between the final installation and the manufactured products are a common problem in the context of aerospace electrical manufacturing engineering. One way to mitigate the risk and avoid such discrepancies is to reduce the probability of error creation to the minimum. Innovative methodologies based on predictive algorithms developed using machine learning techniques within the context of artificial intelligence can help to achieve this goal and ensure zero errors during the creation of the manufacturing process. Design techniques based on error predictions and risk assessment prior the failures occurrence can be used to enhance safety. Predicting potential errors or failures in advanced can help engineers to take preventive measures in order to mitigate or eliminate the risks. This reliable methodology is validated by a Monte Carlo analysis which has been performed on three critical parameters over 1000 simulations. The results presented in this study, which was carried out using a real dataset related to the electrical harnesses installed in a C295 military aircraft, estimate a reduction of 93% in time and 90% in error during creation of engineering manufacturing processes. Overall, the resulting model allows to enhance performance and reliability on the manufacturing processes.

Autonomous linear lighting systems

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Passive and active visibility of subjects (especially pedestrians) is one of the key issues of road safety. Majority of solutions are based on the utilization of retroreflective materials functioning under direct illumination from external light sources only. Passive lighting element is composed from textile tape coated by fluorescent pigments which emit light due to direct illumination from external sources. The selection of proper fluorescent pigments is based on measurement of time to decay of illumination intensity to the limited value of sufficient visibility in the dark. Active lighting element are working without necessity of direct illumination. As active lighting element, the linear composite consists from side emitting optical fiber covered by woven textile layer, power supply and LED light sources is developed.

The hybrid illumination system composed from active and passive lighting elements are temporarily working even after the active lighting is temporarily switched off.

The description of basic properties of both active and passive part of hybrid system will be proposed. The light intensity decay of hybrid system as a function of distance from LED will be measured by special device and described by simple model. The analysis of hybrid illumination system will be realized by the other special testing device characterizing of illumination intensity in the phase of active and passive lighting. The extension of total illumination time by using of combination of active and passive illumination will be quantified. Based on the analysis the final hybrid system will be designed.

Active lighting element can be main part of autonomous linear lighting systems (ALLS). These systems are usually constructed as arrays of LEDs connected by (metal) wires. This solution has the disadvantage of local heating, higher energy consumption limiting the operating time and sensitivity to mechanical stress. This contribution describes the construction of an autonomous line lighting system based on side-emitting optical fibers, which eliminate or at least strongly limit the shortcomings of previous solutions. Basic areas of possible use ALLS for local lighting in places where there is no access to electric grid are also mentioned. Options for low energy emergency lighting will be presented.

AIQUAMA: Towards Zero-Error Manual and Hybrid Assembly Processes

Daniel Porta *(Cognitive Assistants, German Research Center for Artificial Intelligence (DFKI), Saarbrücken, Germany)*

Detecting anomalies and errors in a production process too late causes immense costs and has a negative impact on sustainability and productivity. It is therefore of utmost importance to detect, explain and eliminate such errors as early as possible – ideally as soon as they occur – by taking appropriate measures or avoiding them altogether in advance. In this sense, the German-Czech cooperation project AIQUAMA (AI-based Quality Management for Smart Factories) aims at zero-defect production based on incremental quality monitoring close to real time during production. This is done by evaluating multi-sensor data streams using AI methods.

AIQUAMA uses a combination of symbolic models and statistical machine learning based on real but also synthetic training data with the help of no/low-code ML frameworks in combination with standardized digital twins based on Asset Administration Shells.

We present a part of the project results focussing on error sources to be detected in manual as well as in hybrid assembly, where a human worker performs work together with a collaborative robot. For this purpose, concrete services for object recognition of material, hand tracking, and skeleton tracking were implemented and deployed in an overarching edge-to-cloud service infrastructure together with AI services for, e.g., intention and plan recognition and tracking.

As proof-of-concept, we instrumented an assembly workstation in our Human-Robot-Collaboration Lab with the required sensor technology and a collaborative (mobile) robot where we effectively demonstrate and evaluate zero-error manual and hybrid assembly processes.

8. Engineering in Health Care

Engineering in Health Care: Diagnosis, Therapy and Future Trends

Shankar Krishnan *(Past President, IFMBE; Vice President, IUPESM, USA)*

The healthcare systems face unprecedented challenges across the globe. While doctors, nurses, and the clinical staff interact with patients to provide necessary care, smart fusions of multiple disciplines in engineering have played a vital role in the advancement of healthcare by developing new diagnostic techniques and innovative treatments. The objective of the presentation is to highlight some applications of relevant technologies in disease diagnosis and therapy to enhance healthcare delivery effectiveness and to explore future trends to improve the quality of life.

Relevant technological advances include artificial intelligence (AI) and machine learning (ML), Internet of Things (IoT), big data and predictive analytics, 3D Printing, nanotechnology, Virtual (VR) and Augmented Reality, Smart sensors, wearables, cloud computing, and digital twins.

Engineering technologies have revolutionized diagnostic processes for a myriad of diseases affecting the cardiovascular, cancer, stroke, diabetes, neurological, and renal systems. Considering that early-stage disease detection will lead to favorable outcomes, engineers have designed and developed specific tools for accurate determination of the presence and the stage of the disease. MRI, CT, PET, 3D and 4D ultrasound imaging modalities provide quick, detailed, noninvasive visualizations of internal body structures and organ functions, enabling prompt diagnosis. Data sets from wearable small smart sensors worn on the body tracking a variety of health metrics, such as heart rate, blood pressure, oxygen saturation levels, activity, and sleep patterns are used to monitor patients' health in real-time and identify potential problems. Artificial Intelligence and Machine Learning are employed in the diagnosis of an array of diseases.

Engineering has been instrumental in the development of medical devices and prosthetics that improve the quality of life for patients with various disabilities by creating advanced prosthetic limbs that are more functional and closely mimic natural movement. Medical devices, such as pacemakers, artificial heart valves, and insulin pumps, have become essential in managing chronic conditions and extending patient lifespans. Robotic systems have transformed surgeries by providing surgeons with enhanced precision, dexterity, and visualization. Minimally invasive procedures have reduced patient trauma, accelerated recovery times, and lowered the risk of complications. Innovative engineering designs have created patient-friendly drug delivery systems ranging from transdermal patches to targeted nanoparticles, enabling controlled drug release and improving the efficacy and safety of medications. Targeted drug delivery aims to deliver therapeutics directly to affected tissues or cells, reducing systemic side effects, and increasing treatment effectiveness. These novel applications have triggered paradigm shifts in medical practices expanding the operational scope with increased efficiency. Challenges to be tackled include optimizing the costs for research and development, product launch, care delivery, regulatory compliance, staffing, training, digitalization, and cybersecurity.

New technologies will keep emerging and corresponding innovative applications will continue to evolve in the future. Telehealth and home healthcare will become more common, allowing healthcare more accessible to people in rural areas and to those who have difficulty traveling. Internet of Medical Things (IoMT) will promote remote mobile health, automate record-keeping, enable real-time data sharing, and facilitate seamless collaboration among care teams leading to improved efficiency, accuracy, and patient outcomes. VR and AR will be used to train healthcare providers and to provide patients with an immersive experience during treatment. Brain-Computer Interface (BCI) systems will translate signals from the brain to manageable output commands for controlling external devices. The game-changing implementation of AI and ML in healthcare systems will analyze vast amounts of medical signals, images, and data, identify patterns, and

make predictions, aiding in early disease detection, risk assessment, and personalized treatment plans at a faster speed and greater accuracy. 3D printing and additive manufacturing will create patient-specific implants, prosthetics, and anatomical models for surgical planning, and facilitate the fabrication of complex organs and tissues for transplantation. Bioprinting will revolutionize regenerative medicine and address the organ shortage crisis globally. CRISPR and NGS are poised to revolutionize medicine, with the potential to cure a range of genetic diseases, including neurodegenerative diseases, blood disorders, and cancer.

In conclusion, engineering applications in health care have transcended conventional practices, driving significant advancements in diagnosis and therapy aimed at improving the quality of human life worldwide. Innovative multidisciplinary engineering approaches hold the promise of shaping a future where healthcare will continue to be more accessible, personalized, participatory, predictive, and effective. Embracing the fruits of engineering-healthcare collaboration will undoubtedly lead to further breakthroughs, thus transforming the ways of care delivery by contributing towards achieving the United Nations Sustainable Development Goal 3, “Ensure healthy lives and promote well-being for all at all ages.”

Engineering genomics for healthcare

Wilhelm J Ansorge *(Director Genomics Technology, formerly at EMBL European Molecular Laboratory, Heidelberg, Heidelberg, Germany)*

New knowledge and analytical techniques in biology, medicine, diagnostics, and generally in **Healthcare**, are based on discoveries and developments in physics, applied physics, engineering and chemistry. They originate mostly from fundamental and applied research, sometimes from military or space engineering projects.

Examples of such discoveries and engineering studies (to mention some) are: optics and light spectra, microscope, centrifuge, X-ray, radioactivity, fluorescence, mass spectrometry, semiconductor technology enabling miniaturization, sensitive light detectors, automation and robotics, computer data analysis and collection, Artificial Intelligence, chemistry methods.

Significant role in acceptance and use of engineering technology in healthcare played the **quantitative** methods and strategies of physics and engineering, as they could be applied to the analysis and control of biological systems properties. Next to the biological field, the "Engineering Biology" techniques are increasingly in demand also by health and pharma industry, and are vital in analyses of environmental factors influencing human health (air and water quality, wastewater screening for pathogens, others).

The quantitative methods enable more systematic approach to development and evaluation of novel medicaments and therapies of diseases. They may provide early warnings about a potentially arising pandemics, with an information allowing in some cases rapid preventive actions and production of vaccines.

Molecular Diagnostics for Healthcare

(Wilhelm J. Ansorge, ResearchGate, DOI:10.13140/RG.2.2.11145.01120)

Already largely contributing to the understanding of factors affecting human health and diseases are multidisciplinary developments of automated technology and techniques (based on laser, semiconductor planar technology, microfluidics system for application of biochemicals, modern imaging devices, computer data analysis):

--- Novel DNA and RNA Sequencing methods and Analysis of genomes and Epigenomes, detecting mutations and structural variations in the genome, also detecting methylated bases for studies in epigenomics. With various applications and modifications of PCR techniques.

These methods allow Large projects for Sequencing of Millions of Human Genomes, planned and funded both in the US and Europe. The healthcare field (Genomics, Proteomics, Medical research and Pharma industry) will benefit here from the recent advances and novel techniques for high-throughput analyses.

--- Selected by the *Nature Methods* journal as the method of the year, the Long-read sequencing technique may reveal the presence of alternative splicing and structural variations in genomes, both known to play a role in carcinogenesis and cancer progression. Their detection, and understanding of the regulatory mechanisms will help to develop new therapeutic strategies.

--- After the Human Genome Project, the design of the first complete Human Genome Chip Array, as well as techniques for design and production of smaller, less expensive Microarrays, enabled fast diagnosis in clinics. These could be small microarrays tools dedicated to a specific diagnostic situation, e.g. detection and monitoring of DNA, Protein, Antibodies and monoclonal Antibodies.

---The Human Microbiome Project (also called Second Human Genome Project), engaging all the tools of genomics and proteomics to analyse the collection of microbes in- and on the human body, has helped to clarify some metabolic diseases (among others also the risk factors for obesity).

--- Devices for synthesis and analysis of DNA and proteins, their synthesised products are vital in many diagnostics test.

--- The project “Single Cell as Laboratory” enables the study and visualization of cellular processing of DNA, RNA and proteins, also gene expression and inhibition effects of added biochemicals. This project benefited from the development of Automated Systems for Microinjection and Image Analysis of single Cells, Electro-transfection of cells, various cell Sorting systems.

--- For in-depth analysis of Proteins and Peptides, the Mass Spectrometry Analysis, Nuclear magnetic resonance, other techniques in Proteomics, and in combination with advanced computer programmes, are used to determine sequence of amino acids, structure and modifications of Proteins. Recent nanopore separation techniques allow to detect modifications on full-length proteins.

In healthcare, Protein and Peptide analyses are helping researchers to find the cause, and are vital in understanding and treatment of many diseases.,

Antiaging Research

In another recently emerging field in healthcare, for which an increasingly large funding has been provided, and many techniques developed, is Antiaging research. The hopes are to increase human longevity, and improve the quality of life in aging. The super-agers, as a group of people displaying not the typical diseases of old age, are the centre of the study.

This program (SuperAgers Family Study, superagersstudy.org), aims to analyse many thousands of people aged over 95 years, and their children.

The aim is to establish, to what degree is the secret to their longevity due to their genetics, and if- and how they are transmitted to next generations. If the responsible genes are found, among the many others, perhaps that knowledge could be used (e.g. in development of drugs with the appropriate effect), with the hope to allow other people to benefit from longer and healthier life.

Another line of study in the anti-aging field involves the research on STEM cells, transformation of somatic cells into induced pluripotent stem cells, and reprogramming the cells epigenome. This research area is submitted to limitations with necessary precaution, taking into consideration the non-negligent risk of unwanted side effects, which could be associated with this approach.

Artificial Intelligence in clinics and pharma field

Soon after the introduction of the AI technology, several attempts and considerations emerged about possible applications of this new method in the healthcare, clinics, and in pharma field (in particular to help in the development of new drugs).

A recently published study tested its performance in routine cases in clinics and hospitals (ChatGPT is nearly 72 percent accurate in making medical decisions), and included the reliability test of proposed diagnoses and treatment, as based on the patient's symptoms and personal medical information.

The results were encouraging in some aspects, but the principal conclusion was that at this stage of development, the AI technology for clinics must be still considered as a research tool, it cannot replace a medical doctor and needs human control. At present, this computer technology could improve efficiency in the healthcare, handling clinics data in a speedy manner and saving expenses. But it lacks empathy and creativity, recognizing how vital these aspects are in personal care.

Engineering Wastewater and Air quality analysis for health surveillance

During the past several years, quality of water and air in the countries worldwide advanced to a basic problem in the healthcare. The health authorities are heavily funding development of technologies which are required to improve and recover their acceptable quality. (see in Environment International).

A particular area in prevention of diseases in this field presents the wastewater-based epidemiology (WBE). The analysis of wastewaters and its surveillance is not entirely novel idea, it has been used for decades to follow polio virus, typhoid and cholera. But the WBE became a widely used tool in public health since the Covid-19 pandemic. Over the last few years, many institutions, towns and states have built their wastewater monitoring systems.

The justification for efficiency of this technique is that from people infected, the virus eventually enters the waste sewage. Evaluation of the virus levels in sewage thus provides information about the level of the virus in the region. This information is obtained without the necessity to test the many individual people, with considerable savings of expenses.

Results allow to foresee eventual outbreaks of infection waves, and prepare plan of preventive actions. Eventually it should be possible to obtain the virus sequence, and pass this information to pharma companies, speeding up the production and availability of vaccines.

Such system (e.g. the whole-genome sequencing-based infection prevention and control) should also be able to follow the potential different infection agents, not only variants of coronavirus, but also flu and polio virus, various resistant bacteria, and generally other pathogens. At this time, there are plans in many states to install and monitor such controls at some critical locations, e.g. at large international airports, where pathogens and variants might be detected early.

In a similar development in this area, a new EU-funded project aims to develop a mobile laboratory that can be used to test emerging pathogens in various locations, using advanced molecular technologies, such as next-generation sequencing, various PCR methods, communication and exchange with large data bases.

As an additional advantage of this approach, the techniques of this system should allow to detect also any hazardous micro traces, medicament byproducts, antibiotics, contraceptives, or pesticides. A promising method for the purification problems is the filter engineering technology, tested with novel bound enzymes, which are able to degrade specifically the targeted impurities.

Supranational coordination of the wastewater monitoring projects, with exchange of the data base information, will be required in the future. This will allow faster response of healthcare organisations in cases of potential hazardous situations.

The Air quality could become another public health crisis, as shown in a recent study (see *The Guardian*). It concludes that most people in Europe are living in areas with dangerous levels of air pollution. The study is based on cutting-edge technology and methodologies to gather data, including satellite images and many ground monitoring stations. The result is an in-depth and interactive map displaying the level of pollution in cities and states across Europe, signalling potential health crisis. Finding and developing technologies capable to improve and maintain acceptable air quality, and to eliminate the various pollutions sources, is now one of another great challenges for Engineering in Healthcare.

Designing an IL-6 biosensor for the early detection of sepsis

Ivana Suchánková *(Department of Biology, University of Oxford, Oxford, UK),* ***Giorgio Scattolni*** *(Department of Chemistry, Uppsala University, Uppsala, Sweden),* ***Chiara dalla Santa*** *(Uppsala University, Uppsala, Sweden)*

Sepsis is a life-threatening condition that accounts for 20% of global deaths. The current diagnostic routine of sepsis is acutely slow and is based on non-specific symptoms. Interleukin-6 (IL-6) is a proinflammatory cytokine that is vital to the body's immune response. Il-6 is regarded as a potent biomarker for early-stage sepsis detection. Our team developed a biosensor prototype for the rapid detection of IL-6 in blood plasma. To achieve this, we successfully adapted an electrochemical-aptamer-based detection principle. We immobilized Il-6-specific aptamers to recognize and bind IL-6 from the patient's blood plasma sample. The aptamers undergo conformational change upon binding, proportional to the IL-6 concentration. Our device can measure the Il-6 levels within the dynamic range of 1-2000 pg/mL of Il-6 in blood plasma under 5 minutes. The biosensor project was first presented at the SensUs International Biosensor Competition in 2022 and has since won several awards, including the Impact Maker Award issued by Venture Cup Sweden.

9. Food and Fresh Water Supply

Drinking Water Quality and Treatment – New Challenges

Marek Šváb *(Dekonta, Praha, Czech Republic),* ***Barbora Štěpánová*** *(Dekonta, Praha, Czech Republic),* ***Václav Janda*** *(Department of Water Technology and Environmental Engineering, University of Chemistry and Technology, Praha, Czech Republic)*

For the removal of micropollutants (pesticides, pharmaceuticals, hormones, PFAs…) from water, generally, membrane processes, advanced oxidation and activated carbon adsorption can be used. Aim of our work was to find out, whether granular activated carbon is able to remove effectively these compounds from raw surface water where natural organic matter is present in concentration three – four orders of magnitude higher than the micropollutants. The intention is to use this procedure as pre-treatment of water before its final treatment, for example by infiltration. Sand-filtered real river water was used as input to the columns.

A pilot experiment consisting of three columns was set up. The columns filled by three types of the granular activated carbon have been operated at identical hydraulic loadings (empty bed contact times) for two years. Inlet and outlet concentrations of micropollutants and common parameters of water quality have been analysed.

It was found that for the vast majority of micropollutants, granular activated carbon adsorption worked excellently, regardless of the presence of natural organic matter in water and dense biological settlement in the filters. Only for a few micropollutants did the adsorption efficiency decrease during the two-year experiment. These were mainly low-molecular polar substances.

It has been proven that adsorption on granular activated carbon is an effective step for the pre-treatment of natural surface water before its final treatment, for example by infiltration, where it is necessary to protect valuable subsoil from adverse effects.

The importance of rational water management

Domenico Terenzio *(Consiglio Nazionale degli Ingegneri, Roma, Italy),* ***Ania Lopez*** *(Consiglio Nazionale degli Ingegneri, Roma, Italy)*

Keywords: food materials, food processing, soil fertilization, food preservation, drying, plant irrigation, future foods, food security, health effects of diet, water, soil, light, agri-food chain.

In a time of scarcity of natural resources such as water, a precious asset, it is necessary to make good use of them, the application of technologies and new specialist formulations to enhance the endogenous defenses of plants against biotic and abiotic adversities can help obtain a much higher crop yield with greater effectiveness in improving the qualitative and quantitative yields of crops, and in increasing the natural resistance of plants to pathogens, all in full compliance with the principles of low residuality and sustainability, to the advantage of ecosystem and the well-being of every single creature. Our proposal is based on the rational use of water, as already identified in SDG 6 of the 2030 Agenda, proposing internationally patented solutions for greater benefits from the point of view of agriculture and food quality.

Lifelong education of engineers and its contribution to the green transformation

Miloš Kužvart *(Czech Association of Circular Economy, Czech Republic)*

The Czech Association of Circular Economy (CAObH) strives to spread awareness about the benefits of the circular economy. One of the very important target groups are experts with technical education at the level of companies, ministries, regional authorities and universities.

As a voluntary, independent organization, the Association strives to promote improvements in the material recovery of waste.

The holding of WEC 2023 in Prague, at the seat of the first transalpine university of medieval time, is a confirmation of the importance of education for the host country – the Czech Republic.

Therefore, it is not by chance that three universities are among the members of CAObH – MU Brno, UJEP Ústí nad Labem and the Czech University of Agriculture. Therefore, NO offer to lecture at the university is left unanswered by the Association.

In the last few years, the circular economy has been moving from political theses and proclamations to the implementation phase, where the core of success in the current problems with the price of energy and the lack of raw materials and resources is the application of circular approaches, minimizing the production of waste. It is this current tense period, the period of the war in Ukraine that has lasted for more than a year, that means the increasing importance of innovative approaches, modern technologies and their rapid implementation in practice.

This is precisely the role of the Association: to help the state administration and legislators to create a legal and economic framework for the application of new technologies - I will mention only two: pyrolysis of waste and plasma use of often dangerous waste.

10. Natural and Industrial Disaster Prevention

The role of engineers in accelerating implementation of disaster risk reduction and resilience

Savina Carluccio (International Coalition for Sustainable Infrastructure, London, UK), Katie Momber (International Coalition for Sustainable Infrastructure & Institution of Civil Engineers, London, UK)

The UNDRR's Sendai Framework for Disaster Risk Reduction went through a formal mid-term review to take stock of implementation and impact since its launch in 2015, understand what context shifts have occurred and identify how to accelerate uptake to 2030 and beyond. The International Coalition for Sustainable Infrastructure (ICSI), with support from the Institution of Civil Engineers (ICE) and contribution by WFEO Committee for Disaster Risk Management, led a multi-lingual consultation to elicit the views of 250+ engineering practitioners and experts from over 50 countries. Findings of the consultation were published in a report that was the only contribution from the engineering community to the formal mid-term review process of the Sendai Framework. The publication was extremely well received and referenced several times in the UNDRR Sendai Framework Mid-term Review report.

The following recommendations and key positions are highlighted as areas where the engineering community can offer a significant contribution to accelerate implementation. Implementation of disaster risk reduction and resilience is a multi-stakeholder effort and engineers have a key role to play.

1. The role of DRR and resilience needs to be highlighted in relation to global agendas

There is a need to elevate DRR and resilience in relation to the Sustainable Development Goals (SDGs) and other global agendas, and to better connect them to other systemic drivers and priorities.

2. Develop and implement systemic risk and resilience frameworks and establish resilience focused agencies and governing bodies

There is an urgency to develop policies, regulations, codes, plans or other mechanisms that encourage or enforce the uptake of DRR and resilience measures, and to establish agencies or bodies that oversee their implementation. Multi-national agencies can play a key role assisting during the pre-development phase and enhancing local capacities during implementation.

3. Accelerate improvement of data collection, analysis and methodology through technological advances and sustained investment

Improved understanding of technological abilities and increased investment are needed to accelerate the development and uptake of new technology beyond its current trajectory. Technological advancements can push the envelope of traditional risk assessments that include resilience thinking to deal with uncertainty, systemic complexity, and long-term approaches that incorporate climate change impacts.

4. Encourage multi-disciplinary cross-sector collaboration among experts to tackle complex challenges

Extensive collaboration among expert groups from different backgrounds (engineers, planners, social scientists, climate scientists, data scientists, finance experts etc.) is needed to develop better assessments and build local capacity during project implementation. There is also a need for the engineering community to engage more proactively and provide input into policy development and early-stage project development.

5. Educate policymakers, practitioners, and the public on DRR and resilience concepts

Education could enhance understanding of the importance of DRR and resilience. Educating and building capacity of policymakers is a priority, since they are responsible for developing regulations and incentives

to increase the uptake of DRR and resilience. Enhancing capacity of practitioners at local level is urgently needed, and educational settings and civil society have a key role to play here.

A later ICSI report, which draws on an event held at the UNDRR Risk Reduction Hub, outlines key opportunities and solutions to these challenges, complemented by real-world case studies from across the globe. Some key takeaways from the report are:

- Good governance is critical to enhancing resilience, particularly in the context of disaster risk reduction (DRR). There is an urgent need for the policy and regulatory environment to better consider the risks of today and those of the future.
- Scaling up resilience solutions requires sustained financing, and access to resources, training, and capacity building opportunities. It requires the establishment and maintenance of stakeholder partnerships and strong governance structures that foster accountability, trust, and the empowerment of local communities. Justice, transparency, and inclusivity need to be at the core of any solution, with frontline communities centred and reflected in resilience interventions.
- Globally, there is a lack of capacity to imagine infrastructure in a systemic way. This means that we need to bring in a multi-sectoral approach that considers the interconnectedness of different systems. We need to think in terms of systems, not silos, in order to scale infrastructure resilience and bring experts together to promote an integrated approach.
- The engineering community can offer a significant contribution to accelerate the implementation of DRR and resilience in infrastructure systems. For example, they can capitalise on technological advancements to enhance traditional risk assessments to include resilience thinking. This would help with better understanding uncertainty, systemic complexity, and long-term approaches that incorporate climate change impacts. The breadth of case studies and examples presented in this publication is a striking testament to the need for everyone involved in the development of infrastructure to come to the table to truly accelerate the implementation of DRR and resilience.

Flood Risk Management in View of Climate Change in Africa

Ivy M Getanda (Kenya Rural Roads Authority, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya)

Introduction

Africa, comprising 54 states, experiences diverse climatic conditions ranging from equatorial to desert. Rainfall and river flow in the continent exhibit high variability across different spatial and temporal scales. In Kenya, the Kenya Meteorological Department has issued warnings of heavy downpours from October to December 2023 due to the El Niño climate phenomenon, presenting complex challenges for flood management in vulnerable areas. Over the past decade, floods have surpassed droughts in terms of the number of affected people. This paper sheds light on flood risks in Africa by presenting data from both measured and unmeasured catchments, as well as other flood-prone regions. Additionally, the paper emphasizes the significance of urban and rural flooding in many African nations and its impact on critical infrastructure like roads and bridges. Furthermore, it delves into flood mitigation techniques in Africa and their repercussions on communities, soil quality, and land amidst a climate crisis. Strategies to mitigate flood risks encompass enhancing the flood resilience of roads, utilizing ensemble flow forecasting, employing impact-based forecasting, creating flood hazard maps through modeling and mapping, increasing flood awareness, and enhancing preparedness, among other measures. The consequences of floods extend to soil degradation and its adverse effects on agricultural production. Degradation and erosion of watersheds, driven by intensive cultivation, overgrazing, population growth, and deforestation, have resulted in reduced crop yields and heightened flood risks. Flood risk management stands as a pivotal focal point in Africa's climate change adaptation planning. In conclusion, the enhancement of end-to-end flood early warning systems, considering scientific, technical, and institutional/governance dimensions, proves pivotal in mitigating flood risks in Africa.

Objectives

This paper aims to exemplify effective flood management practices in the cities of Cape Town, Durban, Nairobi, and Mombasa, and other African Countries providing concise insights into disaster risk reduction methods, with a particular emphasis on ecosystem- and nature-based solutions. The research is based on a comprehensive literature review conducted through desktop research.

Flood Risks and Flood Management Approaches:

Augmenting Flood Resilience

Increasing flood resilience involves employing methods such as Coupled Ensemble Flow Forecasting and Flood Modeling and Mapping to establish early warning systems ahead of potential floods. Current and projected flood risks in Africa are substantial and escalating. The practice of flood risk management for bolstering resilience in Africa is still in its early stages. It has gained prominence in urban areas and in some of the largest river basins (such as the Congo/Zaire, Niger, Nile, Zambezi, Senegal, and Lake Chad), where population growth in flood-prone areas has been rapid.

Urban areas may face various types of flooding, influenced by factors like location, physical attributes, and climate change risks.

Flooding, the most common natural disaster, has seen a significant uptick in reported incidents since 1990. It can result from a combination of meteorological and hydrological extremes, including extreme precipitation, as well as human activities like unplanned urban expansion, settlement in flood-prone areas, and deficient drainage due to inadequate infrastructure or increased impermeable surfaces, all of which elevate flood risk (Gordon & Kwawu, 2020; Jha et al., 2012). This interplay can lead to urban floods, where runoff from fluvial, pluvial, coastal, or groundwater sources surpasses the capacity of the urban drainage system.

Various types of floods include riverine flooding (arising from water in a river or drainage channel surpassing the channel's capacity, inundating the floodplain) or coastal floods (caused by elevated sea levels due to storm surges) (WWF, 2016). Due to rising sea levels, more frequent storm surges, heightened climate variability, and increased extreme precipitation driven by climate change, urban flooding has become more frequent and unpredictable.

Rapid urbanization is essential for building adaptive capacity.

The rapid growth of high-density populations in urban areas in many developing nations has led to the extensive expansion of impermeable roads and rooftops, a reduction in natural flood storage, and an increased exposure of people and assets to water-related disasters. The existing water management systems in urbanized areas often struggle to cope with the concurrent challenges of climate change, urbanization, and inadequate urban planning.

A broad spectrum of interventions and measures exists to mitigate flood risk at different scales.

These range from traditional grey infrastructure measures to green approaches. While cities have primarily responded to flood risks through infrastructure solutions, natural and ecosystem-based solutions are gaining recognition (Ilieva et al., 2018). Measures to reduce flood risks within a city must encompass both the city context and the broader catchment or watershed area, necessitating interventions at different temporal scales (Gunnell et al., 2019). The literature review also uncovers various terminologies and a diverse array of nature-based measures applicable in different contexts for flood risk management.

Integrated Flood Risk Management (IFRM) encompasses a comprehensive approach, combining both structural and non-structural elements.

Structural elements aim to directly regulate water flow both outside and within urban settlements, encompassing hard-engineered structures like flood defenses and drainage channels, along with natural measures like wetlands and natural buffers. Moreover, IFRM incorporates non-structural measures such as improved planning and management in urban development. These measures serve various purposes, including emergency planning and management (encompassing warning systems and evacuation), heightened preparedness through awareness campaigns, flood avoidance through land use planning, and expediting recovery, alongside the concept of "building back better" to enhance resilience against future flood disasters.

Ecosystem-based adaptation (EbA) strives to reinstate and enhance the natural dynamics of ecosystems to buffer against the adverse impacts of climate change.

EbA entails approaches that reduce vulnerability and enhance the resilience of socio-ecological systems to both climatic and non-climatic risks, while also generating societal benefits. Positioned as a subset within the Natural and Nature-Based Solutions (NBS) portfolio, EbA entails employing biodiversity and ecosystem services for climate change adaptation and mitigation (Lo, 2016; Dhyani et al., 2020). EbA acknowledges that future changes remain uncertain and possesses the potential to respond to these uncertainties, thus offering an advantage over hard engineering measures, which primarily aim to safeguard assets under assumed flood magnitudes (Iacob et al., 2014). Illustrations encompass the restoration of wetland habitats within catchment areas, the planting of wetland vegetation to curb erosion, or the preservation of mangrove ecosystems for coastal protection (Gordon & Kwawu, 2020).

Adopting a nature-based approach to flood risk reduction necessitates a nuanced comprehension of the hydrological system's dynamics.

Consequently, flood risks must be addressed through an integrated approach that transcends sectoral or municipal boundaries (Ilieva et al., 2018). The selection of ecosystem-based adaptation measures must be

thoroughly understood by national and local authorities, and harmonized with existing policies and legislation (Gordon & Kwawu, 2020). Several approaches and urban planning concepts propose strategies for fortifying cities against climate change impacts, particularly in flood management.

Non-structural Flood Management Approaches:

Flood Risk Researches

Addressing flood risk in informal settlements presents a complex challenge, often revolving around land ownership and tenure issues, and the decision-making process concerning shack locations. Consequently, inhabitants of these settlements are hesitant to invest in properties, as they do not own the land, and the response from local governments depends on whether informal settlements are established on private land or in areas designated for stormwater drainage.

Mapping Flood Vulnerability in Informal Settlements

The exponential growth of informal settlements in ecologically vital wetlands has increased their exposure to risks from both coastal storm surges and flooding. Continuous mapping efforts for settlements like Soweto in South Africa, Kibera in Kenya, Ajengule in Nigeria, Cazenga in Angola, and Agbogbloshie in Ghana, among others, can forecast early warning signs before the onset of floods.

Progressive stormwater management approaches

Intervention strategies are imperative for improving the deficient drainage systems in Africa. The installation of smart drainage systems represents an innovative step towards reducing flood risk in urban areas. Flood Sensors and Monitoring Systems leverage real-time data to monitor water levels, identify flood events, and alert authorities and residents about potential flooding.

Structural Flood Management Approaches

Grey Structural Approaches

Sea walls: In Cape Town, infrastructural solutions like sea walls have been implemented, despite the challenges posed by rising sea levels.

Gravel Platforms: In Green Parks, an informal settlement on the Cape Flats, gravel platforms have been constructed beneath residential dwellings. These platforms are slightly sloped to facilitate the runoff of rain and excess water, thereby reducing exposure to flooding.

Ecosystem-based Structural Approaches

EbA constitutes a natural approach to climate adaptation, leveraging ecosystem services. It is less likely to yield adverse consequences and tends to be more cost-effective compared to many physical interventions. Below are examples of EbA strategies employed in Cape Town for coastal protection and flood risk reduction.

Dune Restoration

Cape Town provides a noteworthy example of utilizing ecosystem services in a coastal setting (Cartwright, Brundit & Fairhurst, 2008). The city's coastal dunes have been disconnected from their natural sand source due to disrupted tidal transport and restricted sand movement from inner flats and rivers, caused by dams and weirs.

Kelp Beds and Wetlands

The city recognizes the importance of protecting kelp beds as a natural buffer against erosion. This measure also aids in creating and stabilizing sand dunes, attracting various organisms crucial for the nutrient cycle, and preserving biodiversity.

Community-based Spatial Redesign (CBA)

CBA proves to be an effective strategy for incorporating bottom-up knowledge, as communities possess a deep understanding of local dynamics. Consequently, they can identify interventions that are most likely to be sustainable and embraced by the community to reduce environmental risks. Research indicates that community-led reblocking processes (rearranging shacks in a settlement to facilitate flood drainage and service delivery) exemplify powerful instances of CBA and transformative action.

Green Infrastructure

Solutions such as bioswales, rain gardens, and green roofs within urban environments absorb stormwater runoff, reducing the risk of flooding.

Flood Barriers

Deployable flood barriers offer a rapid and dependable defense against flooding. Recent advancements include inflatable barriers and self-deploying barriers triggered by rising water levels.

Smart Drainage Systems

These systems employ sensors and real-time data to optimize stormwater drainage, minimizing the risk of flooding. Earth observations play a crucial role in disaster monitoring and bolstering resilience in water basins.

Conclusion

Enhancing flood resilience in view of climate change demands consistent steps, including coupled ensemble flow forecasting, impact-based forecasting, integrated flood risk management, production of flood hazard maps through modeling and mapping, efficient flood reduction infrastructure, land use planning management, and community environment conservation funds for water resources management.

Using Wavenumber-Frequency Maps from Lamb Waves to Inspect Aluminum Plates

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In this paper we use Lamb waves to detect and characterize cracks in aluminum plates.

The detection of cracks is performed by a pitch catch method. Although Lamb waves antisymmetric A0 and symmetric S0 modes could be propagated in the plate, only S0 modes are launched by one angle beam probe, from one side of the plate, and detected on the other opposite side by a PZT disk sensor.

The two sensors are moved simultaneously on each side of the plate. The ultrasound beam always points to the PZT sensor. In this way a large portion of the plate is scanned.

If the ultrasonic beam is intersected by a crack, a sudden variation on the PZT signal is observed. In this case part of the original beam is transmitted and another part is reflected. The interaction of the original beam with the defect originates conversion of modes. The analysis of the mode content in the transmitted and in the reflected beam can be used as a tool to infer on the defect characteristics that caused such conversion between propagation modes.

In the experimental tests we used an aluminum plate with a thickness T=2 mm, and a central frequency of the emitted bursts equal to F0=350 kHz.

By using a fft transformation on time and on wavenumber domains it was possible to separate the beams components after interaction with plate cracks, orthogonal to the beam travel direction.

Wavenumber-frequency maps show a show a strong dependence of converted modes with cracks' depth.

Capacity building on isolation facilities preparedness for future infectious diseases pandemic

Pak-Leung Yuen *(Hong Kong Institution of Engineers, Hong Kong, China)*

Despite decades of rapid health care technological development and advancement seen in both therapeutic and diagnostic aspects the recent COVID 19 pandemic has unveiled the important but less prominent area which entail more engineering thought through into the capable core ventilation design and the associated capacity building being simple yet fast enough to establish in meeting the high demand in short time for patient isolation. As witnessed in the COVID 19 pandemic the isolation facilities in health care venues are key to cater for transmission-based precaution measures in healthcare facilities to avoid nosocomial infections and intensification of the diseases outbreaks. Infectious patient should be placed into a negative pressure setting to prevent outflow of less clean air to areas outside of the setting from causing unwanted infections, and with the introduced high air change rate within the setting to achieve good air dilution or effectively exhausting out of the less clean air all in a controlled manner. During the COVID 19 pandemic in respond to such imminent needs for rapid surges of infected patients several innovative isolation setups have been devised ranging from very simple to more sophisticated design and construction were put into practical use successfully throughout the different waves of the pandemic. The knowledge and experience gathered would be suggested to turn into much more useful references for capacity building of isolation facilities enabling fast response to tackle future sudden attack from disease pandemic.

Assessing flood-induced damage to bridges in extraordinary weather events: the case study of March 2022 (Italy)

Andrea Valerio (ARUP, Milan, Italy), Christian Capuano (ARUP, Milan, Italy), Barbara Polidoro (ARUP, Milan, Italy), Francesco Ballio (Politecnico di Milano, Milan, Italy), Maurizio Brocchini (Università Politecnica delle Marche, Ancona, Italy), Giovanna Darvini (Università Politecnica delle Marche, Ancona, Italy)

Introduction

On the 15th and 16th of September 2022, a devastating weather-induced flood event struck several municipalities in the Marche region (Central Italy). The calamitous event primarily affected the provinces of Ancona, Pesaro and Urbino, causing 13 casualties, 50 injuries, 150 displaced people and economic losses worth about 2 billion Euros.

In the days following the event, several investigative campaigns have been carried out by various organizations and for different purposes. These ranged from the immediate post-event assessment, coordinated by the Civil Protection Department and consisting of mapping flooded areas and major damages to rivers embankments and the transport network with the aim of securing the affected areas, to field surveys dedicated to gaining a detailed understanding of the event's impact on the territory and local communities.

The latter, coordinated by Professor Maurizio Brocchini (Università Politecnica delle Marche) and Professor Francesco Ballio (Politecnico di Milano), involved the collaboration of over 100 researchers from 22 Italian and UK academic institutions and industry partners. The aim was to provide valuable data to managing authorities and local communities, to inform future resilience strategies, by building a comprehensive picture of the impact caused by the flood.

ARUP was involved in the investigation on the damage of bridges, with the goal of better understanding the causes of their failure. The campaign consisted in collecting damage data to enable:

- an understanding of the correlations between location/importance of the asset and level of damage;

- a characterisation of the hydraulic phenomenon and the causes for the structural failures;

- an assessment of the degree of resilience of different structural types, by identifying the main features which influenced their performance during the flood event.

Description of the area and criticalities

Marche region, located in Central Italy, covers an area of 9.365,86 km², with a predominantly hilly terrain (69% hills, 31% mountains). The region has a population of 536,000 inhabitants with a density of 158 inhabitants/km², lower than the national average (196 inhabitants/km²), with the 82% of the municipalities being situated in hilly areas.

As for the majority of the Italian territory, hydro-geological instability represents a significant issue for the region. Among the natural factors for hydro-geological instability is its geological and geomorphological conformation, characterised by a complex orography and generally small river basins with extremely rapid response times to precipitation.

The first historical records regarding floods that caused direct harm to the population date back to 1807. From then until the present day, there have been at least 24 major meteoroclimatic events, characterised by either intense or prolonged rainfall, which resulted in flooding with casualties, missing and displaced individuals.

Marche has also a history of landslides and widespread erosion due to intense and prolonged rainfall. The most significant one was undoubtedly the landslide in Ancona on December 13, 1982, resulting in over 3,650 displaced people.

The region is also prone to earthquakes. 97.3% of the territory, equivalent to 230 municipalities, has been classified as having a medium or high seismic risk, having been affected by several events in recent decades.

Description of the flood event

From the late morning of Thursday, September 15, 2022, some thunderstorm systems formed on the Tyrrhenian side of the Italian peninsula, aided by the presence of moisture from the Tyrrhenian Sea and the topography of Sardinia, Corsica, and Tuscany. As these systems moved eastward, they generated additional thunderstorm cells that gradually affected Tuscany and Umbria before extending into the Marche region. In the initial phase, the phenomena primarily affected the northern central mountainous and upper hilly areas of the region. In the late afternoon, a self-healing and stationary system formed, impacting not only the inland areas but also the hilly and coastal parts of the Ancona province.

Having started at around 5:00 PM the main rainfall event lasted seven hours, with heavy precipitation reaching peaks of 100 mm/hour between 7:00 PM and 9:00 PM, and cumulative rainfalls of 384mm and 419 mm over 6 and 12 hours periods respectively, as recorded in Cantiano weather station (Pesaro e Urbino province), an amount equivalent to approximately 30% of the average yearly rainfall recorded in the area. The effect of such exceptional rainfall was amplified, in the area of Senigallia (Ancora province) by the peculiar hydrological features of the Misa-Nevola rivers watershed. The upstream Misa-Nevola sub-basins (Arcevia, Barbara, Serra dei Conti) have a time of concentration of about 4-7 hours, equal to the duration of the rainfall event. This meant that all the rainfall contributed to flooding the rivers and that both rivers reached flood simultaneously, resulting in a disastrous combined effect in the city of Senigallia, where the river outlet is situated.

Description of the local infrastructure system

Marche region has a road transport network comprising 168 km of highways and 5162 km of regional and provincial roads. The density of highways is 1.7 km for every 100 km², (below national average of 2.6 km / 100 km²), while the density of secondary (national, regional and provincial roads) is approximately 66 km / 100 km², above the national average of 52 km / 100 km². The bridge assets most heavily affected by the flood are located on this secondary road network, crossing over or alongside Misa and Nevola rivers or their tributaries.

The typical structural typologies encountered in this area are simply supported reinforced or prestressed concrete beam-and-slab decks and single/multi-span masonry arch bridges. This data was confirmed during the site investigation, where out of a total of 63 examined structures, 35No. (55%) were simply-supported concrete bridges with one to three spans with span lengths varying from 10 to 30 m, and 22No. (35%) were monolithic masonry arches with a typical span length of 10 m. The remaining minority of investigated structures consist of steel-concrete composite decks, in either simply supported or continuous span arrangement, with span lengths varying from 10 to 45 m.

Description of the bridge damage detection activities

During the site investigation the following data was gathered:

- General asset information: location, type of road carried, type of obstacle crossed, proximity to urban centres, importance of crossing, etc.

- Structural characteristics: deck typology, articulation, materials, members dimensions, history of strengthening and any other relevant details;

- Hydraulic characteristics: riverbed characteristics, including geometry, material, presence of weirs/other hydraulic measures downstream, water level reached during the flood event, etc.;

- Flood-induced effects: information concerning structural damages caused by the flood and the effects on riverbed and riverbanks (scour, riverbed lowering, riverbank erosion, etc.);

- Photographs: visual documentation to record the conditions of the structures after the flooding event.

Description of damages to bridges

Bridge partial or total failures due to flooding can occur for various reasons, often stemming from a combination of factors. The typical damages observed in the bridges investigated are listed below:

- Damage due to hydraulic forces: hydrodynamic pressure exerted by fast-flowing water on the structure and its ancillary elements (e.g. parapets, utilities). This can typically be attributed both to design incompliance (e.g. clearance requirements to deck soffit not satisfied, substructure not designed for design value of hydraulic force) or exceptionality of the flood (return period beyond that assumed when the bridge was designed).

- Scour: process by which fast-moving water erodes the riverbed adjacent to the foundations of the bridge, undermining the substructure stability;

- Debris impact: flood waters carrying large debris, including trees, logs, and other objects lodged in the irrigation channels that feed into the water basin which, due to lack of a clear and controlled maintenance strategy, were never removed;

- Erosion of approach roads/riverbank: flooding can erode the approach roads leading to the bridge. If the road embankment is washed away it can leave the bridge abutments and wing walls unsupported and unprotected against hydraulic forces.

Geographically, the most onerous damages and the only total collapse cases concentrated in the upstream region of the Misa-Nevola system, due a combination of structural and hydraulic features of the assets therein located. The majority of failed structures were short-span masonry arches or reinforced concrete simply supported decks having been subject to the complete run-off of the bank material behind abutments.

The first typology of bridge relies heavily on the presence of backfill material and the degree of restraint provided by the soil behind the abutment and the wingwalls. The erosion therefore caused first the instability of the abutments and wing walls, then the spandrel walls, with consequent run-off of the infill material leaving the arch barrel unbalanced and entirely exposed to water.

The second typology of bridge is characterised by a low degree of structural redundancy. This meant that once the flood had eroded the soil behind the abutments, these started displacing out-of-plane, leaving the deck unsupported.

Resilience strategy

Response to the event

The resilience response activated by the local authorities, in coordination with the Civil Protection Department, hours after the event, consisted in rescuing and assisting the population affected, and restoring the functionality of public services. An immediate post-event assessment of the condition of the strategic network infrastructure together with the critical interventions (e.g. reconstruction of damaged riverbanks) was carried out. A state of emergency with a duration of 12 months was established. A Committee was then set up to design, coordinate and run all the urgency and long-term activities needed to restore full functionality of damaged activities and implement all actions and infrastructures required for the flood mitigation.

The average downtime for commercial activities in the city of Senigallia, based on ARUP's survey on buildings condition, was estimated between 1 and 3 weeks. An average team of 5-6 people would be needed to

restore a typical store in the city centre. Significantly longer times and human efforts are being needed to restore industrial and agricultural activities.

A number of collapsed bridges are still waiting to be demolished and reconstructed. This has led to the decision of extending the state of emergency for a further 12 months.

Long-term strategies

The advisable critical steps towards an enhancement of the resilience of this area of Marche region are:

1. Improving all the knowledge needed, i.e. both monitoring and modelling, to produce a master plan of flood mitigation actions and measures, all along the river basin, from the source to the mouth;
2. Educating the population to flood risk: despite living within the riverbed, the local population has not been educated to reduce the risk of flooding (e.g., moving to higher floors) as much as it has been, for example, in relation to seismic risk;
3. Development of an adequate warning system, having two fundamental characteristics: 1) ubiquity, 2) redundancy. The first characteristic is necessary so that all citizens (from the elderly with limited mobility and technology skills to residents in very remote areas) receive warnings. The second is essential to ensure that the system is robust and not compromised by accidents such as power outages, malfunctioning phone networks, etc. Redundancy is achieved by implementing several different warning systems, allowing at least one to function in the event of the aforementioned accidents.
4. Detailed and extensive analysis of the stability of all river embankments;
5. Rationale planning of mitigation measures and infrastructures, which could blend engineered and nature-based solutions, possibly with multiple use (e.g. expansion basins for both flood and draught risk) and through an incremental approach, starting from the measures characterized by the least potentially negative impacts;
6. Rational decisions in planning the reconstruction of collapsed or heavily damaged bridges (e.g. avoid options which have proven to be not resilient in the flood event, thoroughly assess the potential for movable bridges especially for strategic crossings);
7. Mitigation measures that address the various needs encountered along the course of the rivers (from natural flood basins to expansion basins, spillways, riverbed dredging, etc.). This will have to be done while considering each project within a comprehensive basin framework;
8. Revision, in the light of the new dynamics forced by a changing climate, of laws and norms that regulate the management and use of materials characterizing river basins (e.g. sediments, vegetation, etc.);
9. Coordinated action by all Public Institutions involved in the management of river basin functioning and its interaction with the sea, to reduce all “bureaucratic viscosities” that negatively influence implementation of all needed actions and measures.

National Strategy and National Action Plan for Protection Against CBRN Threats in the Czech Republic

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The Czech government and the responsible Czech authorities consider security problems to be key issues of the State's internal policy. It is obvious that, at present, issues of state security are becoming a priority in the daily activities of the government, constitutional officials, and individual departments of the national economy. The fear of an escalating conflict has proven to be justified, as stated above, and requires the Czech Republic to take measures to maintain internal security and support international efforts in dealing with all events, be they military and political, hygienic and epidemiological, or other events have a negative effect on life on our planet.

The threat of CBRN misuse is also gaining importance. In 1995, the Japanese religious sect Aum Shinrikyo attacked the Tokyo subway with sarin, causing 12 deaths and nearly 5,000 injuries. (Tu 2002, Tu 2018). Places where large numbers of people gather for various reasons are known to be the target of terrorist attacks causing serious loss of life and health of the population, material damage, and causing fear and panic among the population.

Therefore, it is important that the Czech Republic also pays increased attention to protection against chemical, biological, and radiological terrorism in vulnerable public places (for example, in the Prague Metro/Underground). However, they must also seriously deal with all possible catastrophic scenarios of attacks and assaults using CBRN.

The Czech Republic has certainly not lagged behind in such an important area as CBRN protection. We can be confident of this, be it through the development and introduction of means of radiation, chemical, biological research, means and reagents for the decontamination of equipment, material of all kinds, and persons, individual and collective protection, prophylaxis and the treatment of affected persons of the armed forces and the general population. In 1990 and 1991, the chemical unit of the Czechoslovak army was involved in the Gulf War, and its operations within the mission of international forces, equipment, and readiness were positively evaluated at an international forum. Proof is also found in the performance of a state scientific research project for the Ministry of the Interior between 2002 to 2003 entitled, "New terrorist threats, chemical, biological, radiological, and nuclear terrorism" (Matoušek 2003). Based on this scientific and research grant, student texts were prepared and published at the University of Defence in Brno in 2005 (Matoušek 2005).

Entirely new specialized publications entitled, "Nuclear, radiological and chemical weapons, radiation and chemical accidents" (Vičar 2020), and "Protection against weapons of mass destruction in the Czech Republic" (Sabol 2021) were published at universities in the Czech Republic.

In another case, a habilitation thesis from 2011 (Mika 2011) focused on the issue of protecting the population from chemical terrorism, where a total of 91 different measures were proposed in specific areas, i.e., preventive measures, punitive measures, rescue and protective measures, mitigation measures, liquidation measures and recovery.

The good preparedness of everyone (paramedics, medical personnel, police, special hospitals, special military units, the general population, etc.) for extraordinary events and crisis situation, especially for managing their consequences, including possible terrorist CBRN attacks, requires the following necessary procedures in particular (Mika 2011):

- Systematic preparation of control units and authorities for the possibility of CBRN terrorism;
- Sufficient knowledge of CBRN terrorism acquired by the population (knowledge of the population about possible extraordinary events and emergency situations at the place of their residence or work, including terrorist attacks; clarification of the methods of warning and protection of the population; questions, etc., answered by the administrative authorities at the place their residence);
- Basic provision of written instructions on CBRN terrorism to the general population and their correct response (description of possible emergency events, including terrorist attacks; methods of warning the population; shelters for the population and protection systems; improvised protective equipment and aids, what to pack for an evacuation, evacuation routes, assembly points for the evacuated population, etc.);
- Practical training of residents for cases of CBRN attacks; necessary activities and use of various personal protective equipment and aids; production of improvised protective equipment; training in what to pack in the case of an evacuation; training in the evacuation of the population; comprehensive training of acquired skills and habits; training of the population in response to possible extraordinary events and emergency situations);
- Theoretical training of rescuers and policemen for cases of CBRN attacks and assaults (acquiring the necessary basic knowledge and awareness of CBRN issues);
- Practical training of first responders, rescuers, and police officers on training grounds and in exercises in the case of CBRN terrorism (acquiring the necessary skills and habits for operations in extraordinary events and emergency situations [terrorist attacks]; and
- Systematic, regular, and comprehensive verification of knowledge, skills and habits of rescuers through not only written tests, but also practical verification in the field.

The overall preparedness of the population for extraordinary events, crisis situations, emergency situations, and their adverse effects is a very complex, complicated, and long-term issue. In the Czech Republic, a system for preparing all groups of residents for extraordinary events and extraordinary situations has not yet been created (only partially for primary school pupils and secondary school students). An integral part of such preparation must be regular and systematic preparation of the population for possible CBRN attacks.

The current situation in the area of protection against CBRN in the Czech Republic is at a fairly good level, but the state of preparedness must be constantly improved.

The Czech Republic has gradually developed several large and detailed integrated rescue system emergency response plans for the most important areas of CBRN, as shown below:

- Reaction to the misuse of biological warfare agents and biological agents against the population (General Directorate of the Fire and Rescue Service of the Czech Republic, Emergency Response Plan 2006),
- Reaction to dirty bombs or other dangerous radioactive materials (General Directorate of the Fire and Rescue Service of the Czech Republic, Emergency Response Plan 2015),
- Reaction to the misuse of chemical warfare agents and toxic industrial chemicals in the Prague Metro/Underground (General Directorate of the Fire and Rescue Service of the Czech Republic, Emergency Response Plan 2013).

Despite the fact that the above-mentioned emergency response plans cover the area of CBRN quite comprehensively, we still see certain professional gaps in the area of CBRN protection. That is why it would be very useful and beneficial to create a National CBRN strategy in the Czech Republic and subsequently a National CBRN action plan to protect the population and professional rescuers from the mentioned threats.

Here we should chronologically list the measures from prevention, detection, identification, and monitoring of dangerous substances, through the evacuation and sheltering of the population, protection, rescue, medical care, safe and quick treatment of victims, hospitalization of affected persons and rescuers, to decontamination, restoration, and reconstruction of affected and contaminated areas.

The basic proposal of the CBRN strategy for the fight against CBRN terrorism and the protection of the population in the conditions of the Czech Republic was published in 2015 at the CSCM – World Congress on CBRN Science and Consequence Management in Croatia (Mašek 2015). A brief summary of the draft strategy is given below:

1. *Distribute a small, concentrated booklet on the main CBRN threats and CBRN defences [at several different levels: to the public and to all different members of the emergency services, emergency personnel, hospital staff].*
2. *Equip selected crowded public places [such as subways, airports, large supermarkets, sports stadiums, concert halls, large cinemas] with fast and reliable detection devices for chemical, biological, and radiation detection.*
3. *Train members of the local security forces of the so-called soft targets and local specialist personnel in handling CBRN events and the immediate steps necessary to survive such an event, to minimize possible losses with a focus on saving and protecting human lives.*
4. *Provide security personnel and local personnel of so-called soft targets with escape masks as part of their professional uniforms and standard equipment.*
5. *Train and exercise guards and other security personnel in the use of escape masks and their immediate distribution to vulnerable persons at the scene of a CBRN incident.*
6. *Prepare in advance simple and clear warning messages [for every emergency: chemical, biological, and radioactive] that instruct and guide the affected population to evacuate buildings as quickly as possible.*
7. *Train and exercise local medical teams (paramedics and hospital staff) to perform rapid clinical identification of the event and possible medications to be used for rapid and reliable treatment.*
8. *Prepare and test, especially for so-called soft targets, local escape systems and professional personnel for the rapid evacuation of the entire population to a safe area.*
9. *Improve preparedness for dealing with people inside and around contaminated areas.*
10. *Create a combined doctrine involving all participating organizations on site and with local first responders.*
11. *Establish command and control of rescue operations in a protected and clean environment until the transfer of responsibility to the basic and other components of the integrated system, including the decontamination of rescuers and victims outside the contaminated area.*
12. *Train and exercise, especially for so-called soft targets, all local guards, agencies and organizations and improve their knowledge, experience and preparedness for CBRN events.*

There is a clear need to pay great and permanent attention to the issues of defence and protection of the state and its population, and have the necessary documentation prepared for the management of activities in extraordinary conditions at all levels. It is also necessary to prepare not only experts in the components of the integrated rescue (emergency) system, armed forces, but also crisis managers in the national economy, in state and self-governing bodies, and public institutions.

The high-quality and sufficient professional documentation created must be constantly updated, supported by material and technical security, which will represent a long-term burden on the state budget due to the breadth of the problem. The system of education of the population of all age categories, the involvement of educational institutions, the information process to the necessary extent without subjective opinions, which ultimately lead to mistrust and rejection of the measures taken, must also play a role in the CBRN preparedness of the state and its population.

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Designing buildings for multi-hazard resilience; Kenya's experience in building code review

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Aim

This paper aims to present the experience Kenya has gone through in developing a new building code that integrates multi-hazard resilient designs.

Case description

Kenya gained her independence from Britain in 1963. The British government had gazetted a building code in 1948.

In 1968, the 1948 building code was adopted by independence government as the Kenya's building code. It was adopted as a by-law under the local government adoptive by-laws. The code continued in use but in 1996 a building collapsed in Nairobi. A commission was formed to look into why the building collapsed. The commission called "Mutiso commission" came up with a number of recommendations including the need to revise the building code which was considered outdated and failing to guide design of buildings appropriately.

I am a member of the committee appointed by the Permanent Secretary to review the building code and it has been an enriching experience as during the process, it became necessary to include wind maps, seismic maps and other types of hazard maps in the building code. This was aimed at ensuring that Engineers using the maps and modern design codes, which Kenya having adopted structural Eurocodes in 2012, will produce multi-hazard resilient buildings and infrastructure.

Conclusions

Buildings and infrastructure we design must be able to withstand multi-hazards. These include earthquakes, floods, fires, cyclones, landslides etc.

Kenya's experience has proven that inclusion of multi-hazard maps in the development of building code and road design manuals is important to designing multi-hazard resilient infrastructure.

Engineering in support of resilience and sustainability strategies: successful examples

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Needs of the modern world and the progress of sciences have led to the development of new technologies that are applied by engineers to solve several problems for society wellbeing. Among them, is the increasing number of natural disasters with high death tolls, and great loss and damage in housing, infrastructure, and economy, that menaces strategies of resilience and sustainability of communities.

A series of cases were analyzed where a natural hazardous event occurred in different geographic environments and with different-size populations at risk. The analysis also included how strong was the previous – prospective – management of risk. Most of the cases became as disasters. Here, we present two cases, among the few ones where the work previous to and simultaneous with the ongoing event successfully prevented the disaster.

During the last decade, China has developed modern IA-based landslide early warning systems. The one installed in Xingyi, Guizhou allowed the timely evacuation several days before a harmful event, saving more than 400 lives, in 2017. The second case deals with the effective response to Cyclone Gabrielle that hits New Zealand in February 2023.

In the preparedness process, early warning systems are a clue tool to save lives, despite material damage may occur. Those systems are effective only with a complete involvement of the concerned populations and fully trust their authorities.

Displaying examples of best engineering practices applied to the DRM, can effectively provide an important contribution to countries and communities developing strategies towards their resilience and sustainability.

Safety and security of radiation and nuclear facilities in Ukraine in view of the present military operations

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From the outset of a full-scale Russian invasion of Ukraine in February 2022, the safety and security of many radioactive sources, nuclear materials, and relevant wastes were directly or indirectly affected. In particular, military operations have seriously been threatening the safe function of Ukrainian nuclear power plants, raising the risk of a nuclear emergency whose effects would contaminate large areas far from the borders of Ukraine. Because of nearby military activities, Ukraine's Zaporizhzhya Nuclear Power Plant (ZNPP) has experienced sporadic losses of off-site power, which is critical to the safe operation of the plant. Shelling near ZNPP's spent fuel storage facility damaged the plant's external power supply system. Russia also conducted repeated strikes against a radiological storage facility near Kharkiv (Kharkiv Institute for Physics and Technology), Kyiv (Kyiv Institute for Nuclear Research), and other similar facilities. The IAEA team's recent reports further underscore the nuclear safety and security risks facing Ukraine and other European regions.

In addition to nuclear installations, one must pay adequate attention to the damages and losses of high-activity radioactive sources installed and used in many industrial, research and especially medical facilities, many of which have been severely affected or destroyed. This is particularly serious in areas not fully controlled by relevant nuclear regulatory authorities. If no action is taken, this may result in radioactive contamination of vast territories and changes of radioactive sources into orphan sources, which may present a grave danger to unaware persons. There is an urgent need to evaluate the situation of unattended radioactive materials and ensure adequate control of exposure levels. It would be required to carefully monitor and update the inventory of all significant radioactive sources and nuclear material, including those in damaged waste repositories.

In general, one has to distinguish between two main types of radiation sources. Radiation generators produce (ionising) radiation based on the interaction of accelerated charged particles with suitable targets; on the other side, the radioactive sources continuously emit radiation following the decay of unstable nuclides. While the first type of radiation source is fully controlled by the supply of electrical energy (and thus stops producing radiation once the power supply is switched off), radionuclides continuously emit radiation, the intensity of which is going down in accordance with the exponential law. This means that protection measures against unwanted exposure to radiation emitted by radionuclides must ensure the shield around such sources when it is not used.

Average worldwide radiation exposure from natural sources is around 2.4 mSv/y. Anything above this should be justified and minimised following relevant international standards and national regulations. The applications of radiation and nuclear technologies are beneficial in many areas and, under normal and controlled situations, do not present any excessive health harm. The situation is different in case of any accident or radiological emergency, including a radiological terrorist attack, where persons may receive very high doses.

In Ukraine, thousands of radioactive sources are used or stored in various buildings and other facilities. Due to ongoing military operations, some of these installations have recently been damaged or destroyed. It is assumed that uncontrolled releases of radioactive substances from such objects and laboratories may result in additional exposure to the local population and the spreading of radioactive contamination, which could affect even places at a considerable distance from the source of the contamination.

Besides the use of radioactive technologies, including their applications in medicine, industry, research, agriculture, chemistry and other fields, people may also be exposed to radionuclides released from nuclear power plants (NPPs), spent fuel storage facilities, research reactors, radioactive waste disposal facilities and

uranium processing plants. All these sources of radioactive materials discharged into the environment contribute to the exposure of the Ukrainian population. If everything is going according to the regulations, the exposure is so small that it can be accepted. In case of an accident or impact of military actions, the exposure may be over the recommended levels or limits introduced by the Regulatory Authorities, and adequate measures should be adopted to reduce it to acceptable doses.

In order to introduce any mitigation measures, the situation should be evaluated using appropriate radiation monitors in terms of the actual radiation risk. For obvious reasons, this is not possible in areas where there is ongoing fighting, and thus, the required data about actual radiation levels are not available. This is why any assistance to Ukraine should address these issues, including training radiation protection specialists, delivery of relevant instrumentations and adopting efficient arrangements to reduce radiation risk. In this context, it is especially important to assess real circumstances concerning the safety and security of Ukrainian NPPs, including the decommissioned nuclear block and the sarcophagus storing the nuclear block four destroyed during the worst world accident in this field in 1986 at Chornobyl. The same applies to a certain extent to research reactors and special neutron sources.

Radioactivity spreads mainly via the air if there is an uncontrolled release of radioactive material from the damaged radioactive source or its shielding and encapsulation. The spread depends also on the strength and the direction of the wind. A particular factor playing an important role is also the chemical and physical properties of the radioactive substance involved. The behaviour of a radioactive cloud, thus, is very much affected by the meteorological conditions in the area.

In the case of an accident at the Zaporizhzhia Nuclear Power Plant (ZNPP), radioactive contamination would mainly affect not only Ukraine but also neighbouring countries, including Romania, Slovakia, Poland and Baltic countries. Such an accident would threaten not only Kyiv but also the occupied territories of Donbas. The accident would threaten not only the western part of Ukraine but also the occupied territories of Donbas.

The results of modelling the atmospheric transfer and dispersion of radioactive Cs-137 aerosols were obtained using the Weather Research Forecasting (WRF). Other simulations considering different meteorological situations show that the radioactive fallout will predominantly affect Belarus and the northwestern part of Russia.

The armed conflict has continued to threaten nuclear safety and security in Ukraine. An increase in military activity in the country, as well as in the military actions and presence of the Russian army at the ZNPP, creates some concerns regarding the escalation of activities, which may further worsen the present situation. The involvement of the IAEA in monitoring radiation levels and contamination contributes to a better and more reliable assessment of radiation and nuclear risks. The problem which has not been satisfactorily solved so far is to get more information about radioactive materials released from damaged and destroyed facilities located in the military zone, which are not accessible for independent monitoring. The same can be attributed to spent radioactive sources and nuclear waste storage sites. It would be desirable to increase efforts to ensure safe access to the places where a higher level of radiation is expected but, up to now, not thoroughly analysed to assess a real danger arising from the potential exposure of the local population.

Following the Russian invasion and ongoing war against Ukraine, Ukrainian civil nuclear energy power infrastructure, including high-activity radioactive sources and nuclear waste repositories, poses risks that exceed internationally introduced limits and standards generally associated with various peaceful applications of nuclear and radiological materials. The country has to be prepared to minimise the consequences of the war, which will undoubtedly worsen the radiation protection of the population against the harmful effects of radioactive contamination. In order to cope with such a situation, Ukraine would need assistance from the international community.

The paper provides a multifaceted assessment of the current situation of radiation and nuclear safety in the country, including some proposals for actions to be taken as soon as possible to minimize exposure of the population to danger which is not under control. This will require some assistance in terms of instrumentation, training and inventory of all radioactive and nuclear material. One of the crucial aims should also address the misuse of orphan sources and other hazardous materials for constructing CBRN bombs. The presentation also addresses the reliability of the national power infrastructure necessary for nuclear facilities' safe and secure operation. Environmental issues will also be addressed, including monitoring and decontaminating affected areas. Close cooperation with the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU), as a competent national authority, will be necessary for all these tasks.

From the outset of a full-scale Russian invasion of Ukraine in February 2022, the safety and security of radioactive sources, nuclear materials, and wastes were directly or indirectly affected. Military operations have seriously been threatening the safe function of Ukrainian nuclear power plants, raising the risk of a nuclear emergency whose effects would contaminate large areas far from the borders of Ukraine. The IAEA team's recent reports underscore the importance of nuclear safety and security risks facing Ukraine and other European regions. In addition to nuclear installations, one must pay adequate attention to the damages and losses of high-activity radioactive sources installed and used in many industrial, research and especially medical facilities, many of which have been severely affected or destroyed.

Radiation and nuclear disaster prevention: Important role of risk quantification and its communication during and after an accident

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The paper summarises the main requirements for ensuring adequate radiation protection in applying radiation and nuclear technologies in many areas, especially in industry, medicine and research. The efforts should be concentrated predominantly on the protection of workers, patients, members of the public and appropriate measures should be taken in order to control radioactive contamination around facilities which are releasing radioactive effluents into the environment. This contamination, which may be very serious in cases of nuclear accidents, should be strictly regulated in accordance with national and international standards. Special attention should be paid to mitigating of large nuclear accidents such as Chornobyl and Fukushima [1], which resulted in the discharge of massive amounts of radioactive materials into the surrounding areas. In assessing the consequences of any use of radiation or production of energy in nuclear power plants, one has to adopt a rigorous approach and evaluate the situation based on the latest knowledge of radiation effects. It is important not to underestimate and, at the same time, not overestimate the negative impact of these technologies.

The risk assessment is based on the current quantities and the critical review of the current system of radiation quantities reflecting external and internal exposure of affected persons. The problems of quantifying exposure characterising stochastic and deterministic effects present some difficulties in the communication and interpretation of monitoring results. The importance of communicating radiation risk to the public is highlighted in order to stress its role during and after the accidents. Adequate communication can significantly suppress the uncertainty and panic of a poorly informed population, which may otherwise underestimate or overestimate the real danger of the accident. Risk communication is the real-time exchange of information, advice and opinions between experts or officials and people who face a threat to their survival, health or economic or social well-being. Psychological, sociological, political, and other impacts on public perception often occur mainly due to poor risk communication. The main goal of communication is to prevent ineffective, fear-driven, and potentially damaging public responses to radiation and nuclear crises. Normally, the impact of nuclear accidents is, on many occasions, presented in a vastly exaggerated way that overestimates the real consequences compared to other accidents (e.g., in Bhopal in India or road accidents).

On the other side, risk quantification plays a crucial role in assessing the consequences of radiation exposure under normal and emergency situations. It is based on appropriate physical and bio-physical quantities that reflect stochastic and deterministic effects induced in the human body. These quantities have been constantly developing to reflect the biological effects caused by radiation. A particular problem in this area could be attributed to the fact that there are in radiation protection too many quantities, most of which cannot be measured directly. This is causing some confusion even among radiation workers who may not always distinguish among such quantities as dose equivalent, equivalent dose, ambient dose equivalent, committed effective dose, RBE dose and committed RBE dose.

In general, radiation protection mechanisms have to adequately protect persons against both external and internal exposure. The total exposure can be presented as a sum of the contribution from radiation incident on the body's surface and radiation emitted by radionuclides, which enter the body through inhalation or ingestion and expose the tissues from inside. Some specific protective measures must be in place to control external radiation sources [2].

The radiation situation, including its impact on persons, is evaluated by appropriate quantities and other parameters characterising the activity of the source, the intensity of the radiation field, and finally, the exposure of the affected person taking into account radiobiological effects of various types of radiation.

The source is usually described by activity (number of radioactive decays per second) or emission (number of particles or photons emitted by the source in 1 second).

Since there is a big difference between the different biological effects of radiation, two diverse systems of radiation protection are in use: one for low-level exposures, where only stochastic effects are expected (they occur with the probability proportional to the dose, and the other for high doses causing in a short time some observable effects where their severity depends on the dose [3].

Risk communication is considered a *crucial* and curative *part* of any radiation and nuclear energy application*. It must also be applied to radioactive contamination and the emergency management cycle.* Risk communication can facilitate remediation and the return to normal life in the medium and long term. Mass media play a central role in spreading information to the public. The recent nuclear accident in Japan induced massive media coverage. It is essential to use simple language and avoid special scientific terms which may confuse members of the public. Risk communication aims to enable people at risk to make informed decisions to mitigate the effects of a threat (hazard) – such as a disease outbreak – and take protective and preventive measures.

Emphasis should be placed on the education and training of the general public in order to acquire some basic understanding of radiation protection. This is important for achieving better cooperation and coordination between the public and the first responders, as well as relevant authorities and stakeholders, during radiation or nuclear emergencies. The main goal is to minimise the consequences of such events in terms of personal exposure and the radioactive contamination of the environment.

The main objective of radiation protection and nuclear safety is the achievement of proper operating conditions and the prevention or mitigation of accident consequences, resulting in the protection of workers, patients, members of the public and the environment from undue radiation hazards and radioactive contamination.

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11. Climate Change Mitigation and Adaptation

Climate change mitigation – projected global paths

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Undeniable global warming has been observed and is projected to continue. Climate impact science identifies reasons for concern, because disadvantages of the warming outweigh advantages, globally. In this contribution, we discuss mitigation options that allow avoiding dangerous anthropogenic interference with the climate system. Many countries have reduced greenhouse gas (GHG) emissions but there has been rapid emissions growth in other states. In result, global anthropogenic GHG emissions have continued to rise, decreasing the likelihood of meeting the Paris Agreement targets. In order not to exceed 1.5°C (2°C) warming, it is necessary to reduce GHG emissions by half in 2030s (2040s), relative to 2019, and to reach net zero emissions in 2050s (2070s). In European Union, there is a "fit-for-55" plan, projecting 55% emissions reduction relative to 1990. Net zero GHG emissions imply the need of CO_2 removal offsetting residual emissions. Terrestrial ecosystems are presently an important carbon sink, absorbing almost 1/3 of anthropogenic CO_2 emissions. Pathways that lead to Paris targets require faster near-term transformations and higher upfront transition costs, but augur long-term economic gains and earlier benefits in avoided climate change impacts. The efficient climate policy depends on decisions in the technological, economic, environmental, socio-cultural and institutional realms that lead to emission reduction in such sectors and systems as energy (foremost), transport, buildings, industry, and land use. There is a hiatus between the science-based emission-reduction aspirations and the politics-driven outcome, so that while striving towards mitigation to 1.5°C/2°C, planning adaption to 3°C warming is necessary.

How city-states can lead the gas transition towards a fossil fuel free future

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Engineering is the foundation for the delivery of infrastructure and technology. The world is rapidly moving towards a fossil fuel free future, and this transition will require a skilled engineering workforce with the necessary skills to tackle the engineering challenges that come with it.

The ACT Government is leading the way with deep decarbonisation of its electricity supply and leading action to transition heating and transport away from conventional energy supplies like gas, petrol and diesel.

Canberra: the climate action capital

Canberra, Australia's capital, is delivering one of the most ambitious climate action agendas in the world. Canberra's achievements show that designing a carbon-neutral, thriving city is complex, but possible.

Climate change is one of the biggest challenges we face, yet we have an opportunity to build a smarter, healthier, net zero future.

A net zero Canberra will:

- improve air quality by reducing emissions
- create a cleaner, greener, more sustainable city
- reduce the use of fossil fuels, and
- increase local employment in the renewable energy sector and clean technology sectors.

Sustainable energy infrastructure, access to efficient technologies for buildings and homes, minimising waste and climate-resilient planning are moving Canberra closer to its target of net-zero emissions by 2045.

The ACT Government is working with willing partners across the community, and beyond our borders, to ensure Canberra is prepared for new challenges and able to grasp the opportunities that will come from the next phase of the journey to net zero.

The key commitments to achieve net-zero emissions by 2045 include:

- Phasing out fossil fuel gas and electrifying our city by 2045
- Expanding the number of zero emissions vehicles to 80-90% of new light vehicle sales by 2030
- Phasing out registration of new light internal combustion engine vehicles from 2035, and
- Reforming the ACT's building and planning system to ensure a transition to best practice climate-ready and environmentally sustainable buildings and planning.

Electrification Program

Fossil-fuel gas accounts for more than 20% of carbon emissions in Canberra. Canberra is the first jurisdiction in Australia to make firm commitments to phase out its fossil fuel gas connections.

The plan is to electrify the city by 2045, and to explore the potential for a renewable gas market where electrification is not a viable option for certain, niche commercial energy needs.

The ACT Government is approaching the transition responsibly and sustainably over the next 20 years. The goal is to enable ACT homes and businesses to save money by making smart climate choices transitioning appliances to electric options at a time that is right for them.

By the end of 2022, Canberra had a population of 457,000, projected to grow to 653,000 by 2045. Households make up about 127,827 of the 131,550 gas users in the ACT and a recent report projects a 60% decline in gas use from 2023.

This means we need innovative solutions for multi-unit dwellings, a substantial number of new electric appliances for home and businesses, and green gas solutions. Combined with new all-electric suburbs, this will drive strong demand for electric appliances, suited to our colder climate.

Reducing Government Emissions

Government operations account for approximately 7% of total fossil fuel gas emissions in the ACT. This means electrifying up to ten thousand public housing properties, upgrading public pools to be heated with electricity, finding zero emissions alternatives for waste collection services and electrifying the schools and health facilities that service our community.

Appliances that the ACT Government will need over the next two decades to achieve net zero include:

- HVAC systems for both residential and commercial settings
- Efficient electric hot water heat pumps
- Zero emissions vehicles for providing waste and emergency management services and public transport, and
- Efficient electric hot water heating for swimming pools and other specialised areas.

Building our energy storage solutions

Large- and small-scale energy storage will help Canberra store excess renewable energy and release it when it's needed.

The "Big Canberra Battery" will provide at least 250 megawatts of power to support grid reliability and security through the development of a diverse range of batteries that will vary in size, purpose and design.

The project is being delivered in three streams:

- Stream 1, large, grid-connected batteries, will deliver batteries over 10 megawatts.
- Stream 2, batteries at government sites, will install behind the meter batteries at government sites like schools and depots.
- Stream 3, neighbourhood-scale batteries, will develop smaller batteries (500 kilowatts – 5 megawatts) that are connected to the distribution network.

Together these three streams will enhance the large-scale battery sector within Canberra and support the ACT Government's electrification initiatives.

Nation-leading Zero Emissions Vehicle (ZEV) uptake

Canberra is home to Australia's most ambitious ZEV targets and most generous ZEV incentives.

The ACT Zero Emissions Vehicles Strategy focuses on how the uptake of ZEVs will be supported to cut transport emissions.

- As of April 2023, 1 in 5 new cars registered in the ACT are ZEVs.
- The ACT consistently holds the highest market share in Australia for ZEVs; in the first quarter of 2023, the ACT's ZEV sales accounted for 18.9% of market share.
- With generous ZEV adoption incentives, the ACT is supporting investment in and exploring the best options for public charging in our city.

- By 2030, the ACT Government's target is for 80-90% of new car sales in the ACT to be ZEVs, creating significant market opportunities.
- The number of ZEVs in the ACT is rapidly increasing with a total of 3,897 registered in the ACT in 2023 up from just 827 in 2020, thanks to incentives like free vehicle registration for ZEVs and zero interest loans up to $15,000 for households to buy a ZEV.

The engineering challenges of electrification

While the ACT has ambitious emissions reduction and living infrastructure targets to inform what the future will look like, there is uncertainty around how these targets will be achieved and the impacts this might have, depending on the pathway chosen.

The electrification of the transport system and move away from fossil fuel gas presents substantial technical challenges for the ACT, with major shifts in how and when energy is used.

The ACT Chief Engineer, Mr Adrian Piani, will explore the journey the ACT has undertaken so far transitioning from gas and provide insights into the future opportunities and challenges, including:

- transitioning complex buildings
- finding alternatives for specific gas requirements
- supporting households with lower incomes and renters
- the future of the gas network, and
- opportunities for the engineering workforce

Engineers need to be prepared for these new challenges and equipped with the skills required to meet them. The ACT's leadership in this area will not only benefit the community but serve as an example for other jurisdictions looking to make similar transitions away from fossil fuels.

As we tackle the challenges of climate change and look to innovative solutions, we aim to collaborate, share knowledge with, and learn from partners, cities, states and countries. By working together, we can deliver on our shared ambition for effective climate action.

Biophilic engineering – creating resilient, sustainable, and healthy controlled environments in an era of climate change

Bruce S Sanderson *(Bruce Sanderson Pty Ltd, Melbourne, Australia)*

Introduction

Biophilic engineering is the application of art and science to the optimum conversion of the resources of nature to the uses of humankind. The word "Biophilia" is derived from two ancient Greek words: “bio” meaning “life”, and “philia” meaning “love”. It is a human personality trait that is fundamental to harmonious relationships between humans and wherever life exists.

As an attribute of the engineering discipline, biophilia describes a way of applying the science of nature to solve technical problems and increase efficiency and productivity of systems, whilst being cognizant and caring of life. Humans are part of nature. Our secular fate is inexorably interconnected with the natural world and its vigour, vitality, and viability. Humans are characterized by high intelligence and cognitive skills – such as logic and reasoning, communication, emotional intelligence, collaboration, and qualitative analysis – so there is great ability and potential to create harmony and balance with the natural world. Biophilic engineering provides a pathway to attain this goal.

This thesis focuses on biophilia applied to controlled environments, those in which the physical properties – primarily hygrothermal, respiratory, visual, and sanitary – necessarily for the comfort and health of human occupants, are provided and maintained. Biophilic engineering in this context has significant ability to create resiliency, sustainability, and healthiness for the benefit of humans, particularly when faced with the impact of acute changes in climate. The topic is exceedingly relevant to the WEC 2023 theme: “Engineering for Life”.

Biophilic engineering in application to controlled environments

Controlled environments primarily employ artificial rather than natural processes, requiring the use of materials and energy – sources of fragility, depletion, and unsustainability. Conversely, those which employ biophilic engineering principles, conserve materials and energy, leading to resiliency, sustainability, and human well-being.

This thesis explores the application of biophilia engineering specifically as inspiration for the provision of artificially controlled environments. By applying living matter and natural functions, and vernacular designs – those which humans have developed over centuries of harmonious existence with their surroundings – the claim of creating resiliency, sustainability, and wellbeing from biophilic engineering is explained and demonstrated.

Examples of controlled environments embodying biophilic engineering principles to each of the prime physical properties necessary for human wellbeing are cited and described as evidence for this claim, including the hygrothermal performance of the ancient cave dwellings of Sassi di Matera in the Italian city of Matera (inhabited since 7000 BC), the physiological and cognitive performance of exposure to biophilic-engineered controlled environments, and a wastewater treatment system that mimics the processes of a natural ecosystem via a self-contained network of natural ecological systems that support toxic waste-consuming microorganisms.

Resiliency, Sustainability and Health

Resiliency is the ability of a system or process to recover from or adapt to changes. Biophilic engineering can support resiliency by incorporating nature-based systems, reduce stress levels among occupants of controlled environments by providing access to natural phenomena, such as light, air, and living materials.

Sustainability is a social goal for people to co-exist on the earth over a long time. Biophilic engineering has a significant role in promoting sustainability by granting ability to lessen the impact on the environment, curtail the consumption of natural resources, and foster ongoing equilibrium with nature, even amidst a period of unusual and substantial climate change.

Biophilic engineering can help reduce anxiety and stress levels among occupants of controlled environments and create feelings of wellbeing by providing access to natural light, natural ventilation, natural materials, living organisms and views of nature, evoking emotions of connection with the natural world, leading to a deeper sense of happiness and purpose.

Biophilic engineering and the UN Sustainable Development Goals

The United Nations Sustainable Development Goals, were adopted in 2015 as a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity. There are seventeen integrated goals which collectively acknowledge that development must balance social, economic, and environmental sustainability factors. Biophilic engineering will create improvements in human health and well-being, improve sustainability and resilience, safeguard the conversion energy and materials, aid the mitigation of climate change by aiding the preservation and restoration of interactions between the biotic (animals, plants, and other organisms) factors and the physical environment, which can aid the mitigation of climate change. These capabilities embody answers to the following Sustainable Development Goals: *SDG 3 – Good Health and Well-being; SDG 11 – Sustainable Cities and Communities; SDG 12 – Responsible Consumption and Production; SDG 13 – Climate Action; and SDG 15 – Life on Land*.

Conclusion

To preserve and enhance quality of life in an era of unusual and severe climate change, humankind must adopt measures that will overcome detrimental impacts and ensure controlled environments endure as places appropriate for habitation. Biophilic engineering offers a valuable means of attaining such a vitally important objective.

Water efficiency in large airports – case study

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The increase in population, the economic growth model and/or climate change explain the problems of water stress or even water scarcity that are progressively observed in many regions of the planet. In Europe, for example, drought situations are increasingly frequent and intense, especially in the south, due essentially to the climate change. To address this problem, in addition to raising consumer awareness, demand-side water management policies should be adopted as a priority.

In the urban sector, besides to considering "hybrid" systems (with drinking water from the main and rainwater harvesting and/or reuse of effluents in buildings, for example), water efficiency measures are needed at the level of buildings and urban infrastructure. In existing buildings, mainly in large buildings for collective use, water efficiency audits are an appropriate approach to find the proper interventions. For this reason, the managing entity of airports in Portugal (ANA) decided to carry out water efficiency audits in eight airports and this article describes the main interventions considered and the results achieved in the five main airports: Porto, Faro, Lisbon, Madeira Island and Azores (island of S. Miguel). These airports have a consumption of drinking water greater than half a million cubic meters per year.

In general, the main objective of a water efficiency audit in a large installation focuses on reducing consumption of drinking water, through the analysis of the potential application of possible intervention measures that constitute the so-called 5R principle of water efficiency in buildings:

1. a) Reduce consumption;
2. b) Reduce losses and waste;
3. c) Reuse water;
4. d) Recycle water;
5. e) Resort to alternative sources.

The first R – “Reduce consumption”, involves the adoption of efficient products or devices (or their appropriate regulation), without prejudice to other non-technical measures (raising awareness, for example). The second R – “Reducing losses and waste”, may involve interventions such as, for example, controlling leaks in the network and losses in devices or installing circuits for the circulation and return of sanitary hot water.

The difference between reuse and recycling of water (3rd and 4th R) has to do with the fact that, respectively, a “series” use or the reintroduction of water at the beginning of the circuit (after treatment) is considered. Finally, the resort of alternative sources may involve the use of rainwater, groundwater or even salt water, desalinated or not.

In the case of airports, the health requirements of a place of intense public use limit the application of some of these measures. The use of greywater in buildings, for example, which is already practiced at the level of residential buildings (allowing the use of effluents from baths and washbasins for flushing toilets, washing or watering), requires a more careful approach at the level of buildings for use public, with greater

demands for analytical control, health and safety plans, etc., which generally undermines its economic viability. Effluent recycling is also a technology that may be viable in some cases, such as the use of treated water in WWTP (Waste Water Treatment Plants) for irrigation of green areas, for example.

Regarding rainwater harvesting, there are already studies in Portugal that estimate the viability of these installations depending on the country's climate region and the intended use of rainwater. With regard to local desalination, which could be considered for airports close to the sea, as is the case in Madeira, the Azores or Faro, the current production costs per m^3 in small/medium installations are still significantly higher than the current cost of the supplied potable water by the public network in Portugal, which is why this hypothesis was not contemplated. There are other alternative sources (underground or surface) that were considered on a case-by-case basis.

Within the scope of water efficiency audits, there are measures that can be applied immediately and have a great impact, without the need for additional studies, as is the case with the intervention of installed devices. These interventions were considered as short-term interventions and the results presented focused essentially on their results. With regard to measures that require additional engineering or feasibility studies, the audit focused on identifying them and proposing their further development (medium/long-term interventions), when their feasibility was admitted in the light of available data.

To obtain the volumes consumed in the different uses at the airports, records from installed water flow meters in each sector were used. To determine the flow rates in faucets and showers, analogue and/or digital flow meters were used during the audits. In flushing cisterns, the volume was obtained according to the manufacturer's information and confirmed by sampling using a volumetric method. Closing times of timed devices were measured with a stopwatch.

The adequate flows in the different devices were defined considering the existing water efficiency labelling scheme in Portugal, under the responsibility of ANQIP (National Association for Quality in Building Installations), considering the values corresponding to the "A" category labels

The interventions considered were the following:

1. a) Regarding the washbasin taps and showers, the application of flow reducers was considered to obtain reference values of 4 L/min and 8 L/min, respectively. It should be noted that, in Portugal, flow reducers are also tested and certified by ANQIP, that makes available “flow rate-pressure” curves for the different reducers on the market, thus allowing the choice of the most convenient models depending on the local pressure and the desired flow rates. Upon verification of the impossibility of placing the reducer (due to device defect, incompatible model or other reasons), the replacement of the device was considered;
2. b) In the case of cisterns, the installation of dual flush mechanisms was considered, in cases where the installed cisterns had a complete flush. In the new and existing dual flush mechanisms, their regulation to 6/3 litres was also considered, when the measured values were higher;
3. c) In timed devices (taps, showers or flush valves) where an excessive closing time was detected (clearly longer than 10 seconds in washbasin taps, 30 seconds in showers or 8 seconds in urinals flush valves), the application of stroke reduction rings or equivalent solution was considered, whenever available by the manufacturer. Otherwise, replacement of the device with one from category “A” was considered;

Results confirms that there is an immediate potential to reduce consumption in sanitary installations, with low costs and short payback periods, through simple interventions on devices (such as the installation of reducers or proper regulation of closing times). The estimated annual economy of drinking water with these

short-term measures in the five airports is almost 60,000.00 m^3, representing 12.5 % of total drinking water consumption.

Other measures, designated medium/long term, as they require complementary engineering studies and additional feasibility studies, may significantly increase the global reduction of consumption or the replacement of drinking water with non-potable water. These measures usually correspond to the use of alternative origins or to water reuse, and may include the harvest of rainwater, water from bottles retained in security checkpoints or discharged by planes (not used on flights), water from underground aquifers, water lines or ditches, reuse of water used in firefighting exercises and tests, reuse of aircraft washing water, treated water in public WWTP for reuse, treated water in private WWTP for reuse, locally desalinated water, etc.

This study showed that these measures, despite the enormous potential for reducing or replacing consumption, lack analysis on a case by case basis, noting that, in the five studied airports, the proposed medium/long-term solutions diverged significantly. In any case, it can be observed that, in addition to the efficiency in the uses, the range of possibilities for reuse or resorting to alternative sources is very vast in infrastructures such as airports and their study should be stimulated, especially in the face of increasing situations of scarcity of freshwater or water stress.

Towards Sustainability

Ian F Thomas (I F Thomas & Associates, Williamstown, Australia)

This paper addresses excessive and inequitable consumption of the world's resources, human-caused climate change, world poverty and the extinction of other species – all of which result from the uncontrolled growth of our populations and economies. I address Existential Risk, Population, Poverty & Economic Growth and Sustainable Fuels.

Existential Risk

Also known as X-Risk, this is the likelihood of the premature extinction of our human species. It has two categories – external-caused and human-caused. I give examples of both.

A number of organisations are studying existential risk with the aim of making it known to governments and to the general public, and at finding means to avoid it. I give examples of these and also photographs of people who have contributed significantly to this work.

In conclusion I quote Nick Bostrom, Oxford University:-

'A very small reduction in existential risk will save countless future lives and is therefore more important than any other global public good'.

Population

Human population has been growing exponentially over nearly all of recorded time. The solution to the current food plight, overcrowding, competition for resources, the fuel dilemma, impacts on climate, impacts on biodiversity and species extinctions, is for our population to stabilise. Current world population occupying 244 countries is 8.06 billion people rising 2.3 people/second.

The rate of growth and the extent to which it is accelerating is indicated by the doubling time. Births today are 206,700/day rising at 4.2 per second and deaths are 93,600/day rising at 1.9 per second. I provide a graph showing doubling time in the period 1715 to 1999.

The issue is one of appropriate sharing of the world's resources and of whether a stabilisation should it occur, will be at or above a sustainable level. The level which is sustainable will vary in different parts of the world; arid countries for example may have large areas but little productive capacity. 923 million are 'food insecure'. China with 1300 million people will double its energy use by 2030.

I show the typical microbial growth and decline curve. Because microorganisms grow so rapidly compared with ourselves, we are able to see what happens especially in instances where the total environment is finite for example in a rain puddle or a petri-dish.

There have been many works completed on the subject of sustainable population, sustainable economies and the elimination of poverty and I summarise some of these contributions and their conclusions.

- The conclusions are far-reaching and raise many questions for further study especially the transition from growth to global equilibrium. Ideally, that transition should be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his or her individual human potential.

Poverty and Economic Growth

Poverty or rather the elimination of it in favour of equality for all peoples, is measured by the Gini Index. This is a nought to one scale where nought represents complete equality and one represents complete inequality. It is usually expressed as a percentage that is, from zero to 100%.

While it is as important to stabilise world economies as it is to stabilise world populations, ironically, the only way presently that poverty could be reduced, is by raising the average income of poor countries. Max Roser, a prominent worker in this field, says that what a person is or does is not something that will affect whether or not they are in poverty. Rather, what matters is whether they are born into a wealthy country or a poor one. It has been established that a datum for poverty is $30/day. Comparing a rich country Denmark, with a poor country Ethiopia, 14% of people in Denmark live on less that the poverty datum and 99% in people in Ethiopia.

I present graphs showing Gini indices by country, the mean daily income by country and also one showing global poverty – those living on less than $30/day.

It has been suggested that world economy would need to grow to five times its present level in order to substantially eliminate poverty. As we are already having large negative effects on the environment, climate and causing numerous other species to become extinct or threatened, this is clearly not going to be easy and perhaps not the solution. Rather the need is to reduce consumption per capita in 'rich' countries so that there is a more equitable distribution of resources to help those in poorer countries who are desperate for the basics.

The United Nations has 17 Sustainable Development Goals. My main concern regarding the UN goals is that as good as they are, they are words and can only work if governments, organisations and individuals act to cause them to happen. It can also be said that we are failing miserably in some areas such as with plastic waste and with generally inadequate waste recycling.

I suggest ways in which we as individuals can be less wasteful and assist the move towards a fairer and more sustainable world for all inhabitants.

Sustainable fuels

We engineers can and should actively develop ways of improving the availability of renewable fuels, of caring for other species of plants and animals and advancing technology in the common interest. I will now comment further on potential for safe and sustainable alternative fuels and power sources.

Vegetable oil fuel

Vegetable oil fuels are one of many sustainable energy sources which can be used when fossil fuels run out. Vegetable oils may be trans-esterified or hydrotreated to produce volatile, conventional hydrocarbon fuels. My work considers unprocessed vegetable oil used either in neat form or in blends with other fuels such as conventional diesel fuel. This avoids the higher cost and risk of processing while gaining a big safety advantage in transport, storage and use because of the higher flashpoints of vegetable oils.

The compression ignition engine (oil engine) was invented by Herbert Akroyd Stuart and patented in 1886. The oil engine was very successful and 32,417 were manufactured. This was before Rudolf Diesel developed and patented his improved, higher pressure design. An engine designed specifically for running on vegetable oil was developed by Ludwig Elsbett in 1977.

I conducted a 45,000km on-road trial using a 50/50 blend of waste vegetable oil and diesel fuel in an unmodified 1996 Mitsubishi Triton utility vehicle. I showed that this fuel was not only viable but overall, performed marginally better than diesel fuel alone.

Regretfully we are collectively moving towards ever more dangerous fuels. Hydrogen is inherently the most dangerous of all.

I have generated a list of 264 non-food vegetable oil species and their properties and established that there are close to 2000 halophyte species available. I give examples of salt-tolerant and arid area growing oil-producing plant species together with some photographs.

Nuclear power

Nearly all commercially produced nuclear energy is produced by the nuclear fission method. I discuss the current use of breeder reactors using Uranium-235 nuclear fuel and estimate the number of years this fuel will last. This method also produces radioactive waste and generates Plutonium-239 which can be used to make nuclear weapons. Radioactive waste can take millions of years to degrade and currently there are no options available for disposal of existing and future radioactive wastes, only long term storage. I look at some of these storage proposals. Such facilities could cause problems for civilisations far into the future.

I consider in some detail research which is being undertaken to produce safer nuclear power such as Nuclear Fusion and the Thorium Cycle and the expected timeline for when these safer forms may be available.

Hydroelectric Power

Hydroelectricity is produced in four ways, impoundment. run-of-river, pumped hydro and pumped storage. Pumped hydro involves a turbine to pump water from a low to a high reservoir and in reverse to generate power. The water reservoir is thus a form of battery and currently represents 94% of global energy storage capacity. I show examples.

Tidal/Wave Power

Scotland and Canada have the highest tidal flows in the world and consequently are 'ripe' for exploitation to produce electricity. In Scotland at the widening funnel in which the North Sea flow meets those of the Norwegian Sea, the region is thought to have 25% of Europe's tidal power resources and 10% of its wave power potential.

Small turbines acting in the same way in water as wind turbines in air are attached to floating structures, anchored to the seabed using chains or fixed to the seabed. It is mooted that the UK can produce 11% of its energy requirement in this way. These were first proposed to operate in estuaries but are now being developed for the open sea. I show pictures of examples in Scotland.

Concentrated Solar Power

Concentrated solar power uses mirrors or lenses to collect the sun's heat and direct it to a tower to heat a working fluid. This then generates electricity for example via a heat engine, usually a steam turbine, connected to a power generator.

I show a photograph of the largest proposed Noor (Nur) Complex in Morocco located in the Sahara Desert town of Ouarzazate which is some 200km south-east of Marrakesh. It will have a capacity of 580 MW.

Wind Power

Wind farms can be on-shore and off-shore, vertically rotating and horizontally rotating, geared to the generator or directly driving it. Marine wind turbines are able to capture larger wind-speeds than those on land. They are commonly known as offshore turbines anchored to the seabed. This can only be done to a certain depth but stabilised floating platforms with chains anchoring them in position, can go into far deeper water and therefore areas of even higher winds.

Wind turbines comprise a series of usually three variable pitch blades, a nacelle containing the gear box and generator or a directly connected generator, tower and foundations. I show examples.

Photovoltaic Power Systems

A photovoltaic (PV) cell, commonly called a solar cell, is a non-mechanical device that converts sunlight directly into electricity. Some PV cells can convert artificial light into electricity. Listed world PV farms show a total of 64 sites above 300 MW capacity. The highest capacity in this list is the Gonbe Talatan Solar Park in China at 15,730 MW DC. 8 of the other 63 sites produce AC power and all of the rest, DC power.

Electricity

Electricity is used in cars both as hybrids and as dedicated battery electric vehicles (BEVs or simply EVs). There are many problems with electric vehicles including limited range and insufficient recharging stations. Current lithium-ion batteries are prone to spontaneously catching fire, the fire is extremely difficult to put out and cases are known where small vapour cloud explosions have occurred. Last year, NSW (Australia) had 300 Lithium ion battery fires. I show a diagram of an electric vehicle and a photograph of a new electric utility vehicle.

Hydrogen

Hydrogen fuel cell vehicles (FCEVs) are now becoming almost common but have the same sorts of disadvantage as EVs plus some significant dangerous issues – they use hydrogen with a flashpoint (boiling point) of minus 253^{o}C compared with petrol minus 43^{o}C, diesel fuel 62^{o}C and vegetable oils typically 200+^{o}C.

I show diagrams of a fuel cell and a hydrogen fuel tank and photographs of buses fuelled by hydrogen.

Ethanol

Recently, India announced that it had successfully developed a prototype hybrid vehicle capable of running on 100% ethanol. It is based on the Toyota Innova HyCross hybrid which can cover 40% of distance travelled using ethanol and the remaining 60% using electricity.

Methanol

The Danish shipping company Maersk has commenced the maiden voyage of its first vessel of an intended fleet of 25 ‘green methanol’ powered cargo ships also capable of running on fossil fuels.

The full paper containing numerous photographs and diagrams is available from the author (ifta@ifta.com.au).

Resilience design in buildings and civil engineering works to adapt to climate change

Jing He (CAST, China Institute of Building Standard Design & Research, Beijing, China)

Global climate change is currently impacting and will continue to affect our lives. The increasing frequency and intensity of extreme weather events caused by climate change, such as floods, heatwaves, and hurricanes, along with chronic changes like rising sea levels and thawing permafrost, pose significant challenges for buildings and civil engineering works with lifespans spanning several decades or even centuries. The design of these assets may have been based on historical meteorological data from the past few decades. However, today, the underlying assumptions for design are no longer static. To adapt to a changing future, built assets need to be designed with sufficient resilience.

Enhancing resilience to climate change needs to be prioritized in the design of buildings and civil engineering works. New challenges also present opportunities for innovation. Engineers and meteorologists are collaborating closely to incorporate the findings of climate change projections from the scientific community into engineering practice. This report will present the potential impacts of climate change on buildings and civil engineering, as well as advancements in resilient design methods, innovative adaptation strategies, and design standards for buildings and civil engineering works to adapt to climate change.

The principal role of water and vegetation in the distribution of solar energy and in creation local and global climate

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Measured values of both incoming and reflected shortwave solar radiation and longwave radiation/heat fluxes between land surface and atmosphere show high variability depending on the amount of air humidity and cloud cover for a given season of the year.

Land cover changes like deforestation, drainage, urbanization result in a decrease of rate of water vaporization (evapotranspiration). The shift from water vaporization (latent heat flux) to sensible heat flux, ie from vaporization cooling to release of sensible heat (surface warming) represents several hundred Wm^{-2} on a sunny day. Warm air ascends fast from overheated surfaces, sucks water vapor from surroundings and transport it high in the atmosphere. Dew point, condensation of water vapor and formation of clouds occur too high, water does not come back in form of small rain, short water cycle is broken. Overheated landscape blocks income of wet air from ocean.

Vegetation supplied with water cools itself by evaporation water. Uptake of each molecule of CO2 during photosynthesis is linked with release (evaporation) of several hundred water molecules. Several Wm^{-2} is stored to plant biomass by photosynthesis, several hundred Wm^{-2} is transformed to water vapor. Air above forest has high relative humidity and its surface temperature is low, wet air ascends slowly and dew point is reached in c. 1 km height. Water vapor condensates, air pressure drops, small rain occurs, water returns to land, horizontal movement of wet air from see is facilitated (biotic pump).

The paper is supported by measured data, easily reproducible and published scientific papers including references to including teaching texts aimed at correcting “plant blindness”.

Effects of Environmental Taxes on Environmental Deterioration and Energy Consumption among the Vise grad Countries

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Today, protecting the environment is a top issue for global policy. In essence, the literature has identified several macroeconomic problems as factors in environmental deterioration. The purpose of the investigation was to explore environmental deterioration (EVD) and energy consumption by Vise grad regions. Environmental taxes (ENTX) and carbon taxes have been proving to be a significant factor in lessening the dependence on non-renewable energy. The analysis was carried out for the period 1994-2021, employing the fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS). The empirical findings indicate that energy consumption (ENC) had a positive whiles ENTX had a negative nexus with EVD for the Vise grad nations. Similarly, the moderating role of ENTX*ENC – EVD exhibited an inverse affiliation. In the long run, the dependence on non-renewable energy appreciates EVD. However, effective policy implementation of ENTX will lead to quality of the environment. The empirical results have shown that ENTX can be employed to control the demand and utilization of coal, gas, and nuclear in the Vise grad regions. Human capital (HUC), urbanization (URB), and trade openness (TRO) produce a negative relation with EVD. By offering fresh perspectives from Vise grad economies, the current study contributes to the body of literature on the issues causing environmental plummet. This research also offers policymakers and government organizations in these areas a reference point for their investments in more eco-friendly technology, human capital, urbanization, trade openness, and appropriate environmental levies to demonstrate the quality of the environment.

12. From the Earth to the Universe

Impact Analysis of Earth Observation Applications on the Sustainable Development Goals within the Living Resources Sector

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Earth Observation (EO) consist in the gathering of data and images that are used to monitor changes in Earth's natural and built environments, with applications in radically diverse areas. Several market sectors are starting to exploit the products of the Space Sector to retrieve continuous and accurate data. The large production of EO data, other than directly assist business activities, has a relevant role in the monitoring of their related development. Starting from 2015, EO data are considered as a valid option to provide support to monitor the SDGs on a continuous basis, the main guidelines for the world sustainable development. The aim of this work is to provide a framework and a methodology that allows the association of satellites activities related to the sector of living resources to the indicators of the Sustainable Development Goals, building a correlation method that enables to analyze the impact and potential of EO in the described context.

Satellite Database

The analysis makes use of a database of current space missions, either with optical or radar instruments. The optical database presents in total 480 satellites, among which there are 93 single satellites and 31 constellations; the radar database presents in total 96 satellites, among which there are 25 single satellites and 12 constellations. Information for EO satellites which can be summarized into different categories:

- Mission Specifics: data regarding the satellite name, producer, operator, mission history and other logistic details;

- Orbital Elements: parameters required to uniquely identify the satellite orbit. In this work the following have been included: orbit altitude, which affects spatial resolution and coverage and in order to have a more specific evolution of the altitude throughout the orbit, it is expressed in terms of apogee and perigee; inclination, which determines the ground coverage satellites will orbit on; orbit period, which also determines the quality of images and together with the other elements is an input required to perform estimation algorithms;

- Sensor Specifics: details about the payload on-board, regarding the spectral, spatial, and temporal resolution; in this work, the sensors are simplified to a restricted number of spectral typologies, including passive (or optical) sensors (Multispectral, Hyperspectral, Panchromatic, Thermal Infrared and Passive Microwave) and active sensors (Synthetic Aperture Radar).

To retrieve an approximate and standard value of the optical satellite revisit time, a swath width estimation algorithm and successively a revisit time (RT) estimation algorithm were defined. The swath width estimation methodology was adapted from the work of Scalera (Marcello Scalera. Social value rating of earth remote sensing missions through the United Nations sustainable development goals 2030. Master's thesis, Politecnico di Milano, 2019), while the modelling of the Revisit Time is defined according to a technique proposed by Luo et al. (Guangming Dai Xin Luo, Maocai Wang. A novel technique to compute the revisit time of satellites and its application in remote sensing satellite optimization design. International Journal of Aerospace Engineering, 2017).

Living Resources Catalogue

Users in managed living resources refer to human activities exploiting natural organic resources. According to the European Association of Remote Sensing Companies (EARSC) taxonomy, this includes agriculture, fishing, and forestry sectors. In order to have an approximate idea of how the current orbiting EO satellites could be employed to sustain the several applications included in this market sector, a functional and structured system was required, thus leading towards the concept of a catalogue. The structural elements of the catalogue were defined as follows:

- Categories are intended as a thematic container, to provide a proper market context for each analyzed application; they are a re-interpretation of the market segments defined by EARSC, and include Agricultural Management, Forestry, Water Resources Management and Natural Disasters Monitoring and Early Warning;

- Applications represent the services or activities target of Earth Observation downstream segment, and that stimulate the production of datasets that successively are employed to populate the Sustainable Development Goals indicators, thus they are the core of the overall framework;

- Essential Variables are the basic parameters that get directly measured by the satellite sensors and allow a simple correlation between the catalogue applications and the database. For Each application, one or more essential variables will be assigned as necessary to measure to accomplish them, together with spatial and temporal requirements for Local Coverage and Regional Coverage. The Essential Variables identified as necessary to describe the living resources applications are: Vegetation Indices, Land Surface Temperature, Biomass, Soil Organic Carbon, Evapotranspiration, Soil Moisture, Sea Surface Temperature, Water Salinity, Chlorophyll-a, Water Turbidity, Water Surface Detection, Precipitation, Atmospheric Temperature.

Categories and Applications

For the living resources catalogue the following categories were defined:

- Agricultural Management, including 8 applications such as Crop Condition Monitoring or Yield Estimation;
- Forestry Management, to which were assigned 3 applications directly related to forestry (Resources Management, Deforestation and Forest types maps) and Land Cover Monitoring;
- Water Resources Management, containing applications related to oceans and inland water bodies;
- Natural Disaster Monitoring that includes the control of events such as droughts, floods, wildfires and oil spill in oceans.

Impact Analysis Framework

A research presented by the Centre for Environment and Sustainability was selected as a reference to develop an efficient methodology for the application analysis. In a previous work, an initial version of a 'Maturity Matrix Framework' (MMF) (Murphy Andries, Morse. Translation of earth observation data into sustainable development indicators: An analytical framework. Sustainability, 6, 2018.) was designed to evaluate the usefulness of EO to help populate the SDG indicators giving scores to the indicators according to their relationship with EO technology. In a successive research article (Murphy Andries, Morse. Seeing sustainability from space: Using earth observation data to populate the unsustainable development goal indicators. Sustainability, 6, 2019.) the framework evolved to a MMF 2.0 via semi-structured, expert interviews that influenced the components and the scoring system applied. The purpose was therefore to build an analytical matrix framework based on the same criteria defined in the MMF 2.0 but adapted to the context of Earth Observation applications within the Living Resources Sector. Each application associated to a specific indicator was evaluated adopting a set of parameters, defined as premises, with a score from 1 to 5.

The selected premises are: Data Processing Method, Directness, Completeness, Requirement for Non-EO Information, Practicability, Cost Effectiveness.

The procedure adopted to assess the impact of the various EO Applications to the suitable SDG indicators is as follows: starting from the metadata of the indicators, the applications were selected accordingly and successively evaluated through the premises, retrieving a score for each application (Application Impact Score, AIS) and through a weighted average the Indicator Impact Score (IIS) is retrieved, where the weights coincide with the Completeness premise.

Final Evaluation Dashboard

The collection of the Indicator Impact Scores is presented in the final dashboard in the following list, for all the SDGs analyzed. The impact of the Living Resources applications on the indicators according with its relevance emphasize is highlighted.

Goal 2: no hunger

- Target 2.3.1 (Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size), score 2.5
- Target 2.4.1 (Proportion of agricultural area under productive and sustainable agriculture), score 2.2
- Target 2.a.1 (The agriculture orientation index for government expenditures), score 1.8
- Target 2.b.1 (Agricultural export subsidies), score 1.7
- Target 2.c.1 (Indicator of food price anomalies), score 2.8

Goal 3: good health

- Target 3.9.2 (Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)), score 2.5

Goal 6: clean water and sanitation

- Target 6.1.1 (Proportion of population using safely managed drinking water services), score 1.5
- Target 6.3.1 (Proportion of domestic and industrial wastewater flows safely treated), score 2.3
- Target 6.3.2 (Proportion of bodies of water with good ambient water quality), score 2.3
- Target 6.4.1 (Change in water-use efficiency over time), score 3.8
- Target 6.4.2 (Level of water stress: freshwater withdrawal as a proportion of available freshwater resources), score 3.8
- Target 6.6.1 (Change in the extent of water-related ecosystems over time), score 4.3

Goal 9: innovation and infrastructure

- Target 9.1.1 (Proportion of the rural population who live within 2 km of an all-season road), score 4

Goal 11: sustainable cities and communities

- Target 11.3.1 (Ratio of land consumption rate to population growth rate), score 4.7
- Target 11.5.2 (Direct economic loss attributed to disasters in relation to global domestic product (GDP)), score 2.5

Goal 14: life below water

- Target 14.1.1 ((a) Index of coastal eutrophication; and (b) plastic debris density), score 3.3

- Target 14.2.1 (Number of countries using ecosystem-based approaches to managing marine areas), score 2
- Target 14.3.1 (Average marine acidity (pH) measured at agreed suite of representative sampling stations), score 1.8
- Target 14.4.1 (Proportion of fish stocks within biologically sustainable levels), score 2

Goal 15: life on land

- Target 15.1.1 (Forest area as a proportion of total land area), score 4.3
- Target 15.1.2 (Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type), score 3.7
- Target 15.2.1 (Progress towards sustainable forest management), score 4.7
- Target 15.3.1 (Proportion of land that is degraded over total land area), score 4.8
- Target 15.4.1 (Coverage by protected areas of important sites for mountain biodiversity), score 3.8
- Target 15.4.2 (Mountain Green Cover Index), score 4.8
- Target 15.5.1 (Red List Index), score 2.2

The pattern of the scores is coherent with other analysis, where the Goal 15 is the one strictly related to the observation of natural resources, therefore showing a stronger relationship with the Living Resources Sector.

Conclusions

From the brief numerical analysis performed on the Living Resources Catalogue applications, a general better performance of satellite constellations can be observed, but more details and specifications are required to obtain more refined statistical analysis. An interesting result from this work is that a very high percentage of satellites constellations can perform the applications of the catalogue, and therefore successively populate the indicators of the SDGs.

The Role of Engineering and Engineers in Contemporary Society

Maria Prieto-Laffargue *(Past President, World Federation of Engineering Organisations, Madrid, Spain)*

The Paper starts with a short overview of how technological innovations have shaped civilizations throughout the history of Humanity, enabling human welfare and development. The World Today: Where are We? What Characterizes our Contemporary Society? What are the World's essential parameters in 2023? Its challenges and its risks? Is it possible to generate inclusive and sustainable benefits for all the Planet inhabitants? Without any doubt, the author will argue. Technology is here, once again, to achieve exactly that. But something has changed in the Society of the XXI Century. Right now, the pure nature of available disruptive technologies makes technological intelligence the most powerful geostrategic instrument.

"Technology is Power". And engineers are pivotal actors in the changing World order, as the main agents devising, defining, and handling technology uses and implementation. Humanity's Social and Economic Progress on Earth has always been contingent upon the diffusion and application of scientific knowledge. The social an economic dimensions have been inherent to engineering, but in our Contemporary Society a new dimension appears: geostrategy.

What means Engineering, today? Who are the Engineers of today? What are their duties and responsibilities? What do Engineers do? The author makes a foray into the pure nature of the emerging disruptive technologies and the deep changes that they bring, both to the engineering practice and the engineer´s role in Society. In the Contemporary Society of the 21st century, the profound interrelation between Geopolitics, Engineering, and Geostrategy set the engineers at the very core of Decision-Making Centers.

13. Young Engineers Forum

Establishing Young Engineers Forums for Enhanced Collaboration and Opportunities

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The field of engineering stands at the precipice of an era characterized by unprecedented technological advancements, ever-evolving challenges, and a relentless demand for innovation. In this rapidly changing landscape, nurturing the talent and potential of young engineers has become not just a goal but a necessity to ensure the enduring success and vibrancy of the engineering profession. This extended abstract presents a comprehensive case for the establishment of Young Engineers Forums (YEFs) within each national engineering organization, emphasizing the manifold benefits and transformative potential they offer.

The Need for Young Engineers Forums:

Engineering, as a discipline, has always thrived on the principles of innovation, problem-solving, and collaboration. In an age where interdisciplinary solutions are increasingly essential, and global challenges such as climate change, urbanization, and sustainable development require multifaceted expertise, YEFs emerge as a critical bridge between established professionals and emerging talents. They serve as incubators of ideas, hubs of knowledge, and engines of progress. Here are some of the pivotal benefits that YEFs bring to the fore:

Networking and Collaboration: YEFs will serve as dynamic platforms where young engineers can transcend geographical boundaries to connect, collaborate, and exchange ideas. The power of networking cannot be overstated, and these forums will empower young engineers to build relationships with like-minded professionals, fostering a culture of cross-pollination of ideas and experiences. This interconnectedness will be instrumental in addressing complex, real-world engineering challenges that often require expertise from multiple domains.

Professional Development: Continuous learning and skill enhancement are prerequisites for success in the engineering field. YEFs will take on the role of catalysts for professional development. Through a spectrum of activities including workshops, seminars, webinars, and conferences, young engineers will have access to cutting-edge knowledge and emerging trends. Furthermore, YEFs can collaborate with educational institutions to create mentorship programs, enabling experienced engineers to impart their wisdom to the next generation.

Mentorship Opportunities: The guidance and mentorship of seasoned engineers are invaluable for the growth and development of young professionals. YEFs will facilitate mentor-mentee relationships that transcend traditional boundaries. These mentorships will not only provide career guidance but also inculcate a strong sense of ethics, responsibility, and leadership within young engineers.

Job Opportunities: Transitioning from academia to the professional world can be a daunting task. YEFs can step in as intermediaries, creating a bridge between young engineers and potential employers. They can organize job fairs, connect young engineers with internship opportunities, and facilitate industry visits, making the transition smoother and more informed.

Advocacy and Representation: YEFs will assume the role of advocates for the rights and concerns of young engineers within national engineering organizations. Their presence ensures that the unique perspectives, aspirations, and challenges of young professionals are not only heard but also acted upon. This advocacy will foster an environment of inclusivity and progress.

Research and Innovation: As engines of innovation, YEFs can encourage research and development activities among young engineers. They can provide funding, resources, and a supportive community for innovative projects. This can drive technological advancements and contribute to the engineering profession's evolution.

Community Engagement: Beyond professional development, YEFs can engage with local communities and educational institutions to promote STEM education and inspire the next generation of engineers. This outreach can help address the STEM skills gap and contribute to the development of a well-rounded engineering ecosystem.

In sum, the establishment of Young Engineers Forums at the national level represents an investment in the future of engineering. These forums not only empower young engineers to excel in their careers but also contribute significantly to the advancement of the engineering profession as a whole. By fostering collaboration, promoting professional development, nurturing mentorship, facilitating job opportunities, championing advocacy, and driving innovation, YEFs embody the very essence of progress and promise within the engineering community.

14. Women in Science and Engineering

Integrating 50+ Associations to Support Women in Engineering in Taiwan

Wen-Jean Hsueh *(Women in Engineering Committee, Chinese Institute of Engineers, Taipei, Taiwan)*

To jump-start women leadership in engineering and technology, Chinese Institute of Engineers' one small step in 2012 to put one female director on board for the first time in its 101-year history has embarked a journey of cross-disciplinary collaboration and female empowerment for a more diverse and vibrant workforce for the engineering community. Through intense statistical survey, qualitative research, communications, and delegations in the industry, academia, and government, activities involving forming social groups within disciplines and companies, sharing experiences across disciplines and industries, mentoring, focal themes discussions, policy propositions and modifications have been conducted all around. An annual national conference for women in science & technology has been thus established due to collaboration of more than 50 STEM associations. In addition to the results of the appearance of more women being seen, the subtle know-how of motivating mostly male leaders to make changes in their domains and the communications and methodologies to raise attentions and ensure actions are consequences of numerous trials and errors which are immensely worthy of the efforts. This presentation is to share insights and raise issues for discussions amongst the engineering community.

The importance of black female representation in rural KwaZulu-Natal in the science and engineering field

S'thandazile S Ncube *(ECSA, Pretoria, South Africa)*

In KwaZulu-Natal South Africa, where majority of females are housewives and don't always finish high-school because indigenous Zulu men do not believe that a female is supposed to finish high-school yet alone be working, it is important to have a black female engineer to represent that we can achieve great success in a male dominant environment.

With KwaZulu-Natal having the highest number of child pregnancies, where majority of the residents are people of colour, it is not common that girl children even consider finishing school because they are already mothers before they finish their schooling and usually focus on raising their children instead of finishing their schooling. Having a black female civil engineering technologist to look up to that has completed school and has gone through varsity and is working in a predominantly male environment is motivation for them to focus on their studies and not be held back by the preconceived idea that woman are only good for reproduction purposes.

South African government has tried its best to encourage girls to study in science and engineering but do not always make the effort to go to rural communities and getting the technologies to these areas has also been a challenge in South Africa so playing my part in reaching these small communities is of great benefit to the future generation of females in science and engineering.

Empowering the Next Generation: Nurturing Young Women's Potential in Science and Engineering for Future Leadership Roles

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Abstract: In a rapidly evolving world heavily influenced by science and technology, the underrepresentation of women in leadership roles within the fields of science and engineering remains a persistent concern. This paper aims to address this issue by exploring the critical factors that contribute to nurturing the potential of young women in these domains, enabling them to assume leadership roles in the future. The study emphasizes the pivotal roles of mentorship, skill development, and role models in empowering young women.

Employing a mixed-methods approach, including surveys and extensive review of existing literature, this paper delves into the significance of mentorship as a key mechanism for fostering personal and professional growth. The findings highlight the effectiveness of mentorship programs in providing guidance, support, and opportunities for skill enhancement, thereby helping young women navigate challenges and build self-confidence. The research illuminates the role of skill development in imparting technical expertise and soft skills, enabling young women to compete on equal footing with their male counterparts.

Furthermore, the significance of prominent female leaders inspires young women to envision themselves in top-tier leadership positions. The presence of relatable role models combats stereotypes, providing tangible proof of women's achievements and dismantling gender-based misconceptions.

By cultivating effective mentorship relationships, offering skill development opportunities, and highlighting the achievements of female role models, society can create an environment that harnesses the potential of all aspiring leaders, regardless of gender. Such initiatives are vital for achieving gender parity and fostering innovation in science and engineering on a global scale.

Keywords: Future Leaders, Mentorship, Leadership, Confidence, Women Engineers, Role Models

Introduction

In today's rapidly advancing world, the fields of science and engineering play a pivotal role in shaping our future. Despite the progress made in recent years towards gender equality, women remain significantly underrepresented in leadership roles within these fields. This paper seeks to address this issue by examining the key strategies that can empower young women to realize their potential as future leaders in science and engineering. The study focuses on the importance of mentorship, skill development, and the presence of relatable role models in nurturing the growth of young women in these domains.

In societies where progress increasingly hinges on advancements in science and technology, it is imperative to not only acknowledge the gender disparity but also actively engage in initiatives that empower and elevate young women in these fields. The journey towards greater gender parity in science and engineering leadership begins with a deep understanding of the challenges at hand, which this paper endeavors to unravel and address. This paper delves into the underrepresentation of women in leadership roles in the engineering field, drawing from factual statistics both internationally and within the context of Kenya.

Objectives of the Research:

- *To Understand the Factors Contributing to Underrepresentation*: This research will discuss the factors such as work place discrimination, self-doubt, and lack of mentorship opportunities that contribute to the underrepresentation of women in science and engineering leadership. By identifying these factors, we can better develop strategies to counteract them.

- *To Examine the Role of Mentorship*: The study will investigate the importance of mentorship in nurturing the potential of young women. It aims to understand how mentorship programs can provide guidance, support, and opportunities for skill enhancement, thus helping young women overcome obstacles and build confidence.
- *To Explore the Significance of Skill Development*: Skill development is crucial for young women to compete on equal footing with their male counterparts. This research will analyze how skill development programs can impart technical expertise and soft skills, equipping women with the tools they need to excel in science and engineering.
- *To Highlight the Impact of Role Models*: The presence of relatable female role models is essential in combating stereotypes and inspiring young women. This research will examine how prominent female leaders can serve as tangible proof of women's achievements and help dismantle gender-based misconceptions.
- *To Advocate for Change*: Ultimately, this research aims to advocate for initiatives that foster an inclusive environment in science and engineering.

Research Methodology

To ensure the comprehensiveness and relevance of the research, a multi-faceted approach to data collection was adopted, integrating insights from the latest literature in addition to surveys for women engineers in Kenya. This mixed-methods approach aimed to provide a holistic view of the factors influencing the empowerment of young women in science and engineering.

An extensive review of the latest academic literature, reports, and case studies was conducted. The literature review allowed the incorporate the most current and relevant findings regarding the underrepresentation of women in leadership roles in engineering and the strategies employed to empower young women in the field.

In parallel, surveys were administered to female engineering professionals in Kenya. Participants were recruited through professional networks, engineering organizations, and mentorship programs. The sample included women engineers from different sectors of engineering and varying career stages to ensure a diverse representation of experiences.

The surveys aimed to gather information on participants' experiences with mentorship, skill development, and the influence of role models in their careers. Questions were designed to capture quantitative data on these factors while also allowing participants to provide qualitative insights through open-ended questions.

Underrepresentation of Women in Engineering Leadership Roles

Globally, women account for just 30% of researchers in science and engineering, as reported by the UNESCO Institute for Statistics (2023). When focus was put on engineering leadership positions, the gender gap becomes even more pronounced. In many countries, the percentage of women holding high-ranking engineering roles is less than 20%. This gender disparity persists despite increasing efforts to promote diversity and inclusion in STEM fields. For instance, in Kenya about 8% of women are registered as professional engineers according to recent data from the Engineers Board of Kenya. These statistics underscore the urgent need for initiatives that address the gender gap in science and engineering leadership.

Factors Contributing to Underrepresentation

Several factors contribute to the underrepresentation of women in science and engineering leadership roles. These include:

Gender Stereotypes: Societal stereotypes and biases often discourage young girls from pursuing STEM (Science, Technology, Engineering, and Mathematics) subjects, leading to fewer women considering careers in these fields.

Lack of Female Role Models: The scarcity of female role models in science and engineering can make it challenging for young women to envision themselves in leadership positions within the field.

Self-Doubt/Imposter Syndrome: Many women in engineering struggle with imposter syndrome, a feeling of inadequacy and self-doubt despite their qualifications and accomplishments. This can lead to reduced confidence and reluctance to take on new challenges.

Workplace Bias: Gender bias and discrimination persist in science and engineering workplaces, hindering women's career advancement and impacting their representation in leadership roles.

Work-Life Balance Challenges: Balancing family responsibilities with a demanding career in science or engineering can be particularly challenging for women, influencing their decisions about pursuing leadership positions.

A survey done in Kenya revealed the different challenges young women engineers faced. 33% of young women engineers cited that they experienced work place discrimination, 8% experienced sexual harassment, 30% had periods of self-doubt and 25% lacked mentorship opportunities. Similarly, a survey was done for the mentors and role models to compare their experiences. 18% of mentors experienced work place discrimination, 9% experienced sexual harassment 18% had instances of self-doubt. Lack of mentorship opportunities was cited as the biggest challenge towards career progression for mentors with 36% of them mentioning it as a major challenge.

Despite the challenges mentioned above, mentors and role models indicated that they were able to rise to leadership roles and in turn provide mentorship to young engineers. Participants of the survey consistently highlighted the value of having mentors who provided guidance during critical career decisions and offered insights into navigating workplace challenges. Many participants emphasized the role of mentors in challenging their self-doubt, enabling them to take on leadership roles with renewed confidence.

Holistic Approaches to Closing the Gender Gap in Engineering Leadership

- Mentorship

Mentorship programs have proven to be effective in empowering young women pursuing careers in science and engineering. The programs serve as a catalyst for young engineers to attain leadership roles by providing guidance, support, and a sense of belonging, helping mentees overcome obstacles they may face. In Kenya, initiatives like the “She-for-She Engineers” mentorship program by the Institute of Engineers of Kenya (IEK) Women Engineers Chapter connects professional female engineers with young female engineering students and engineers-in-training, fostering their personal and professional development. Such programs offer young women the opportunity to learn from experienced professionals who have successfully navigated their respective fields. Mentors provide valuable insights, share their own experiences, and offer advice on work-life balance, career choices, skill development, and goal setting. This guidance helps mentees make informed decisions about their academic and professional journeys for career growth.

- Skill Development

Empowering young female engineers requires equipping them with the necessary skills and confidence to excel in their chosen fields. Skill development programs, workshops, and educational initiatives that encourage girls to pursue STEM subjects can help bridge the gender gap. Investing in skill development and education tailored to the needs and aspirations of young women in these fields is essential. Providing access to quality STEM education and professional development opportunities can help bridge the gender

gap in science and engineering leadership Gbedomon (2016). In Kenya, organizations like AkiraChix focus on equipping young women with skills in technology, design, and entrepreneurship. Their programs provide a supportive environment for skill development and have resulted in young Kenyan women pursuing successful careers in technology and engineering. Embracing such initiatives will help forge a path towards leadership for women in STEM.

- Role Models

The presence of successful female engineers in leadership positions serves as inspiration and validation for young women pursuing careers in these fields. Prominent role models, both nationally and internationally, can help break down gender stereotypes and encourage more young women to pursue leadership roles in science and engineering. Role models inspire young women by showcasing what is possible. Seeing someone who looks like them in a leadership position or making significant contributions to science and engineering can spark their interest and motivation. By highlighting the achievements of female engineers and fostering mentorship relationships, we can continue to cultivating a new generation of empowered and accomplished women in STEM fields. When young women witness other women succeeding in these fields, they are more likely to believe in their own potential. Role models contribute not only to individual success but also to the diversity, innovation, and progress globally. Young women who have role models in STEM tend to have greater confidence in their abilities. This increased self-assurance can lead to increased persistence and resilience in the face of obstacles.

Conclusion

The underrepresentation of women in leadership roles in the science and engineering fields is a global challenge that hampers diversity, innovation, and progress. Nurturing the potential of young female scientists and engineers through mentorship, skill development, and the presence of role models is essential to bridge this gap. Efforts to empower the next generation of female scientists and engineers should be a global endeavor, involving governments, educational institutions, scientific organizations, and industry leaders. By working together to address these issues and provide young women with the tools and opportunities they need to succeed, we can create a more equitable and innovative future for the science and engineering fields.

As a recommendation, the creation of an international platform for networking and support can facilitate collaboration and empowerment across borders, enabling young women to receive mentorship, network with their role models and ultimately take on leadership roles in science and engineering.

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How to create a culture for women in engineering

Anastasia Pesce *(Product Assurance and Safety Department, ESA, Noordwijk, the Netherlands)*

Nowadays, female scientists are an integral part of the scientific community. However, the scientific public scenery remains mostly male, regardless of the increase of women in these professions. To establish a culture for women's visibility, a few steps are necessary. The first one is recognizing barriers. Women (and thus society, therefore), face cultural and practical barriers to women's inclusion in public events. For example, women tend to refrain from identifying themselves as experts and to have their names quoted. This is a cultural trait that is mostly internalized and a consequence of our culture. The second step towards gender inclusivity is establishing and applying policies and quotas for women in events. Typically, the quotas of women at conferences reflect the quotas of women in the industry. Finally, for women to overcome practical difficulties, enabling actions are recommended.

Global and general data and facts on the gender gaps are analyzed, highlighting the status of the European Space Agency and in the aerospace sector. In this context, the impact on the visibility of women in space and the media outreach had a significant impact on concrete actions. Establishing a culture of visibility in media, conferences, and company boards is a fundamental factor for establishing a culture of women's visibility. However, how to establish it? How to overcome the existing barriers? In the presentation, a toolkit that could be easily adopted at conferences is presented together with some useful enabling actions, policies, and metrics. Diversity and inclusiveness (DEI) are one of the high priorities of ESA Agenda 2025. Several actions are in place to overcome the challenges for the future.

Using Statistical Indicators in the Engineering Profession to achieve EDI – A policy tool

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The under-representation of women in engineering is a global issue that has been recognized by the World Federation of Engineering Organizations (WFEO). In response, the WFEO has developed initiatives to promote gender diversity and inclusion. These initiatives include the establishment of a Women in Engineering Committee which focuses on promoting the participation of women in engineering education, research and practice. The committee also works to identify and address the barriers that prevent women from pursuing and advancing in engineering careers. Through its effort, the WFEO aims to increase the representation of women in engineering and to create a more equitable, diverse and inclusive engineering profession. This presentation highlights the importance of gender diversity and the role of gender indicators and how they can become an important tool in policy formulation and planning to increase gender diversity. It examines the use of the Gender Scorecard developed by the Women in Engineering Committee, as a tool to achieve this. It considers the efforts made in the last four years and seeks to elevate the need for the scorecard to be adopted and promoted by WFEO and other key actors in the global engineering community.

Gender and Technology: The role of TVET in uplifting traditional knowledge and technologies for rural women in Zimbabwe

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Abstract: This research explored on the role Technical and vocational education training (TVET) plays in uplifting the traditional technologies used by woman in the rural Zimbabwe. The few women in TVET education proved to be effective in designing products that enhances livelihood of rural women by identifying need through experience and exposure. However use of traditional technologies has challenges of improvements though they preserve the traditional knowledge and folklore. The solution to promote these technologies which are prevalent with mostly women who traditionally run the day to day household chores is by incorporating the women TVET students in promoting appropriate technology through redesigning equipment for sustainability of traditional knowledge developed by women. From the derived samples of 5% rural women who take education up to TVET colleges and exposed to design work, they all design towards enhancing traditional technologies used by women. The research unleashed the gap between gender and technological development that supports the appropriate technologies used for the survival by the rural women in Zimbabwe. The research concluded that thorough career guidance has to be provided for in the most marginalised rural schools, for rural girls to take their grassroots technologies up to TVET colleges and enhance them from their background knowledge.

Keywords: Gender, Technology, Traditional Knowledge, Folklore, TVET

1. Introduction

Technical and Vocational Education Training (TVET) has become the cornerstone for livelihood improvement to Zimbabwean rural folks by promoting designing of cheaper equipment to the community. The TVET trained graduates joins the informal sector that specialises in their areas of study producing goods targeting mainly the rural people and this has been accepted as a way of identifying skills for entrepreneurship [1]. The few women in TVET education have proven to be effective in designing products that enhances livelihood of rural women through experience and exposure at the same time maintaining the traditional knowledge. Women in rural areas are the main custodians of traditional knowledge due to their contributions towards the day to day running of the household chores. Among the traditional knowledges in Zimbabwe are knowledge on agriculture, food preservation methods, food processing, medicine and decorative craft skills. Rural women over time have devised methods of collecting, preserving and producing food in the community. This research explored on the role woman in TVET plays in uplifting the traditional technologies used by woman in the rural Zimbabwe community. Traditional knowledge has helped as the basis for problem identification for students in TVET colleges when identifying projects for their academic fulfilments. This ranges from civil and mechanical works in the traditional construction of rural kitchens, huts, fireplaces, charcoal stoves, maize shellers, peanut shellers, 'tsotso' stoves, solar vegetable driers, chili grinders, peanut butter making machines, enhanced manual 'sawer' for small grains (rapoko).This research focused on items and equipment made to ease the burden of food production, preparation and preservation in the daily life of a rural woman.

2. Literature

Literature is awash with basic traditional knowledge that marks the identity of different cultures in Zimbabwe and how they have been enhanced with technology either to increase production or to improve quality. Traditionally women are groomed for the day to day running of the household leading them to devising the means of survival to ease the burden of the ever increasing chores. Literature in TVET talks on benefits of TVET to the community rather than the benefits of inclusion of the affected that is women in rural households. Women cook, harvest and source for daily food and prepare the recipes for each day making sure the food is properly preserved for future use. There is an indication that TVET trained graduates are mainly

apprenticed in the informal sector like Magaba in Mbare high density area were they apply their technologies to produce goods [2].In Zimbabwe this informal sector is the sole supplier of appropriate technology tools and machines for the rural community. [3] Nigerian vocational education training indicated that indigenous technical and vocational skills are those skills that utilize natural resources to satisfy humanity needs. This human need satisfaction can be achieved by incorporating local talented or TVET trained graduates. The talents can be obtained from those that grew up using the technology who are in this instance the rural girls who join TVET colleges. The traditional training has been passed down to children through generations maintaining the myths associated on these different methods as a value and respect to the traditions. [4] Preservation of harvested grains for future use in the rural kitchen is mainly cantered on sun drying which takes long and lack protection from the outside environment as indicated on the research on post-harvest technologies, methods in India. This indication shows the need for a better design to protect the food from contamination but not doing away with the method of drying the food and grains as a preservative method. National goals rally behind maintaining traditional knowledges and passing on to future generations without distortion. The knowledge that rural girls possess with regards to methods used in the rural community have been ignored. Designers produce what they can, without considering the real challenges faced by rural women. The traditional knowledge need to be used to benefit the community by acting local and thinking global [5].

3. Research Gap

The research unleashes the gap between gender and technological development that supports traditional knowledge technologies used for the survival by the rural women in Zimbabwe. The knowledge on how to satisfy the actual need of women in the rural set up cannot be explored without involvement of the affected who are mainly women. Researches are mainly on the benefit of TVET education on general aspects without considering rural women who promotes traditional knowledge and folklore. Studies carried out were concerned with TVET education collaboration with the industry and to satisfy the industry labour needs forgetting the silent rural woman.

4. Methodology

Female mechanical engineering students with rural background were sampled from 3 TVET institutions and these make up 5%.The identified students were assessed on the type of projects they designed and intended to design based on their background knowledge. A homestead that has adopted the new technology was conveniently sampled as a pilot to assess the effects of new technology on the traditional knowledge and folklore. The research conveniently sampled all the equipment used at the sampled homestead to check the effects and adaptability of new technologies by rural women maintaining the product quality according to TK. The women were observed using the initial traditional methods and then the effects of the said new technologies that are needed by women to prove the benefits of improved technologies. Interviews on the reasons for designs and the intentions were all clear based on experience and knowledge of how it is done. Observation was used to collect salient data on the effectiveness of the improved technology without distorting the traditional knowledge. The designs are mainly based on the knowledge of how it is currently done and devising an improved method which is less cumbersome but coming up with the same product or maintaining the same values as before. An experiment was done to check on the difference in time for the production of peanut butter (based on 20 litter bucket). The experiment was done starting from peanut shelling, roasting, pounding and then grinding. This strategy was adopted to seek answers to the effectiveness of designed machines towards reducing the burden of a rural woman, and to check the influence of background when coming up with designs. ‘Mabumbe’ (a traditional meat ball relish substitute made from pumpkin seeds which has high nutritional values) making was also demonstrated as well and a suitable machine is still to be designed basing on the knowledge from one of

the TVET trained girl. The designed machines sampled were peanut 'shellers', peanut butter making machines, vegetable driers, chilli grinders, grain silos the from the 15 girls sampled from the TVET institutions only two had a design which was guided by the company and all the others had the intention to improve a rural woman's life.

5. Findings and discussions

The female students' designs were centred on machines that ease the burden of a rural woman. The research identified the differences in time frames of operation using the original traditional methods and using the new technologies. For peanut butter making, it took 8 hours using the traditional methods. Production using peanut Sheller, roaster and peanut butter machine took 1 hour 40 minutes. The designs are life changing to the women who have multiple house chores and they have adapted well to the use of machinery designed. The sampled homestead which adopted 4 of these new designs has become a role model to the community and hiring out the machine services to the other community members who now have extra hours for other activities indicating acceptance of the new designs. The peanut butter had no difference and the taste remained the same. The 'mabumbe' recipe was delicious and but the process was draining to the woman, and a need was identified for a processing machine. Improved methods of production and preservation does not distort the traditional knowledge, it only increases the production levels and reduces time. TVET trained female graduates in the informal sector manufacture tools and equipment improving appropriate technology that has been in use in the rural areas for centuries. This has helped maintain traditional knowledge through better, improved equipment and tools that maintains and shorten the production processes. This reinforces cultural values of Zimbabwe through the continual use of traditional ways of doing things at an improved level. These emerging technologies are maintaining conformity to traditional processes without distorting the cultural basis. The adapted designs serve the purposes

6. Recommendations

The Government of Zimbabwe must adopt involvement by participation of rural women so to produce designs which will be adopted and accepted by rural women. The solution to promote these technologies which are prevalent with mostly women who traditionally run the day to day household chores is by incorporating the women TVET students in promoting appropriate technology through redesigning equipment for sustainability of traditional knowledge developed by women. The study also recommends the introduction of TVET centres in rural areas and recruitment of more women in the technical courses for them to design from experience to ease the burden of women. There is also need to attach students in the rural households to observe the traditional knowledges so as to find ways of maintaining the traditional knowledges without distorting them. This can allow for products produced from traditional knowledge to be monetised through geographical indication (GI) and registration for identification to the outside communities and countries.

List of symbols

TVET Technical and vocational education training

GI Geographical indications

TK Traditional knowledge

IP Intellectual Property

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Czech Women in Engineering and Science

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Similarly as in many other disciplines, even in science outstanding men personalities prevail. The reason can be found in tradition and in women other duties. Even in the Czech Republic gender balance generally has not been so far fully implemented, in comparison with e.g. Nordic countries. Nevertheless in science and applied field several outstanding women personalities can be found. From them three women representing different field and time periods were selected.

Eliska Novakova (1921–2000) was the first woman who got higher recognition in forestry. She studied forest faculty, Czech Technical University Prague, later faculty of natural sciences at the Charles University Prague. Her specialization was forest zoology – the main field of her activities at the forest faculty Prague. In 1959 she obtained title of PhD., in 1987 doctor of biological sciences. As the importance of the environmental problems grew, Dr. Novákova focused to impact of various man activities on the environment and countryside. She became specialists in various institutions dealing with these questions, including Forestry and Game Management Research Institute, Institute of Country Management and Protection, Institute of Country Ecology etc. Also her educational activities at universities and post-gradual study education were broad. She was member of several scientific organizations and the Minister of the Environment prize winner in 1998. Dr. Novakova combined successfully theoretical knowledge with its practical application.

Dagmar Dykyjova (1914–2011) studied faculty of natural sciences at the Charles University Prague – specialization plant physiology. After graduation she began to work there at the Institute for Plant Physiology, until 1938, when the Czech universities were closed by German occupants. After this period, Dr. Dykyjova changed work at several institutions, with exception of a short period 1953–1957, when she return to pedagogical activities at Charles University. In 1964 she obtained the opportunity to work at the Botanical Institute of the Czechoslovak Academy of Sciences, at Třeboň, South Bohemia. Her research focused to the ecology of wetlands and wetland plants and to the ecology of Central European orchids. She became the author, co-author or editor of numerous scientific publications. She developed activities also to popularization and sensitive approach to environmental management, nature conservation and management of natural resources. She was involved in activities of the International Biological Programme (1965), as well as the Man and Biosphere Programme (1971). In 2001 Dr Dykyjova obtained International Fellowship Award from the Society of Wetland Sciences. At national level, she was awarded by J. G. Mendel gold medial by the Czechoslovak Academy of Sciences in 1984 and prize of the minister of the environment.

Katerina Demnerova (1947) studied Biotechnological University Prague. In the period 2006 – 2013 she became a head of the Institute of Biochemistry and Microbiology. At present she is acting professor at Biotechnological University, specialized in food and environmental microbiology, including methods of genetic modification. She has participated in about 40 projects oriented to food microbiology and methods of pollutants deletion from the environment, both national and international. Her rich pedagogical activities are oriented to the students and post-graduate students of the Biotechnological University. Prof. Demnerova is a member of various scientific committees, head of the food microbiology section of the Czechoslovak Microbiological Society and member of several scientific journals editor committees. In 2011 she obtained the Milada Paulova prize for women scientists for their contribution to development of scientific field.

The study has proved that women can reach outstanding results in their professional activities combined with leading position, comparable with those of their men colleagues. These can even achieve along with other women duties.

Committee on Water (CW) SDG Goals: Water Challenges

Engineering, Groundwater, and Integrated Water Resources Management

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Water is a universal good that knows no borders and is available in many regions of the planet, but probably in many places the most accessible freshwater is the one that cannot be seen, groundwater.

The vast majority of planet's freshwater resources are found in aquifers (99%), and one-third of humanity depends on groundwater for its subsistence. It provides almost half of the world's drinking water, and nearly 70% of the groundwater withdrawn is used for agriculture, supplying 38% of the world's irrigated land. It is the world's most extracted raw material. Annually, over 200 times more groundwater is abstracted from the earth than oil. Groundwater is vital not only for humans but also for the ecosystems that depend on it and biodiversity.

These resources are also threatened by climate change, but mainly by human activities. Population growth and current lifestyles are depleting these resources to provide us with more food and goods. Groundwater is more protected than surface water from pollution, but this has not prevented humans from contaminating this water. The value of groundwater goes far beyond the mere quantitative and should not be judged only by this data.

Given the relevance of this resource, the Water Committee of WFEO has drafted its new report on "Engineering, Groundwater, and IWRM". The presentation aims to highlight the relevance of groundwater and how, from an engineering perspective, it should address the management of this resource.

Nexus water-energy-nutrients in buildings

Armando B. Silva Afonso (WFEO (Committee on Water) and University of Aveiro (RISCO), Aveiro, Portugal)

The increasing need for sustainable use of energy and resources globally, as a result of population growth, the economic developing model and, in some regions, climate change, requires a holistic and integrated approach as a guiding principle of development policies. This principle is highlighted in the UN Agenda 2030, where it is stated that it is through this integrated approach that cross-connections between social progress, economic growth and environmental protection can be promoted.

Energy and basic resources – water and food – are closely interconnected, which is why the water-energy-food nexus constitutes the essential integrated approach for the sustainable development of humanity to be ensured. In general terms, water is crucial in most forms of energy production and energy is necessary for many uses of water, such as supplying populations or heating domestic hot water. Water and energy are also closely linked to food. In a world with a growing global population, agriculture is responsible for 70% of total freshwater withdrawal, while food production and its supply chain represent around 30% of global energy consumption.

This water-energy-food nexus can also be valid in urban environments and can be adapted for buildings, particularly in their use phase. In this case, this nexus must be seen in relation to the interconnection between water, energy and nutrients (or fertilizers).

Due to sustainability concerns, net zero-energy buildings (NZEB) have already become a reality in many parts of the world and the next steps should be the design and dissemination of net zero-water and net zero-nutrients buildings. But this approach should not and cannot be done independently. In fact, "net zero-buildings" should be the constructive solutions of the future, but they should consider the intrinsic relationship between water, energy and nutrients in urban environments.

The net zero-building concept intertwines with the circular use of resources, but these concepts are not equivalent. In the case of energy, net zero energy buildings do not mean a circular use of the resource, but rather that the total amount of energy resources used by the building is approximately equal to the amount of renewable resources produced or available on site. In the case of water, part of the resource can be used in a circular manner (water recycling), but alternative renewable sources such as rainwater can also be considered. In the case of zero-nutrients buildings, the use of resources can be circular, given that nutrients such as phosphorus, for example, can be recovered from urine and used as fertilizers in urban agriculture.

The aim of this article is to highlight, at the level of urban environments, the strong connections between water, energy and nutrients. Based on the review of some recent publications in this area, it is intended to integrate the results obtained in partial studies related to each of these interconnections and to show the importance of the nexus between energy, water and nutrients in buildings.

With regard to the water-nutrients nexus in buildings, sanitary installations and urinals, when they exist, are essential components in the relationship between these resources. These devices have always played an important role in the context of the water-nutrients nexus and have a high potential, in the future, to make important contributions to the promotion of solutions for the sustainable use of nutrients at the scale of buildings and their surroundings. In fact, the nutrients recovered in buildings, from manure, urine or domestic effluents, can be used in urban agriculture or in the fertilization of public gardens or green roofs.

Currently, in parallel with concerns about water efficiency in toilets, the importance of resource recovery has resurfaced, leading to the development of solutions such as composting toilets

Food production requires a total of seventeen elements, among which nitrogen (N), phosphorus (P) and potassium (K) are considered the fundamental ones (macronutrients). These three elements can be found in human urine, which also contains some of the secondary micronutrients. However, special attention must be paid to phosphorus and the possibility of its recovery. Its scarcity could compromise humanity's food security, but population growth, wars and the intensification of global agriculture are placing increasing pressure on

the finite supply of this resource. About 90% of world P reserves are in China, Russia, USA and Morocco but it is estimated that currently viable reserves will be depleted in the next 30-40 to 300-400 years. These estimates differ due to some uncertainty regarding the volume and quality of these global reserves and the accuracy of future demand estimates.

Furthermore, the discharge of P-rich domestic and industrial effluents and leached fertilizers into water bodies is the main cause of eutrophication, which is probably the most significant unsolved problem in terms of protecting water resources, at least in Europe. While phosphorus recovery is an emergency in the face of food security and pollution problems, its elimination in urine is one of the main causes of loss in the value chain. An average adult excretes about 1 g of phosphorus per day through the urine and there are still no systems in current operation for its recovery in aquatic systems or consolidated solutions for recovery in urban wastewater treatment plants (WWTP). Phosphorus recovery in WWTP is theoretically possible, but recovery at the source, i.e. in buildings, would have numerous advantages in reducing the load on the treatment plant, avoiding dilution and minimizing costs and consumption of energy in the process.

As previously mentioned, most of the nutrients excreted by humans are found in urine. This is why the direct use of maturated urine for agricultural purposes has already been the subject of pilot projects in South Africa, China, Germany and Sweden. Urine diversion in buildings, with or without phosphorus recovery, requires a revolution in current bathrooms, with the installation of urine-diverting toilets, urinals for residential buildings and their generalization for females, etc., associated with new design and sizing rules, etc.

In fact, the biggest concern with using urine as a fertilizer is the possible presence of enteric pathogens. Human urine usually does not contain pathogens, but the careless separation of faeces and faecal cross-contamination can cause such contamination. Another concern should exist regarding the presence of pharmaceuticals and other micropollutants in urine used as fertilizer.

Electric toilets, which use electricity to process waste for nutrient recovery, can be included in the nutrient-energy nexus in buildings. Energy may also be needed to recover the urine and use it as fertilizer, in pumping equipment for example. However, the nexus between energy and nutrients will be of little significance at the level of buildings, in principle, unlike the water-energy nexus, of great relevance and which is analyzed in the next item.

In relation to the water-energy nexus, it can be stated that an important contribution to energy efficiency in buildings can come from water efficiency measures, although this aspect is often neglected in policies to promote energy efficiency in buildings, which are too focused on sectoral measures. In fact, water efficiency in buildings has a significant impact on energy efficiency, not only in the buildings themselves, by reducing the need for heating and water pressurization, but also in public water supply and drainage networks, by reducing the volumes captured, pumped and treated.

The water-energy nexus in WuP was also considered in the recent unified European Water Label (UWL). According to the European Commission, encouraging the replacement of all standard household devices (taps, toilets, showers, bathtubs, washing machines, dishwashers, products for external use, etc.) by water efficient products will result in an overall reduction of annual domestic water consumption up to 35% for taps, 11% for showers and associated energy up to 30%.

The importance of these numbers in the European Union (EU) is evident, considering that the total withdrawal of water for use in taps and showers was estimated at around 25000 Mm^3 in 2010 and the total primary energy need associated in the EU with the use of taps and of showers were estimated at around 3000 PJ^3/year. Total CO_2eq emissions related to annual EU primary energy demand from taps and showers were estimated at around 160 Mton in 2010.

Overall, the water-energy-nutrient nexus in urban environments and buildings is particularly relevant and, in some respects, may be essential for sustainable development and human food security. It should, therefore, be the subject of special attention, in parallel with the global and essential approach to the water-energy-food nexus.

Water Reuse: Opportunities and Challenges under Climate Change Scenarios

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Drought episodes have been getting worse in several regions of the world, namely due to climate change. This scenario reflects the need for more efficient water management, focusing on arid and semi-arid areas. In this sense, water reuse stands out as an important alternative for a sustainable source of water for different purposes. Although the theme is directly related to SDG6 (clean water and sanitation) and SDG13 (climate action), water reuse is indirectly related to the others, mainly SDG 2 (zero hunger). Agricultural irrigation with recycled water can supply both, the water demand, and the nutritional demand of the plant, in a practice known as fertirrigation. Countries like Israel, Cyprus and Malta use almost 100% of their treated effluents in agriculture; United States and China use around 13 billion m3 of recycled water per year; NEWater, in Singapore, represents 40% of treated wastewater; Australia, with a focus on potable reuse, uses 15%. There are several water reuse plants around the world, with specific characteristics and with the aim of minimizing the effects of climate change. Regions like Brazil and Europe have high potential that is still underused, which can generate great business opportunities. However, some barriers can be highlighted, such as regulation (legal, administrative and health aspects) and natural rejection (Factor *Yuck*). Thus, it is important to highlight the importance of a well-structured regulatory framework, adapted to the specificities of each region, in order to encourage the water reuse in a safe and responsible manner, for sustainable development.

Innovative nature-based structures for coastal erosion protection

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Abstract: This research work presents nature-based innovative structures for addressing coastal erosion mitigation, based on the observation of alongshore drift reversal phenomena. Hydro-morphodynamics and wave climate predictions for storm conditions near the Iberian Peninsula shoreline were analysed for defining an optimized maritime structure geometry. Full-scale observation data and numerical modelling using Delft3D, SWAN and XBeach were applied to optimize the geometry of maritime structures. Based on observation of the natural longitudinal drift reversal process, the shape and dimensions of a new structure were defined towards minimizing local erosion problems promoting wave energy dissipation and sediments retention. Additionally, the thermo-mechanical behaviour of innovative armour units composed of recycled steel fibre reinforced concrete (RSFRC) was analysed. The preliminary design and the thermo-mechanical analysis were performed by applying FEMIX software to simulate the concrete maturity, creep, shrinkage and cracking in order to evaluate the cracking risk formation during production of such large elements. Findings indicate that the proposed structure can contribute to the accumulation of sediments downdrift without interrupting longitudinal drift and that the intertidal structure location can create ways to promote biodiversity within the structure, taking into account its special geometric characteristics. Results also demonstrate that RSFRC can significantly increase the armour units' life cycle by maintaining low crack widths without compromising their functionality. With these innovative approaches, it is possible to create effective and sustainable coastal protection structures, highlighting the beneficial effect of nature based-solutions in promoting wave energy dissipation, sediments retention, biodiversity, and environmental benefits through the use of recycled materials.

Keywords: Innovative nature-based coastal protection structures; hydro-morphodynamics modelling; thermo-mechanics modelling; longitudinal drift reversal; recycled steel fibre reinforced concrete.

Introduction

Coastal erosion is a pressing global challenge that threatens the stability of coastal communities and ecosystems. Over the past few years, a steadily accelerating trend in the mean sea level rise has been observed. This sea level rise has been exacerbated by climate change and is of great significance, given that approximately 40% of the world's population lives within 100 km of the coast. The projections made by the IPCC in the late 1980s indeed underscore this trend of sea level rise until 2100, which is particularly concerning for highly energetic coastlines, such as the Portuguese coast.

Several response approaches to this challenge comprise the retreat, accommodation, protection, or doing nothing methodologies. To address this critical issue, this work falls under the category of protection, which includes the hard and soft engineering structures and introduces an innovative research endeavour focused on harnessing the power of nature-based innovation to mitigate coastal erosion problems.

The research is centred on the phenomenon of alongshore drift reversal and its potential to inspire creative approaches for coastal protection strategies, and delves into the complex interplay of hydro-morphodynamics and wave climate during storm conditions, leveraging these insights to define an optimized maritime structure geometry. Through a comprehensive approach, that combines full-scale observations and numerical modelling using Delft3D, SWAN, and XBeach, this research aims to design maritime structures that not only combat local erosion problems but also facilitate wave energy dissipation and sediments retention.

In addition to addressing the structural aspect, this research extends its focus to the thermo-mechanical behaviour of innovative armour units, composed of recycled steel fibre-reinforced concrete (RSFRC). Using advanced FEMIX software, the study analyses the concrete's maturity, creep, shrinkage, and cracking during the production of these sizable elements. The findings underscore the remarkable potential of RSFRC in significantly extending the life cycle of armour units, maintaining low crack widths while preserving their functionality.

Ultimately, this research endeavour highlights the transformative power of nature-based solutions in coastal protection. By promoting wave energy dissipation, sediments retention, biodiversity, and environmental benefits with recycled materials, the proposed innovative approaches offer a promising pathway towards creating effective and sustainable coastal protection structures. In doing so, they not only address the pressing challenges of coastal erosion but also underscore the importance of harnessing the inherent resilience of natural systems to safeguard our coastal environments.

This work aligns with three United Nations Sustainable Development Goals: determining the risk of coastal erosion and identifying adaptation interventions for reducing the vulnerability of coastal infrastructure and climate change impacts (Goal 13.1); and evaluating the most efficient options to protect the populations, the natural and cultural assets and the activities in selected zones (Goals 14.2 and 11.4).

Methods

The methodology employed in this research takes into account the multidisciplinary nature of the research and combines field observations, numerical modelling, and innovative materials analysis to develop and assess nature-based coastal erosion protection structures. The findings are integrated to refine the geometry and design of the proposed nature-based maritime structures. The optimized structures are evaluated for their efficacy in promoting sediment accumulation downdrift and are briefly assessed regarding their contributions to wave energy dissipation, sediments retention, post-cracking behaviour and overall environmental benefits through the use of recycled materials and promoting marine biodiversity. This way, the methodology ensures that the proposed solutions are both effective in addressing erosion issues and environmentally sustainable in the long term.

The following sections outline the key components of the methodology. Detailed information regarding hydro-morphodynamic and thermo-mechanical numerical modelling conditions, and considerations for the design of the innovative armour unit can be found elsewhere.

Field Observations

The study began with an extensive observational data analysis on coastal processes, along different shorelines by giving a special attention to the phenomenon of alongshore drift reversal by systematically observing and recording data related to the reversal process, gaining critical insights into its natural mechanisms and dynamics. This observation, e.g. in Leixões harbour (Portugal) and Laguna beach (USA), serves as a guiding principle for shaping and dimensioning a novel structure, and gives the identification of optimal geometry and dimensions for intertidal structures to maximize their effectiveness in sediment accumulation and biodiversity promotion.

Hydro-Morphodynamic Numerical Modelling

The research applied Delft3D and SWAN (Simulating WAves Nearshore) numerical modelling tool to simulate coastal hydrodynamic changes. This component of the modelling process helps in understanding wave behaviour and energy distribution near the shoreline as these software aids in predicting wave climate under storm conditions.

The XBeach model is used to assess sediment transport and morphological changes in response to different structure geometries and placement scenarios. It aids in optimizing the design of maritime structures.

The input data regarding the significant wave height (H_s) and peak wave period (T_p) values for the numerical models are obtained from a previous study on the Iberian Peninsula extreme wave statistics and on the results of a wave propagation model from offshore to the beach at a specific location in the NW of Portugal (Lima estuary).

Several simulated scenarios (40 scenarios) with different structure shapes and numerical domains were tested using these numerical models. The proposed geometry for the optimized structure is then defined based on the most favourable results regarding the alongshore drift reversal and the sediment accretion patterns. In addition, a comparative analysis between the performance of a traditional and the proposed innovative structure was carried out.

Thermo-Mechanic Numerical Modelling for Innovative Armour Units

The proposed geometry for the armour unit consists of two different blocks that interlock with each other in order to ensure good hydraulic stability and, simultaneously, good structural stability provided by the weight of the blocks. Furthermore, the proposed blocks feature holes that: enhance wave energy dissipation; facilitate the attachment of marine organisms; and, potentially in the future, allow for the confinement of blocks with sisal ropes or other natural fibres to increase block stability and reduce the rocking. For the design, the van der Meer expression for cubic blocks was considered, and it was concluded that the blocks would have a height of 2.5 m and a mass of 36 tonnes.

The research includes a comprehensive analysis of the thermo-mechanical behaviour of an RSFRC armour unit under different cement characteristics (content and type) using FEMIX software during the concrete hardening process. It is important to note that the existence of early age cracks in such large elements formed during this process due to temperature variations can aggravate the risk of breaking due to rocking. The evolution of temperature, stresses and concrete strength, concrete cracking patterns and crack width development as a function of different concrete types and contents are analysed considering the concrete maturity, creep and shrinkage phenomena of large RSFRC elements. In addition, a comparative analysis was conducted in order to understand the influence of the armour unit size on stress evolution and crack formation and to compare the RSFRC and plain concrete behaviour.

Results

This section unveils the main findings obtained through a comprehensive study of nature-based maritime structures.

From the preliminary study of wave propagation, the numerical modelling results indicate that the input values of H_s is 3.5 m and T_p is 15 s for simulations starting 1.7 km off the coast. For a more intense storm scenario, the H_s and T_p values should be 10 m and 19 s, respectively.

The hydrodynamic results allow the observation of the reversal of the longitudinal drift along the slope of the proposed optimized innovative coastal protection structure, while the morphodynamic results show that for waves approaching from the NW direction:

- Sediment accumulation occurs updrift;
- Along the structure’s alignment, there is a zone of sediment accumulation near the coast with a reduction in erosion compared to a situation without the structure;
- Downdrift, there is a significant area of sediment accretion, indicating a substantial sediment transport from North to South;
- Significant erosion zones are observed at the extremities of the structure.

From the comparative analysis, results show that downdrift, there is a quite significant sediment accumulation compared to a scenario with a groin or even without any structure. This suggests that there is a substantial sediment transport favouring sediment accumulation to the south.

Regarding the thermo-mechanical analysis of the proposed innovative coastal protection structure, results depict that the temperature, stresses, concrete strength and crack widths evolution in concrete are proportional to the cement content and to the cement type. From this analysis, the type of cement CEM I 42.5R and the cement content of 435 kg/m^3 were the most adequate for the proposed armour unit, since the stresses evolution lead to no cracks at the end of simulation. Regarding the results obtained for cracking patterns, it was concluded that the scenario with cement type 52.5R exhibited the highest crack reopening at the end of the simulation. Therefore, a comparative analysis was performed for this scenario to understand the influence of block sizes and the type of concrete (plain or fibre-reinforced) on stress evolution and crack formation. From this study, it was concluded that larger blocks result in greater crack widths, and when plain concrete is considered, the crack width is greater than that observed in fibre-reinforced concrete. This indicates that fibres have a positive contribution to the post-cracking behaviour of concrete.

Conclusions

The hydro–morphodynamics modelling results under longitudinal drift reversal conditions allow concluding that the selected innovative structure can be a viable alternative technical solution for protecting coastal zones, since there is no interruption of the longitudinal drift, this way contributing to downdrift sediments accumulation near shoreline.

The innovative cube-like shape armour unit with holes on its faces was designed combining the advantages of the resilience associated to robust blocks and the interlocking abilities in order to obtain good structural and hydraulic stabilities for coastal erosion protection. In addition, it increases the wave energy dissipation and allows the easy attachment of colonies of marine organisms.

Recycled steel fibres as concrete reinforcement (not widely applied in maritime works) exhibit good mechanical response with low energy consumption in production with a positive ecological contribution.

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AI facilitated Smart Irrigation System with carbon reduction and pollution control

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In order to accurately control irrigation water and fertilizer amounts in agricultural fields, enhance water and fertilizer use efficiency, boost crop yields, and reduce carbon emissions from farmland, this study employs a deep learning model coupled with an advanced Penman formula. Based on monitoring data from meteorology, soil, and vegetation, we simulate actual evapotranspiration and develop a novel methodology for estimating the crop water stress index (CWSI). Through the use of remote sensing vegetation monitoring by high-resolution Sentinel satellite, we can estimate CWSI in the scale of 10 m x 10 m spatially.

In conjunction with the root zone water quality model (RZWQM), we simulate nutrient and pollutant transport in soil, propose regional nitrogen and phosphorus fertilizer management strategies, determine the optimal water-fertilizer ratio, and control non-point source pollution in farmland. By evaluating the effects of various cover crops, irrigation systems, and agricultural land-use practices on soil organic carbon, we identify the most effective land management methods for promoting soil carbon sequestration.

Finally, the network transmission protocol is used to obtain real-time data of each sensor, database is used to store and manage the irrigation and fertilization as well as other data including Soil and crop health information etc. in a structured manner. These farmland monitoring data can be also visualized in real time to assist the farmer in making decision.

Committee on Anti-Corruption (CAC): Corruption, an impediment to infrastructures development

Corruption, a Global Impediment to Resilient Infrastructure Development: Strategies for Rwanda and Beyond

Papias Dedeki Kazawadi *(Federation of Africa Engineering Organisations (FAEO), Kigali, Rwanda)*

Corruption remains a pervasive threat to resilient infrastructure development worldwide and Rwanda in particular, with far-reaching consequences for societies and economies. In this article, we delve into the detrimental impact of corruption on infrastructure projects and explore key strategies, including the adoption of projects anti-corruption standards, to combat this pervasive issue. By prioritizing transparency, accountability, integrity, and fostering institutional collaboration, we can create an environment conducive to resilient infrastructure development and maintenance.

As Albert Einstein said, “the world is a dangerous place, not because of those who do evil but because of those who look on and do nothing.” Corruption poses a significant challenge to infrastructure projects at every phase, from conception to disposal. The complex nature of infrastructure projects often involves large investments, multiple stakeholders, and extensive discretion, creating fertile ground for corruption to thrive.

As Robert Klitgaard defined, corruption occurs in situations where there is "monopoly plus discretion minus accountability." This combination of factors enables corruption to flourish, hindering resilient infrastructure development.

Corruption drains valuable financial resources that are critical for infrastructure development. Martin Luther King Jr. once said, “Our lives begin to end the day we become silent about things that matter.” Funds earmarked for resilient infrastructure often fall victim to bribery, extortion, fraud, cartels, embezzlement, fraud, and abuse of power. Such diversion of funds limits investments in quality materials, skilled labor, and advanced technologies, compromising the safety, durability, and overall resilience of infrastructure projects. By eradicating corruption, resources can be allocated more effectively, maximizing the value and longevity of infrastructure investments.

Corrupt practices influence contractor selection and procurement decisions, resulting in substandard infrastructure. This compromises safety and reliability, posing risks to communities, particularly during natural disasters. Moreover, corruption perpetuates social disparities, favoring the interests of a privileged few while leaving marginalized communities underserved. Resilient infrastructure should promote social cohesion, economic opportunities, and improved quality of life for all. By combating corruption, we can ensure equitable infrastructure development that benefits communities at all levels of society.

Corruption erodes public trust in institutions and undermines the legitimacy of infrastructure projects. It hampers collaboration and cooperation necessary for resilient infrastructure development. As President Paul Kagame aptly stated, “Good governance is the best anti-corruption policy” and “Good governance is about putting people at the center of development.” By prioritizing transparency, accountability, integrity, and fostering institutional collaboration, we can ensure that infrastructure projects are well-funded and constructed to high-quality standards. To rebuild public confidence, institutional collaboration is essential, and the involvement of various professionals such as engineers, architects, surveyors, environmentalists, planners, valuers, procurement officers, auditors, accountants, lawyers, prosecutors, and others is crucial. Their collective efforts, expertise, and ethical standards can drive anti-corruption initiatives and ensure the integrity of infrastructure projects in Rwanda.

One of the essential measures to combat corruption in infrastructure development is the adoption of anti-corruption standards. The Projects Anti-Corruption System (PACS), developed by the WFEO-GIACC Alliance, provides a comprehensive framework to detect and prevent corruption in infrastructure projects. PACS serves as a valuable resource for professionals and organizations seeking to uphold integrity and transparency throughout the infrastructure lifecycle. Similarly, the Commonwealth Anti-Corruption Benchmarks offer governments clear guidance on implementing effective anti-corruption measures. These standards provide a roadmap for governments, professional bodies, and stakeholders to establish robust anti-corruption systems that prioritize transparency, accountability, and integrity. By adopting these standards, Rwanda can enhance an environment that deters corruption, promotes fair competition, and ensures value-for-money investments.

To combat corruption effectively, a multi-faceted approach is required. As Martin Luther King Jr. emphasized, “Our lives begin to end the day we become silent about things that matter.” This includes fostering personal and professional ethics, enforcing anti-corruption laws, and establishing accountability systems. Collaboration among built environment professional bodies, governments, and international organizations is crucial in promoting anti-corruption standards and best practices.

In addition to the adoption of anti-corruption standards, reliable capacity-building initiatives, education, and training programs are crucial for professionals and stakeholders involved in infrastructure projects. These programs raise awareness about the risks and consequences of corruption and empower individuals with the knowledge and skills to combat it effectively. By promoting ethical practices, professionals in engineering, architecture, surveying, environmental sciences, planning, valuation, procurement, auditing, accounting, law, and prosecution can play a significant role in upholding integrity in infrastructure development.

Eradicating corruption is essential for resilient infrastructure development. By prioritizing transparency, accountability, integrity, and fostering institutional collaboration, we can ensure that infrastructure projects are well-funded, constructed to high-quality standards, and inclusive. Through the adoption of projects anti-corruption standards, such as PACS and the Commonwealth Anti-Corruption Benchmarks, and the collective efforts of professionals and stakeholders, let us combat corruption and build a future where resilient infrastructure supports sustainable and inclusive development for all Rwandans.

Committee on Disaster Risk Management (CDRM): Engineering the resilience and sustainability in growing cities

The role of engineering organizations in support of sustainability

José Macharé (Peruvian Engineers Association, Lima, Peru)

Sustainability implies the concept of durability. The infrastructure and other engineering systems that public and private entities contribute to meet the needs of the population must ensure the long-lasting characteristic along with that of high quality.

Disaster risk management (DRM) is a set of processes that, at the national and local level, are part of development policies. In particular, it is intended that the components of society are resilient and sustainable. As a system, DRMs comprise a) a hardware made up of facilities, instruments and other physical components, b) a software made up of documents such as laws, decrees, technical manuals and various relational protocols, and c) the human component, people who make the things work from the decision-making down to the operational levels. A large part of the latter are engineers of different specialties.

The World Federation of Engineering Organizations at global level, and its institutional members at national/regional levels, effectively contribute to achieve the Sustainable Development Goals (SDGs) through activities such as capacity development, education standards, technical advisory, and outreach of best practices.

Despite their high capacity, engineering organizations do not always have the necessary visibility to be called to the decision-making tables. Thus, an additional task is to show the achievements in terms of quality, durability and usefulness of engineering works, and their contribution to the resilience and sustainability of society.

Multi-hazard vulnerability assessment: case studies

Valentina Putrino *(Ariel Re UK Limited, London, UK)*

The conference aims to address the critical issue of multi-hazard vulnerability assessment concerning historic and low-engineered masonry structures through a series of case studies conducted in the Philippines. These structures, abundant in the region, hold significant cultural and architectural value but are often susceptible to the adverse impacts of various natural hazards, such as earthquakes, floods, and typhoons. Understanding their vulnerabilities is paramount to preserving cultural heritage and ensuring the safety of communities in disaster-prone areas.

The academic abstract outlines the primary objectives and methodologies of the case studies to be presented during the conference. Firstly, it endeavors to develop an integrated and comprehensive framework for assessing multi-hazard vulnerabilities unique to historic and low-engineered masonry structures. This framework will consider the complexities of these structures' material properties, construction techniques, and historical significance to account for their distinctive responses to different hazard scenarios.

The conference will facilitate in-depth discussions on risk communication and community engagement, emphasizing the importance of involving local stakeholders, experts, and policymakers in the vulnerability assessment process, to raise awareness among communities living in and around historic and low-engineered masonry structures, encouraging the adoption of preparedness measures and sustainable preservation practices.

Committee on Education in Engineering (CEIE)

The Changing State of Engineering Education in the UK

Dawn Bonfield *(Engineering Education Committee, WFEO & King's College London, London, UK)*

This session will discuss the changing nature of engineering and the corresponding new requirements that are expected of the Higher Education engineering curriculum to embed competences such as sustainability, global responsibility, inclusion, entrepreneurship and ethics so as to ensure that these are not additional to, but central to the core curriculum.

It will consider teaching frameworks to educate not only students but engineering academics, and the mechanisms for driving this change. In particular it will look at the recently developed Global Responsibility Reimagined Degree Map, which turns intention into positive action. This tool has a series of exercises that help universities create a map of the changes and choices they can make to keep their curriculum relevant to the challenges of our age. We will discuss the particular initiatives that are taking place within the UK currently.

Challenges in the engineering education in Kenya

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Engineering education in Kenya started at the University of Nairobi (UoN) in the 1950s, when the University was still a College, and later transformed into the first University in Kenya. The curricula taught at the University were heavily borrowed from the British education system. Traditionally, engineering programmes offered at the UoN, were: Civil, Electrical and Mechanical Engineering. Engineering graduates in the country were therefore predominantly from the three disciplines. Later, agricultural engineering was introduced, and was considered to be a subset of mechanical engineering. The three fields are generally the disciplines that were recognized by the regulatory body. In the year 1984, a second university was born, Moi University. Moi University was established to offer more practical engineering degree programmes. It therefore introduced Bachelor of Technology degrees in the following specializations: Electrical and Communications Engineering; Mechanical and Production Engineering; Civil and Structural Engineering; Chemical and Process Engineering; and Textile Engineering. The last two were new programmes in Kenya. The two were also categorized under mechanical engineering by the regulatory body. From the 1990's onwards, Kenya experienced a steep rise in the number of universities offering (or intending to offer) engineering programmes. Currently sixty-eight (68) undergraduate engineering programmes from twenty-three (23) universities are recognized by EBK. There are other programmes in the pipeline for recognition. The requisite growth of the human resource and infrastructure has not matched the rate at which the student population has grown. This raised alarm with the stakeholders, Engineers Registration Board being in the lead.

For the purpose of maintaining quality and regulating engineering practice in Kenya, the Engineers Registration Board (ERB) was established under Engineers Registration Act (Cap. 530) of 1969. ERB licensed engineering graduates to practice in Kenya. In order to license a graduate, the graduate needed to have passed through an accredited engineering programme recognized by ERB. CAP 530, however, had its inadequacies, which necessitated its repeal to enable the Board to effectively regulate the entire value chain of engineering, i.e., engineering education, engineering training and engineering practice. In the year 2011, parliament enacted the Engineers Act No. 43 of 2011 of the Laws of Kenya, which repealed CAP 530, effectively replacing ERB with the Engineers Board of Kenya, EBK. The new Act gave EBK mandate to register engineers and engineering consulting firms, regulate engineering professional services, set standards and develop the general practice of engineering. With this new Act, EBK was mandated to accredit engineering degree programmes in Kenya. It was also mandated to evaluate for purposes of recognizing engineering degrees obtained from foreign jurisdictions, so that holders of these degrees may be licensed to practice in Kenya. A list of such universities recognized by EBK is found on the EBK website https://ebk.go.ke/resource/approved-foreign-engineering-programmes/?tk=1696708972.

In the year 2012, the Universities Act 2012 gave birth to the Commission of University Education (CUE). This Act also gave powers to CUE to accredit all degree programmes, including engineering. This brought a conflict, in that, an engineering degree programme was to be accredited twice, by one by EBK and then by CUE. Being accredited twice also meant that institutions were to pay twice for the same programme. It is worth noting that both CUE and EBK have their own sets of standards that must be satisfied in order for a programme to be accredited. In 2020, the High Court of Kenya, through the judgment issued in NRB HC Petition No. 37, 49 and 106 of 2017 issued on 11th June 2020 ruled that CUE is the only body mandated by law to accredit programmes. This put at loggerheads CUE and the professional regulatory bodies, among them EBK. EBK is in discussions which the relevant stakeholders, including, CUE on what to do so that the graduates do not suffer, due to the contradictions. For postgraduate programmes, it is only CUE which accredits them, since EBK is only interested in the undergraduate programmes.

As mentioned earlier, starting in the year 2000, many new universities in Kenya launched programmes in engineering. Some of the programmes were in line with the traditional ones and others were totally new on the market. The following are some of the challenges that emerged:

- for the traditional programmes, the number of available qualified lecturers in the country was not sufficient to service all the universities.
- Most of the Universities did not have sufficient number of required full-time staff.
- Some universities did not have the requisite laboratory spaces and equipment.
- Some curricula were not approved, yet students had already been admitted to the programmes.
- For the non-traditional programmes, Universities could not find qualified staff within the borders.
- Universities did not have enough financial resources to purchase equipment and hire expatriates for the programmes.
- On the other hand, EBK did not have local experts to evaluate programmes in the emerging areas.
- A number of universities admitted students into unaccredited programmes.
- A high turn-over of lecturers was experienced in some disciplines.

With time, students from some of the unaccredited programmes graduated. Registration as Graduate Engineers from these degree programmes was declined by the regulator. Reasons for refusal were inadequate staff qualifications; training facilities and curriculum/curriculum delivery as required by the standards. The standards provide guidelines on required resources as well as the structure of the curriculum. According to EBK guidelines, the curriculum of an engineering degree programme should meet specific minimums in basic sciences, engineering science, design, and complementary studies.

Industry needs: Graduates from the Kenyan Universities work in the Kenyan industry and beyond. It is therefore necessary that the engineers attributes satisfy the industry needs. Engagements with the industry shows that the needs are wide and dynamic. Feedback from the industry indicate that existing undergraduate curricula do not fully address these needs. Industries have to set aside resources for re-training and upgrading. While the Universities appreciate the deficit in skills-set, development of curricula in emerging areas has faced challenges in terms of recognition/accreditation. There is, therefore, a gap of skills in contemporary industry needs. To understand and work to bridge this gap, there has been concerted effort to improve the university-industry linkages and relations between the board and academia. A few academic staff members have been attached to the industry for a limited period of time, about one (1) month each. Industry partners have been invited to play a big role in the sharing of knowledge, skills and experiences to the university fraternity. Given that the staffing levels in the industry have always been lean, availability of the industry personnel has not been possible.

When it comes to postgraduate studies, very few engineering graduates venture into postgraduate studies leading to engineering qualifications. Many opt to take courses that will better their soft/complementary skills. Limited scholarships for postgraduate studies have also hampered enrolment into the programmes. This consequently has slowed down research which would otherwise have enhanced bankable industrial solutions.

To sharpen the skills of graduates, a number of universities have incorporated industrial attachment in the undergraduate degree programmes. There are efforts to enhance complementary studies in the curricula. The industry encourages more students to undertake postgraduate studies in the core areas of engineering. The industry is however not committal in financing the attachments, research and scholarship.

Curriculum delivery: As a tradition, universities tend to retain the best students for postgraduate studies and eventually absorb them into their faculty. Without proper university-industrial collaborations, this process

denies these good graduates a chance to gain industrial experience. Secondly, many engineering faculty do not have pedagogical qualifications, since it is not a requirement to teaching/lecturing and conducting research in an engineering school. These two comments affect quality of curriculum development and delivery.

Efforts made to bridge the gap: A number of efforts have been made by the National Government, development partners, professional bodies (i.e. EBK and IEK) and individual researchers to bridge this gap. Some of the positive stakeholders' activities that have taken place are:

- disbursement/winning of a grant from the African Development Bank (AfDB) of KShs 39 million shillings to train lecturers at postgraduate level at Egerton University. (https://nation.africa/kenya/news/education/sh39m-afdb-programme-to-train-engineering-lecturers-3494264).

- African Development Fund Country: Kenya Support to The Enhancement of Quality and Relevance in Higher Education, Science and Technology Project. Project Appraisal Report – October 2012 (https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Kenya%20-%20Support%20to%20the%20Enhancement%20of%20Quality%20and%20Relevance%20in%20Higher%20Education%20Science%20and%20Technology%20Project%20-%20Appraisal%20Report.pdf).

- Master's and PhD scholarships tenable at JKUAT and sponsored by Kenya Government and AfDB (https://jkuat.ac.ke/wp-content/uploads/2017/07/African-Development-Bank-Post-Graduate-Scholarship.pdf).

- DAAD Scholarships.

- Higher Education Partnerships for Sub-Saharan Africa project, which has seen funding to Moi University, Technical University of Kenya, Masinde Muliro University of Science and Technology, Murang'a University of Technology, among others. The RAENG sponsorship were disbursed to enhance the capacity of training for engineering faculty in the sub-Saharan region, through industrial internships and trainings. Feedback from the HEP SSA beneficiaries twenty-seven (27) faculty members from five (5) universities indicated that the members appreciated the exposure. The internship enhanced their exposure, improved the knowledge and skills and whence, the delivery of the courses. They recommended that such an activity should be done on a regular basis. Unfortunately, there is no budget allocated to such activities.

- Twenty (20) Masters and Thirteen (13) PhD scholarships from AfDB/Kenya Government to Moi University. Master's and PhD Scholarships in Renewable Energy and Textile Engineering at Moi University to ACE II World Bank project to Moi University. METEGA, MIRET, TEA LP are projects that provided postgraduate scholarships, among others.

While these are wonderful efforts, there is constant internal and external brain drain. Internal brain drain happens as a result of the highly trained experts taking up other duties, which do not require their acquired technical knowledge, or are simply disillusioned to do more. External brain drain is happening when the experts are totally relocating to other countries.

In Conclusion, the engineering education in Kenya is constantly growing. it is however facing a number of challenges, ranging from: low staffing levels, inadequate infrastructure, limitations in curricula content, little financial support for research and innovation, limited university-industry linkages and low subscription into postgraduate programmes. Though various stakeholders have contributed towards improvement of the engineering education in Kenya, to have an impact, more efforts need to be put in and more support from stakeholders is required. An innovative way of sustaining University-Industry linkages has to be devised. EBK together with the WFEO are in partnership in training experts in Kenya who will spearhead the review of the Kenyan programmes, so that the graduates from these programmes are recognized/acceptable globally.

Committee on Energy (CE): Vulnerability of energy systems

Energy storage challenges

Philip Pascall *(Committee on Energy, World Federation of Engineering Organisations, London, UK)*

Introduction

When discussing energy storage, there is a tendency to think exclusively about 'electricity' storage such as pumped hydro and batteries. A much greater amount of energy is stored as natural gas.

Energy storage is also often talked about as though it were the panacea for the transition to net zero, almost as though it were itself a source of future energy. It's not a panacea of course but energy storage will become increasingly important as we transition from dispatchable fossil fuels to renewable sources of primary energy, helping to optimise energy systems as they become more complex.

Variability of renewables

For twelve days from 5 to 16 December 2022, the temperature in the UK was mostly sub-zero, the wind was light and electricity generation from wind totalled about 1,500 GWh; generation from combined cycle gas turbines totalled about 6,000 GWh. That contrasted sharply with the twelve days from 19 to 30 December when the weather was mild and reasonably windy; electricity generation from gas was about 1,500 GWh and from wind was about 3,500 GWh.

This is not of course a rigorous analysis but take 6,000 GWh, or 6 TWh, as indicative of the magnitude of storage of energy that would be needed to cover an extended period of low temperature and light wind in winter, a '*Dunkelflaute*' or 'dark doldrum', for electricity generation.

Fluctuations in demand

At high latitude, or in a continental climate, the seasonal variation in heat energy is much greater than the variability of renewable electricity energy noted above. The maximum monthly demand for natural gas in winter in the UK is around three times the summer minimum.

Consumption in April is close to the average consumption through the year so, if gas production right through the year were equal to average consumption and, starting at the end of April, surplus production in the summer was stored for use in the winter, stored energy of about 70 TWh would be needed.

To put these amounts in perspective, although 70 TWh is much more than present storage capacity, UK total primary energy consumption in 2022 was nearly 2,000 TWh.

Another caveat: this is not a rigorous analysis. More storage might be required to provide for the switch to electricity for heating and transport, to cover losses in conversion processes, or because of year to year variability of renewables. Or less storage might be required because average wind strengths tend to be higher in winter, and because of efficiency improvements, development of heat networks, or additional provision of generation. However, it suggests that considerably more energy storage will be needed to allow for seasonal fluctuations in demand than for variability of renewable energy supply.

Energy storage options

In 2020, pumped hydroelectric storage (PHS) schemes accounted for more than 96% of worldwide capacity of 'electricity' storage, that is potential, kinetic or chemical energy that can be converted easily to electrical energy. There are four PHS schemes in the UK with a total energy storage capacity of nearly 30 GWh.

Battery storage is a rapidly growing market and the aggregate energy capacity in the UK in 2023 is about 3 GWh.

PHS and batteries will continue to provide important balancing services to maintain stability of the national grid. Other technologies will compete for short to medium storage of energy for electricity supply.

However, these storage capacities clearly fall well short of the need for longer-term storage to cover variability of supply and seasonal fluctuations in demand for heat described above. Gas provides a much better prospect for bulk long-term storage of energy.

The UK currently (2023) has gas storage capacity of around 9 to 15 TWh. That's equivalent to about two weeks of gas demand, and at least three hundred times more than the present capacity of PHS. It would be feasible to increase that quantity substantially using salt caverns or depleted natural gas reservoirs.

Many other countries have considerably more gas storage so are better placed to cope with seasonal demand fluctuations, or disruption of supply.

The future gas will be hydrogen or other gas synthesised from renewable sources.

Costs of energy storage

Gas storage is considerably cheaper than other technologies that rely on potential, kinetic or chemical energy. The capital cost of constructing gas storage lies in the range of about 3.5 to 9 $/kWh. The ranges of costs for batteries and PHS are about 150 to 250, and 150 to 450, £/kWh respectively. The capital cost of providing gas storage is therefore around one fiftieth of that for batteries or PHS.

That may seem surprising but the chemical energy in 1 m^3 of natural gas at STP is equivalent to the potential energy of 1 m^3 of water at a height of about 100 m. Gas caverns operate typically at 50 bar or more, so the lower cost can be understood in the context of comparative energy density.

The capital cost (in $/kWh) of storage of liquid fuels such as motor spirit or DERV in large storage tanks may be roughly comparable or cheaper than gas storage.

Switching from fossil fuels to renewables will not be cheap. To do so affordably and realise the promises of benefits from a green economy we hear so much about, we must use energy much more efficiently and effectively than we do now, for example by insulating homes better, using heat pumps, and using electric motors which are much more efficient than internal combustion engines.

Whilst on the subject of costs, levelised cost of energy is not a satisfactory way of comparing costs of different classes of generation, let alone energy storage; overall system costs need to be considered.

Heat networks

Heat networks use low-grade heat, often waste energy, and can be a very effective way of providing heat and reducing carbon emissions in an urban environment. They can also store large quantities of low-grade heat energy relatively cheaply.

Denmark sets a good example where around 65% of citizens are served by heat networks. Copenhagen is an exemplar with several district heat networks; it advertises its credentials with a ski slope on the roof of a waste to energy plant.

District heating networks that mix industrial, commercial and residential inputs and demands provide an opportunity for sharing thermal energy, thereby increasing the overall efficiency of the system.

There is a large untapped potential in the UK where just 2% of the population are connected to heat networks. Perhaps surprisingly, there is a small (by Copenhagen standards anyway) heat network in the City of London. It incorporates a large hot water tank for short term storage, and three deep boreholes serving heat pumps that tap into a considerable resource of low-grade heat in the ground under London. In the summer months when consumers are provided with chilled water, the ground is recharged with heat, extending heat storage to a seasonal time scale.

Heat networks can use carbon dioxide as the energy conveying fluid, in the gaseous phase in the flow part and liquid in the return part of the circuit. Phase changes and connections via heat pumps improve the overall efficiency of the network and allow for both heating and cooling from the same circuit. Long-term

thermal storage can come from a lake or from the ground. An additional advantage is that pipework is significantly smaller diameter than for water systems.

No attempt is made here to quantify the potential for energy storage in heat networks but the success of heat networks in places such as Copenhagen shows that they could make an important contribution to eliminating carbon emissions. As well as using thermal instead of gas energy storage, the efficiency gains from balancing inputs and outputs in a network, using waste heat, heat pumps and low-grade stored energy reduce the need for electricity generation and conversion processes.

Systems engineering, synergies and optimisation

Through much of the last century energy systems were comparatively simple and linear. Simplistically, electricity was generated from coal, heat came from gas, and transportation was powered by petroleum products. Natural gas changed that slightly, being used for electricity generation from the latter part of the century.

As we introduce renewables and greater diversity in our energy networks, our energy systems are becoming interconnected, inter-dependent, and more complex. As well as complexity, these changes introduce opportunities for synergies and optimisation.

A systems engineering approach is therefore vital in the development of this much more complex energy landscape to realise the opportunities, thereby minimising cost to the consumer whilst maintaining security of supply and reaching net zero emissions.

The following are just a few examples of synergies that might be achieved.

At the smallest scale, ‘solar lights’ are replacing kerosene lamps in such places as Sub-Saharan Africa, a step towards reducing the number of people without access to electricity.

Solar panels with batteries might provide round-the-clock electricity for communities in a consistently sunny climate. Batteries also enhance the return on investment. Solar water heating is likely to be a good solution in the same environment. Solar PV for cooling in a sunny climate is also a good match because peak supply and peak demand roughly coincide.

More sophisticated optimisation is needed to interface solar PV and off-peak purchased electricity to minimise the cost of charging an electric vehicle (EV), and to use the EV battery at peak times to reduce demand on the grid or to export electricity to the grid.

As well as absorbing surplus renewable generation, making hydrogen by electrolysis can provide a variable demand for nuclear powered electricity generation which thereby effectively becomes dispatchable. Hydrogen can be produced centrally in large electrolysis plants and distributed by pipeline and tanker, or the electricity can be distributed to small electrolysis plants at depots and filling stations.

At grid scale, the mix of electricity generation, the type and quantity of energy storage, conversion processes, and the transmission and distribution of energy should be optimised to fulfil the objectives of security of supply, affordability and net zero. The system architecture should be consistent with stable energy policies that attract investment in the wide variety of assets needed.

Conclusions

Considerable energy storage will be needed to facilitate the switch from fossil fuels to renewables. The bulk storage medium is likely to be hydrogen or other synthetic low-carbon fuel because gas storage is much cheaper than other forms of energy storage. Thermal storage in heat networks offers untapped potential to improve efficiencies for heating, and to reduce gas storage. A systems engineering approach is needed to optimise all aspects of future energy systems and to achieve resilience, affordability and net zero.

White paper from STC on Energy – The future role of hydrogen as a versatile energy vector in a changing World

Massimiliano Capezzali *(Institute of Energies, School of Engineering and Management Vaud (HEIG-VD) – University of Applied Sciences of Western Switzerland (HES-SO), Yverdon-les-Bains (VD), Switzerland)*

Hydrogen production – The need for decarbonized hydrogen

Hydrogen is expected to bring solutions to the decarbonization of the energy, mobility and industrial sectors – though probably to a lesser extent in the residential sectors – but under certain conditions. Indeed, its place in energy systems is the subject of numerous studies highlighting its possible contribution to present-day and future energy challenges. However, on one hand, it must be noted that many of these analyses suffer from the absence of an evaluation of the complete cost of hydrogen delivered to the final users, in a holistic approach. Hence, an objective measure of its potential competitiveness is still missing, also due to uncertainties on future technology and energy prices. On the other hand, in order to evaluate the possible contribution of hydrogen to decarbonization, its carbon intensity, must be calculated over the entire value chain, for example, the European Commission uses a life cycle limit of 3 kg of CO_2 per kg of hydrogen to characterize decarbonized hydrogen. In that sense, the current habit of distinguishing hydrogen by attributed « colors » can be misleading if used without precautions. Only a precise evaluation of the overall carbon intensity of a given hydrogen-based scenario (including both feedstock and conversion technologies) can ensure that it brings positive environmental benefit for a given usage sector.

Since hydrogen needs to be artificially produced, the basic chemical « source » material as well as the energy vector used to decompose it are of crucial importance. If fossil chemical compounds such as methane and coal ought to be avoided, the main route for obtaining hydrogen is electric water splitting. Hydrogen can be gained back from other molecules in which it has been bound for storage but after having been produced either by steam reforming or water splitting, i.e. from materials such as ammonia, methanol or metal hydrides that are not naturally present in the environment. For water splitting, highly purified water must be provided stemming from a sweet water source or from a dedicated desalinization plant. It must be highlighted that, upon using water or ammonia for obtaining H_2, on top of hydrogen, the chemical reaction produces two gases that can either be further valorized (oxygen) or safely released in the atmosphere (nitrogen), while no carbon is emitted.

In view of the above, the environmental impact and carbon content of the energy vector used for the hydrogen-producing chemical reaction – most of the times electricity to be injected in electrolyzers – is of crucial importance. The energy input thus should be of renewable origin – PV, wind, geothermal or hydro. Alternatively, other energy sources can also be used: i) nuclear power that represents a decarbonized energy source, with high-temperature levels that ensure high-efficiency hydrogen steam-based production processes; ii) natural gas reforming coupled with CCS capacities in order to avoid any direct GHG emissions in the atmosphere and provided the process energy is supplied by renewable resources, e.g. geothermal. Additional hydrogen production routes are presently considered, including methane pyrolysis that leads to the capture of carbon in solid form, thus facilitating further valorization, e.g. in soil conservation and remediation schemes, as well as storage and transport.

Therefore, depending on local specific territorial, as well as infrastructural conditions (e.g. availability of a given low-carbon power resource), a variety of decarbonized hydrogen production pathways can be put in place. However, this shall always imply, as a systemic pre-condition, a sharp increase in low-carbon power generation capacities with respect to present-day levels. In any case, the production of decarbonized (or clean) hydrogen is expected to increase sharply in the three coming decades, along with a huge deployment of additional electrolyzer capacities.

Hydrogen demand – Necessary in hard-to-abate sectors

One question arises quite naturally though, namely why bother using hydrogen as an energy vector, instead of directly taking advantage of renewable and/or low-carbon electricity? Indeed, in order to solve this seemingly paradox, both intermittent production of most renewable energies, as well as technical constraints inherent to certain usage sectors must be taken into account.

It is certainly useful to remind that World's annual consumption of hydrogen stands at about 94 Mt, including 10 Mt in the European Union. The main market is represented by the production of ammonia, a basic chemical compound in many industrial sectors, such as the production of fertilizers. As already mentioned above, the largest proportion is represented by CO_2-laden hydrogen produced by methane reforming. In an emerging market, supply and demand must develop at the same pace. But in the case of hydrogen, a common sense reaction would imply that decarbonized production could start now, even if the additional demand is not there yet: the production of carbon-heavy hydrogen should already be replaced by decarbonized hydrogen to meet the existing demand. Conversely, there exists the risk of having a too fast deployment of additional hydrogen demand that could in principle be satisfied by non-decarbonized hydrogen, if the supply of low-carbon hydrogen is not available in substantial quantities and at viable economic conditions.

The starting point of any renewed interest in hydrogen underlies in the necessity to find ways to store electricity. Indeed, in case of surplus power production, part of the electricity production can be turned into another energy vector to be used at a later time – albeit with unavoidable though reasonable conversion losses –, in various forms – e.g. heat – or stored one more time as chemical material. The conditions under which such a « conversion chain » is considered to be low-carbon have been very precisely defined – both timewise and in terms of spatiality – e.g. by the European Commission. On the other hand, there are many energy-hungry sectors that cannot be electrified and hence need an alternative to either gaseous or liquid fossil fuels: cement plants, steel production, heavy long-haul trucks, aso. It will thus be of crucial importance to identify the complementarity between low-carbon electricity and low-carbon hydrogen and to carefully weigh in which sectors these two routes give way to the most sensible solutions, in economic, environmental, as well as exergetic terms. Under these preconditions, hydrogen, along with biomass valorization, can represent one crucial element in decarbonizing a portion of the hard-to-abate usage sectors.

Hydrogen can be stored in both gaseous and liquid forms, thus requiring compression or liquefaction capacities. It can also be transformed in other chemical compounds such as ammonia, methanol, formic acid and metal hydrides. Each storage method requires different methods in order to retrieve hydrogen and make it available again, with process-specific inherent conversion losses and an energy investment. However, the various storage possibilities address the intrinsic obstacles and the related challenges linked with the transportation of pure hydrogen in compressed or liquified forms.

Last but not least, it must be noted that hydrogen transport and distribution – and thus the emergence of a true hydrogen value chain – can be made significantly easier, as well as financially viable, by using the existing natural gas transport and distribution infrastructure. Indeed, hydrogen can be mixed up with methane up to shares of 20% (so-called blending), depending on the grid specificities and components, while some care must be taken in function of the final usage. The usage of existing natural gas infrastructure is a crucial element in many national hydrogen roadmaps, in countries such as Denmark and Germany for instance.

Hence, in terms of energy usage, hydrogen will certainly be able to bring an important contribution to decarbonization mostly in three sectors. First, in the residential and heating sector, hydrogen-based technologies such as fuel cells can contribute to the efforts aiming at gradually replacing standard oil and gas boilers, with the additional advantage of being able to operate in cogeneration mode and concomitantly generate power. Second, in the industrial sector, hydrogen is one of the unique alternatives to fossil fuels

such as natural gas within high-temperature processes in combustion mode. Third, hydrogen can be used to replace fossil fuels in the mobility sector with privileged focus on heavy-duty transport, light maritime routes (ferries) and trains on non-electrified networks. It must be stressed that hydrogen will not bring an overall solution since the available quantities will be limited, thus highlighting the need to develop sensible policy prioritization based on local conditions. Low-carbon hydrogen should be implemented in situations where maximal environmental and energy positive effects can be attained, taking into account all the constraints. Hydrogen will thus need to be used in complementarity with other technologies.

The contribution of hydrogen will be two-faced in terms of increased sustainability of the energy domain. On one hand, in terms of technology substitution (e.g. gas boilers to fuel cells), it allows aiming at higher (energy and exergy) efficiencies and lower emissions. On the other hand, hydrogen is one of the energy vectors that will allow implementing the so-called « seasonal storage » of the expected excess renewable production in summertime, which is crucial in continental climate countries.

Hydrogen transport

Presently, only a limited transport and distribution pipeline infrastructure dedicated to hydrogen is operative in the World, with some exceptions in some heavily industrialized regions in Europe and North America. Hydrogen can be safely transported by trucks and trains, as well as on board of specifically designed boats in liquified form (although the latter presently are considered to be in a pre-industrial phase). However, the expected increase of both hydrogen production and demand will require developing an – most probably underground – infrastructure comprising of dedicated pipelines, substations and end-use interfaces.

Alternatively, the natural gas transport and distribution grids can be either converted to full hydrogen or used to transport both gases blended in percentages usually chosen well below 20% H_2/CH_4. With adequate adaptations, the mixture can be then be used in stationary or embarked conversion appliances as such (for instance boilers and fuel cells) or undergo so-called deblending processes. The latter allows separating the two gases again, as a function of the final usage in a given network sector, e.g. where a specific industrial site is located. Numerous studies on blending in various grid configurations and typologies, as well as for most residential and industrial applications have been proposed and directives are now available.

Envisioned usage sectors towards maximal positive environmental benefits

The sectors for final usage must be selected carefully based on territorial, economic and environmental criteria, always taking into account the foreseen limited availability of decarbonized hydrogen, at least before the end of the century. Particular care must be taken, for instance, in the mobility sector, where electrification certainly can bring solutions to private individual mobility and in many instances of public transportation, while decarbonized gases and fuels should probably be prioritized for heavy-duty transport, non-electrified public transportation and some typologies of short-track maritime transport, e.g. islands and harbour-bound ferries.

Concomitantly, renewable gases and hydrogen should not be used for individual heating systems but rather be limited to large energy conversion systems supplying neighbourhood district heating systems and industrial sites, fostering co- and tri-generation applications whenever appropriate and financially sound. Strong emphasis must be brought on the crucial need for decarbonized hydrogen in high-temperature industrial processes to replace natural gas and petroleum-derived fuels. Hence, the policy keyword must be sensible prioritization at regional, national and international level, in order to maximally exploit the positive aspects of hydrogen-based technologies.

Regarding non-energy usages of hydrogen, mainly as a fundamental chemical « building block », the contribution of decarbonized H_2 is in fact double. On one hand, it can directly replace hydrogen obtained from fossil energies such as natural gas, thus proportionally improving both GHG emissions and sustainability.

On the other hand, excess renewable energy stored in the form of H_2 would have been « lost » for example due to curtailment procedures enacted in case of excessive production. Therefore, its conversion in chemical components represents a step forward in terms of sustainability and improves the overall resilience of the industrial supply.

Arbitration by market forces, as well as by fact-based (national and international) policies will be needed among all the possible usages of decarbonized hydrogen and gases mentioned above.

Committee on Engineering and the Environment (CEE): Role of engineering in addressing climate change: systemic solutions for global challenges

Engineering the World for Climate Change

Davide Stronati *(Chair of the WFEO CEE, Institution of Civil Engineers (UK) and WFEO, London, UK)*

This is a session organised by the WFEO Standing Technical Committee on Engineering and the Environment.

This session will showcase the work of the varied WFEO committees and colleagues in the area of climate change. This session will outline the vast breath of knowledge and impact that WFEO and the global engineering community have on addressing this global emergency.

The event will see presentations from Chairs and members of WFEO's committees who are actively involved in the achievement of the UN Sustainable Development Goals. We will hear perspetives from engineers about disaster risk management, and reasoned opinions of those who design energy systems around the world. We will also hear about the role of women and young engineers in shaping sustainable infrastructure.

Complex management of disaster risk in climate change setting

José Macharé *(Peruvian Engineers Association, Lima, Peru)*

The ongoing global warming and related climate change are altering natural physical, chemical, geological, and biological processes disturbing the often-fragile equilibria among its components. The effects have been called *slow onset events*, and include: sea level rise, ocean acidification, glacial retreat, increase in temperatures, desertification, deepening of groundwater table, soil salinization, land and forest degradation, and loss of biodiversity. More than events, they are permanent trends of change in systems that underly the short sudden events known as *natural hazards* and associated *man-made hazards*.

Engineering systems and technical actions intended to manage the disaster risk – chiefly processes of risk reduction and prevention – are based on the event occurrence probabilities and an estimated vulnerability level. Climate Change and its effects modify – sometimes in a non-linear way – the entry conditions for modeling the risk. For example, concerning extreme weather events, the return periods are generally calculated considering 30-years period climatology. But recent observations display an increase in intensity and frequency of such events running out of the predicted ranges. On the other hand, unforeseen changes of geographical conditions may increase the exposure, terrain instability, or social fragility and therefore the actual vulnerability level of populations.

Therefore, disaster risk management systems have to become more complex, to design devices and strategies taking into account these changing – and sometimes unexpected – conditions, and setting up more performant early warning systems. All this should be articulated with the mitigation and adaptation processes for CC management.

Adaptation to Climate Change, Water and Engineering

Ignacio González-Castelao Martínez-Peñuela *(Chair of the Standing Technical Committee on Water, WFEO, Madrid, Spain)*

Although there is a chronic and consistent lack of data on almost all water-related SDG-6 indicators, the average progress rate for all of them is 52%. This means that we need to accelerate action, as we are not yet moving at the speed and scale needed to achieve the sustainable development goals set for water.

This current situation is exacerbated primarily by non-climatic factors, such as population growth and current production and consumption patterns. Climate change is an added problem to this current situation, increasing pressure on already stressed water resources. Regarding climate change, the degree of mitigation we achieve will determine the level and measures needed for adaptation. The more mitigation, the less adaptation.

Droughts and floods are also increasingly perceived by society as the visible face of climate change. Faced with this situation, humanity must adapt to these new scenarios.

From an engineering perspective, the main adaptation measures can be grouped into three categories: those related to water supply-demand, extreme weather events and sea level rise. The term “demand” should be holistic and also refer to all other living beings and natural ecosystems.

Adaptation measures bring multiple benefits, but we must build infrastructures from a different perspective putting more value on their relationship with the rest of the stakeholders, such as the environment.

Building a Greener Tomorrow: How Young Engineers are Shaping Sustainable Infrastructure

Firas Nazeeh Bou Diab *(Chair, WFEO Young Engineers / Future Leaders Committee, World Federation of Engineering Organizations (WFEO), Beirut, Lebanon)*

Building a Greener Tomorrow: How Young Engineers are Shaping Sustainable Infrastructure

Introduction

In an era defined by the urgent need to combat climate change, the role of young engineers in shaping sustainable infrastructure is of paramount importance. This extended abstract delves into the innovative approaches and transformative actions undertaken by young engineers to construct a greener tomorrow through sustainable infrastructure development. These emerging leaders are actively driving change by integrating sustainability principles, leveraging advanced technologies, fostering collaboration, and advocating for policy reforms.

The global challenge of climate change has spurred a critical shift in our perspective on infrastructure development. As the effects of environmental degradation become increasingly evident, there is a growing consensus that sustainability must be at the core of all infrastructure projects. Young engineers, often heralded as the future leaders of the industry, are at the forefront of this paradigm shift. This extended abstract explores how they are driving the agenda for sustainable infrastructure by adopting innovative practices, collaborating across sectors, and advocating for policy changes.

Integrating Sustainability Principles

Young engineers are revolutionizing infrastructure development by placing sustainability at the center of their projects. This shift is characterized by:

- Sustainable Design: These future leaders prioritize sustainable design practices that not only meet functional needs but also minimize environmental impact. Concepts like green building, sustainable transportation, and eco-friendly materials are integral to their approach.
- Carbon Emission Reduction: Recognizing the role of infrastructure in greenhouse gas emissions, young engineers are adopting construction methods and materials that reduce carbon emissions and improve energy efficiency.
- Resource Conservation: Sustainable infrastructure aims at conserving vital resources such as water and energy. Young engineers incorporate innovative technologies to achieve resource efficiency and minimize waste.

Leveraging Advanced Technologies and Materials

Advanced technologies and materials have become indispensable tools in the arsenal of young engineers as they work toward sustainable infrastructure:

- Smart Infrastructure: The integration of Internet of Things (IoT) sensors and data analytics allows young engineers to design and manage infrastructure that responds dynamically to environmental conditions, reducing energy consumption and optimizing performance.
- Renewable Energy Integration: Solar panels, wind turbines, and other renewable energy sources are increasingly integrated into infrastructure projects to reduce reliance on fossil fuels.
- Innovative Materials: Young engineers are exploring and adopting eco-friendly building materials, including recycled and sustainable options, to reduce the environmental footprint of construction.

Fostering Collaboration and Knowledge Sharing

Sustainability in infrastructure is a complex endeavor that requires the engagement of diverse stakeholders. Young engineers recognize the power of collaboration and knowledge-sharing:

- Stakeholder Engagement: These future leaders actively engage with policymakers, industry professionals, and the community to build consensus on sustainable infrastructure goals and advocate for policy changes.
- Cross-Sector Collaboration: They bridge gaps between engineering, environmental science, and urban planning, fostering interdisciplinary collaboration to tackle complex sustainability challenges.
- Best Practice Dissemination: By sharing best practices, young engineers accelerate the global adoption of sustainable infrastructure solutions, ultimately contributing to broader climate change mitigation efforts.

Conclusion

In conclusion, young engineers are pivotal in the transformative journey toward building a greener tomorrow through sustainable infrastructure. Their innovative thinking, technical expertise, and commitment to sustainability principles are reshaping the infrastructure landscape. Their ability to foster collaboration and advocate for policy reforms is expediting the transition to more environmentally responsible infrastructure practices. This abstract serves as a call to action, emphasizing the significant contributions of young engineers in constructing a sustainable and resilient future.

As the world confronts the escalating challenges of climate change, young engineers are not merely spectators; they are leaders of change, architects of sustainability, and advocates for a better future. Their efforts, combined with the collective will of the global community, hold the promise of a more sustainable and prosperous tomorrow. Young engineers are not just building infrastructure; they are constructing a legacy of stewardship for generations to come.

The WFEO climate change mitigation best practice project

Jianping Wu *(Tsinghua University, Beijing, China)*

The negative impact of climate change on forests, species, water supply, and human health is immeasurable. The WFEO Climate Change Mitigation best practice project, which focuses on engineering and climate actions, has the potential significance for our obligation to global climate emergency responses via collecting successful project examples on climate change mitigation, and sharing the best practice projects with all WFEO member countries. The cooperation of national members and partners will provide tremendous help to the development of this project, strengthen the partnership between countries. The climate change mitigation best practice project hopes to get help from all WFEO national members.

The speaker will present the detail of the project and the preliminary results and progresses of the project.

The important role of WEF* (Water, Energy and Food) technologies in responding to the challenge of reducing energy poverty by mitigating climate change

Ania Lopez *(WFEO/Consiglio Nazionale degli Ingegneri, Rome, Italy)*

In a context of continuous climate change, wars, political divisions, calamitous events, natural resources have become precious, many solutions through innovation and technology can offer benefits, improving our lives and protecting the environment. Global agreements exist to guide progress towards a green economy and raise the quality of life, the Sustainable Development Goals of Agenda 2030 are milestones in this path, as are the United Nations Framework Convention on Climate Change and the Paris Convention, the bodies belonging to the United Nations, such as UNESCO, FAO and WFEO are carrying out an important work of scientific dissemination to counter this unstoppable change.

There are three great protagonists of this challenge: water, energy and food (WEF), which allows, through a perfect combination of innovation and technology, to rebalance the harmful actions carried out in the past, arguing that our planet has been able to resist any human interference. Take up the challenge launched by FAO in the *Strategic Program framework (2022-2031) the best 4, best production, best food, best environment and best life*, putting these 3 elements at the center and linking each of them with the SDG of the Agenda Food SDG2, Energy SDG7, Water SDG6. Can we help and provide solutions to the problems of today's world? Yes, this is the objective of our proposal.

Committee on Engineering for Innovative Technologies (CEIT): Empowering Engineers – Harnessing Innovative Technologies for Sustainable Development

Digital transformation through engineering: a disruptive new world order in Africa's favour

Martin Manuhwa (WFEO CECB, Harare, Zimbabwe)

Industry 4.0 is an opportunity for the world, especially Africa to achieve most of the Sustainable Development Goals (SDGs) targets. Digital technologies and ICTs developments as represented by broadband internet in artificial intelligence (AI), big data, internet of things (IoT) (medical, energy, transport etc), robotics, artificial intelligence, cloud computing, facial recognition and augmented reality, machine learning and deep learning should be quickly harnessed by all engineering practitioners to accelerate development. The digital transformation crusade has also played a critical and successful role in the fight against COVID-19.

It is the IR4.0 that will ensure Africa leapfrogs the achievement of the SDGs. We are very fortunate to have digital technologies to accelerate the process of inquiry-based or evidence science literacy. While the allure of disruptive technologies cannot be denied, organisations need to carefully evaluate those technologies in their business context.

In the post COVID-19 pandemic era, the digitisation of our lives especially on-line education will be more and more important. However, some 3.8 billion people on earth are not connected or have no access to broadband internet and cannot avail themselves to the benefits of the digital transformation era. This advent of technology should make anti-corruption a lot easier as they bring new means of interconnectedness and unprecedented surveillance. In the Digital era, success is about leading with experience, being agile and blending within the ecosystem. Digital transformation is a journey – "It is a means to an end, not an end in itself".

Committee on Information and Communication (CIC)

Mass Transportation-METRO's Scenario in India

Satyanarayansingh S Rathore *(Institution of Engineers (India), Gandhinagar, India)*

This paper/presentation showcases the scenario of Metros in India. Between 1950-2020 India's population has quadrupled to 1.396 billion, of which 52.9% are active workers. Migration for education and work, draws populations towards cities, leading to massive urban sprawl. Private vehicle ownership in India is currently around 139 million vehicles, as these suburbanites require transport to city centres regularly.

Metros are serving as a key transport solution to rapidly growing urban India. In the year 2004 the cumulative network of metro systems was 42.38 km, whereas today it stands at 832 km with a doubling of network expected within the next decade. Daily ridership has increased from 0.39 million in 2004 to 7.21 million at present. Diligent planning of these networks ensure suburban connectivity with CBDs, commercial centres and other important locations such as educational institutions and religious centres.

Metros could become the primary mode of urban/suburban transport with allied infrastructure and services, they can also help address UN SDG 9 through development of sustainable and resilient transport & infrastructure. Metros also offer the opportunity to develop equitable, inclusive and greener cities in India in line with UN SDG 11, while the overarching benefits pertaining to climate change, public health and social impacts are also accrued. Improved research, adoption of new technology and skilled talent pool because of spurt in Metros in India are providing additional benefits by engaging of institutions, consulting, engineering and public organizations as well. Its impact on employment, economy and health makes its role in India extremely vital.

Committee on Women in Engineering (WIE): Engineering for Life, and the role of women

Engineering for Life: The Role of Women

Jeanette M Southwood *(Vice President, Corporate Affairs and Strategic Partnerships, Engineers Canada, Ottawa, Canada),* ***Yetunde Holloway*** *(Chair, Women in Engineering Committee, World Federation of Engineering Organizations, Lagos, Nigeria),* ***Dawn Bonfield*** *(Royal Society Entrepreneur in Residence, King's College London, London, UK),* ***Wen-Jean Hsueh*** *(Chair, Women in Engineering, Chinese Institute of Engineers, Hsinchu City, Taiwan),* ***Ania Lopez*** *(Project Manager, Italian Government, Consiglio Nazionale degli Ingegneri, Viterbo, Italy),* ***Reine Mbang Essobmadje*** *(Co-founder of Digital Coalition / CEO of Evolving Consulting / Vice-President of GICAM, Douala, Cameroon),* ***Lorato Ntsie*** *(BIM Civil Engineering Consultant, MAP 5D AFRIKA, Johannesburg, South Africa),* ***Lidia Zakowska*** *(Professor in transport engineering, Cracow University of Technology, Cracow, Poland)*

Overview: The WFEO Women in Engineering Committee is honored to introduce an in-person moderated Discussion Panel as part of WEC. The session will dive into the theme 'Engineering for Life' with a special focus on the pivotal role women play in this realm.

Background: Throughout most of history, women have often been perceived as caregivers, the nurturing force behind families and communities. A trend has emerged wherein women are increasingly gravitating towards careers that encapsulate care for our planet. The United Nations' Sustainable Development Goals (SDGs) offer a holistic approach towards people, planet, prosperity, peace, and partnership.

This session aims to address vital questions such as:

- Is the role of women different from men in engineering for life – and why?
- How can engineering rebrand itself as a profession deeply rooted in care and prioritizing people-centric solutions?
- How can mentorship and related initiatives boost representation of women in engineering?
- What factors contribute to underrepresentation of women engineers in business?
- What is – and what could be – the role of professional organisations in attracting and retaining women in engineering? What is the importance of women belonging to professional organizations and holding senior roles in those organizations?

Session Details: The session will take place on October 11 from 5:15-6:45 pm in Club D at the Congress Centre.

Panel Composition: The panel comprises accomplished women engineers from across the globe. Each brings a unique perspective and invaluable experience to the table. Biographies are included at the end of this abstract.

- Jeanette Southwood, Canada (Panel moderator)
- Yetunde Holloway, Nigeria (WFEO WIE Chair)
- Dawn Bonfield, UK (WFEO WIE Deputy Chair)
- Wen-Jean Hsueh, Taiwan
- Ania Lopez, Italy
- Reine Mbang, Cameroon
- Lorato Ntsie, South Africa
- Lidia Zakowska, Poland

Conclusion: We invite delegates and attendees to join us for this enlightening session, as we unravel the intertwining narratives of women in engineering and their significant contributions towards crafting a sustainable, people-focused future. It promises to be a dialogue that not only sheds light on the current landscape but also charts a path for the future role of women in engineering.

Biographies:

Jeanette Southwood, FCAE, FEC, LL.D. (honoris causa), P.Eng., IntPE, Vice President, Corporate Affairs and Strategic Partnerships, Engineers Canada: Engineers Canada is the national organization of the 12 regulators that license Canada's more than 300,000 members of the engineering profession. Before joining Engineers Canada, Jeanette led the Canadian Urban Development & Infrastructure Sector and the Global Sustainable Cities teams at an international consulting firm where she was the first Black woman to be appointed to the senior leadership position of Principal globally. An award-winning engineer and leader, Jeanette is a Fellow of the Canadian Academy of Engineering, which recognizes engineers contributing in exemplary ways towards their disciplinary fields and the wider community. She has received an Honorary Doctorate and also the Ontario Professional Engineers Awards' Engineering Excellence Medal. She was also honoured as one of Canada's Clean50 for her work and dedication to sustainable development, leading change, championing innovation, and changing our world for the better. A dedicated volunteer, Jeanette is a Fellow of Engineers Canada, a recipient of the Province of Ontario's "Leading Women Building Communities Award," and a recipient of Canada's Governor General's Sovereign's Medal for Volunteers. Jeanette has been inducted into the University of Toronto's Engineering Hall of Distinction and was twice named one of WXN Canada's Top 100 Most Powerful Women, as well as being recognized as one of the Women of Innovation. She was appointed an Honorary Captain of the Royal Canadian Navy; she is the first Honorary Captain to be affiliated with the Naval Engineering Community. She was featured in the Royal Canadian Mint's campaign for a new coin honouring Canada's first practising woman engineer, Elsie MacGill. In December 2023, Jeanette will begin serving on the Electrical Safety Authority Board. She is a member of the TD Insurance Advisory Board on Climate Change.

Yetunde Holloway, Chair, Women in Engineering Committee, WFEO: Yetunde is a Civil Engineer from the University of Lagos, Nigeria. She is an Associate of Chartered Arbitrators (UK), ACIArb and works as an executive board member of the Special Committee for Rehabilitation of Public Schools (SCRPS) in Lagos State, a policy implementation agency of the Lagos State Government, dedicated to improving infrastructure in public schools in the State. The team has increased the number of classrooms by an estimated 10-15%, in the last 3.5 years. Newer and modern schools have also been constructed in Elemoro, Igbookuta and other hitherto underserved communities in Lagos. Yetunde is presently the Chair of the WFEO Women in Engineering Committee, and promotes Equity, Diversity and Inclusion (EDI) in the engineering space. As Chair of WIE of WFEO and FAEO, Yetunde's role has included facilitating various events to promote interests of women, especially female engineers, and to highlight their vital roles in achieving the SDGs. She is keenly interested in the development of Strategic Engineering Indicators, as well as the achievement of the SDGs, with particular emphasis on Goal 5. As a STEAM advocate, she initiated the Virtual STEAM ART competition for African girls aged 5-11 (and now boys) across the African Continent. The competition also seeks to engage young minds imaginatively, to address climate change issues, as well as other problems in African communities. It also highpoints the unique collaboration between creativity, innovation and technical expertise. She mentors several young and aspiring engineers and particularly encourages professional development of female in STEM Engr. Holloway represents WFEO on the board of the International Coalition for Sustainable Infrastructure (ICSI). Yetunde is particularly interested in Climate Change issues and believes that "The future of planet Earth can only exist within the precepts of equitable, resilient and sustainable infrastructure, which caters to all, regardless of, race, education, ethnicity, gender, occupation, social status, social strata or creed''.

Dawn Bonfield MBE FREng, Royal Society Entrepreneur in Residence at King's College London: Dawn works with student engineers on addressing the SDGs as entrepreneurs. She has been Royal Academy of Engineering Visiting Professor of Inclusive Engineering at Aston University since 2017, and is the Founder & Director of Towards Vision, a not-for-profit which works towards a vision of diversity and inclusion in engineering. She is Past President and former Chief Executive of the Women's Engineering Society (WES). Dawn is Deputy Chair of the Women in Engineering Committee of the WFEO working on the application of engineering and technology to address gender inequality globally. Dawn has recently been a member of the Engineering Design T level panel, and serves on a number of educational committees promoting engineering and engineering education. She is founder of the social enterprise 'Magnificent Women' which celebrates the history of women in engineering, and she was the founder of International Women in Engineering Day (INWED) which takes place on 23 June annually.

Wen-Jean Hsueh, Chair, Women in Engineering, Chinese Institute of Engineers, Taiwan ROC: Wen-Jean Hsueh co-founded the non-for-profit "tuneUp labs" in 2021 devoting to the exploration of mind through integrating technology and the arts. She was co-founder and general director of Creativity Lab and its subsequent programs at the Industrial Technology Research Institute (ITRI) of Taiwan 2004-2016, leading cross-disciplinary teams to discover unique human-centric values in R&D by integrating technology, design, marketing, and the arts, and thus cultivated numerous creative ideas, talents, and integrators. Wen-Jean often plays the role of vanguard. She became the first technologist to serve as VP for National Taiwan University of Arts 2016-2021; was the first female member elected to the board of directors of Chinese Institute of Engineers in 2012 in its 101 years of history; was the first speaker from Taiwan at the Ars Electronica Forum of Linz, Austria in 2006; pioneered 3D camera and display research at ITRI 1996-2003. She is currently the first engineer ever to serve as member of the Gender Equality Committee of Taiwan's Executive Yuan. Wen-Jean received her PhD in Mechanical Engineering from the California Institute of Technology in 1993. Subsequently she participated in the development of monitoring & diagnostics expert systems for Power Generation and Aircraft Engines at the General Electric Corporate R&D 1993-1996 before returning to her native Taiwan. Her expertise lies in the field of digital imaging and the applications opto-electronic systems, extending to the management of creativity and innovation.

Eng. Ania Lopez, Project Manager for Italian Government Consiglio Nazionale degli Ingegneri (ITALY) WFEO: Ania has a double degree in Mechanical Engineering in Cuba and in Italy, with specialization in Energy. She has over 20 years of experience as an engineer in public and private works in large infrastructures including the Construction, HVAC, Healthcare and Electricity sectors in Italy and abroad. She is a consultant as Project Manager for European project "Next Generation UE" in the authorization procedures of all the Renewable Energy Plants of the Lazio Region. In 2023 coordinated together with the WFEO SG the works for the signing of the Memorandum of Standing (MoU) between WFEO and FAO, participated in the 43rd Conference at FAO in Rome, representing WFEO as an NGO, recently she was nominated by CAST (Chinese Society of Engineer), member of the International Advisory Committee until 2026.Winner of the PhD in Industrial and Management Engineering at the "Antonio Ruberti" Department of Computer, Automatic and Management Engineering, Sapienza University of Rome, with research activities in the field of Agrivoltaic Production and Renewable Energies. Since 2020 she is Chairman of the WFEO Awards Committee and member of the Support Committee and Working Group Reviews. Since 2019 Member of the ExCo of WFEO. From 2011-2022 member of the National Council of Engineers CNI (Ministry of Justice) and of the Foundation Council of the National Council of Engineers, first woman in the history of Italian engineering to be a member of the Executive Council of the CNI, creator of the project "Ingenio al Feminile", for the enhancement of the Figure of the Engineer. Since 2013 she has been the CNI Delegate for the WFEO and an active member of the Women and Energy Permanent Technical Committee.

Reine Mbang Essobmadje, Co-founder of Digital Coalition, CEO of Evolving Consulting, Vice-President of GICAM (Cameroonian Business Council): With a focus on attracting, retaining and maintaining women in STEM, R women in STEM, Reine's accomplishments with the WoMenTor initiative have made a profound impact not only in Cameroon but across Africa. Additionally, as an entrepreneur, she will highlight how engineers shape the economic landscape in creating a just and inclusive society. Reine is a distinguished engineer and entrepreneur. She has been introduced in her engineering school's Hall of Fame and has been recognized as the 2020 EPIC award winner in the "Women Inspiring Women" category. Additionally, in 2023, she clinched the African Women Award for outstanding female in Business Consultancy/ Application development.

Lorato Ntsie, BIM Civil Engineering Consultant, MAP 5D AFRIKA: Lorato is a passionate, award-winning structural engineering technologist, Building Information Modeling (BIM) coordinator, lecturer and a licensed drone pilot with thirteen years' experience in academic and private sector of South Africa. She holds a B-tech in Civil Engineering: Construction Management & structures from the University of Johannesburg. Lorato's work experience includes structural infrastructure design, retaining wall specialty, construction quality monitoring, lecturing structural and BIM engineering at various universities in South Africa. Furthermore, she holds a South African Aviation Authority (SACAA) registered remote pilot license. She is the founder and managing member of MAP 5D Afrika, where she consults in structural design, inspections, project progress monitoring, quantity surveying, infrastructure baseline audit with drones and laser scanners, digitizing and creating internal and external 2D & 3D models. Lorato is passionate about people development, youth empowerment, and volunteers in various committees (Education & Training Panel, Young Member's Panel SAICE. She is an outgoing extrovert who enjoys networking, traveling adventures, enjoys exploring sacred/heritage sites, motivating and bringing forth the positivity & rainbow in others.

Lidia Zakowska, Ph.D., Professor in transport engineering, CUT, Poland: International researcher on sustainable urban mobility, equality in transportation, gender equity in engineering and safety. Author of many publications, project leader and expert in engineering. Active Member of WIE-WFEO, the Polish FSNT-NOT and SITK-RP. As WOMENVAI cofounder and Board Member she works for women equality in engineering and designs engineering solutions to environmental problems.

Committee on Young Engineers / Future Leaders (YE/FL)

The Role of Young Engineers as Future Leaders: Shaping Tomorrow's World

Firas Nazeeh Bou Diab *(Chair, WFEO Young Engineers / Future Leaders Committee, World Federation of Engineering Organizations (WFEO), Beirut, Lebanon)*

Introduction

In an era marked by rapid technological advancements, the significance of young engineers as future leaders cannot be overstated. This extended abstract explores the profound contributions and responsibilities that young engineers bear in shaping a sustainable and prosperous future. With their unique skill set, interdisciplinary mindset, and commitment to innovation, young engineers are poised to address complex global challenges and drive societal progress.

The modern world is undergoing an unprecedented transformation, driven by technological breakthroughs and innovations. In this dynamic landscape, young engineers occupy a pivotal role as architects of tomorrow's world. This extended abstract delves into the multifaceted role of young engineers in shaping a brighter future. It emphasizes their capacity to bring fresh perspectives, harness cutting-edge technologies, promote inclusivity, and develop leadership qualities.

The Unique Skill Set of Young Engineers

Young engineers are distinguished by their solid foundation in Science, Technology, Engineering, and Mathematics (STEM). This educational background equips them with problem-solving abilities and analytical thinking that are invaluable in addressing complex issues. Their skill set encompasses:

- Creative Thinking: Young engineers bring a fresh approach to problem-solving. Their ability to think outside the box is crucial for generating innovative solutions.
- Adaptability: In a rapidly changing technological landscape, adaptability is a vital trait. Young engineers are quick to embrace and leverage emerging technologies.
- Interdisciplinary Perspective: Collaboration across various disciplines is the hallmark of modern engineering. Young engineers are adept at working with professionals from diverse backgrounds to tackle multifaceted challenges.

Empowering Social Innovation and Inclusivity

The role of young engineers extends beyond technical expertise; they play a pivotal role in fostering social innovation and inclusivity. Their unique qualities make them instrumental in bridging gaps and creating equitable solutions:

- Empathy and Communication: Young engineers possess the ability to empathize and connect with diverse communities. This empathy facilitates effective communication, enabling them to understand the real needs of society.
- Inclusive Technologies: Leveraging emerging technologies such as artificial intelligence, robotics, and blockchain, young engineers develop technologies and services that are inclusive, accessible, and beneficial to all.
- Global Perspective: In an interconnected world, young engineers bring a global perspective to problem-solving. They consider the broader impact of their work on society, environment, and international relations.

Cultivating Leadership Qualities

To effectively fulfill their role as future leaders, young engineers must cultivate leadership qualities that extend beyond technical proficiency. These qualities include:

- Effective Communication: The ability to convey complex technical concepts in simple terms is essential for leading diverse teams and engaging with non-technical stakeholders.
- Ethical Decision-Making: In an era of ethical dilemmas posed by technology, young engineers must make ethically sound decisions to ensure the responsible development and deployment of innovations.
- Collaborative Problem-Solving: Collaboration is paramount in the modern world. Young engineers excel in working collaboratively to solve intricate problems, drawing on their interdisciplinary background.
- Lifelong Learning: The ever-evolving nature of technology demands a commitment to lifelong learning. Young engineers embrace continuous education and professional development to stay abreast of emerging trends.

Conclusion

In conclusion, young engineers are the driving force behind technological advancements, sustainability, and social progress. Their contributions as future leaders are instrumental in addressing global challenges and steering society towards a brighter future. Empowering and supporting young engineers in their leadership journey is crucial for the sustainable development and prosperity of our world.

As we look to the future, it is imperative that we recognize the pivotal role of young engineers in shaping the world we envision. Their skills, perspectives, and leadership qualities are indispensable assets in tackling the multifaceted challenges that lie ahead. By harnessing their potential and nurturing their growth, we can aspire to a world that is not only technologically advanced but also more inclusive, equitable, and sustainable. Young engineers are not just the leaders of tomorrow; they are the architects of a better future for all.

Holistic education of engineers to enable innovation and entrepreneurship

Evangelos Pastras *(Working Group on Climate Action (SDG13), WFEO YE/FL, London, UK)*

Use of technology is experiencing unprecedented and exponential growth across sectors. Engineering principles are evolving as the world becomes more complex and interconnected, and our educational, regulatory and professional systems need to accelerate their own development to keep pace. In order to ensure the next generations are adequately equipped to meet the requirements of the industry of tomorrow, engineers of today are required to contribute across several fronts as technical experts and thought leaders, driving change and innovation. Technical specialisation often comes at the expense of effective stakeholder management and communication, hindering the engineering process and impacting the well-rounded tackling of modern challenges such as climate change, misinformation and Artificial Intelligence. The holistic training of young engineers is therefore critical, to ensure they can effectively manage all aspects of project delivery: from financing and procurement, to accounting, reporting and stakeholder management. This way, innovation and entrepreneurship can flourish and produce the solutions and efficiency improvements we need to achieve across value chains for our Sustainable Development Goals, a just energy transition, and our evolution to circular economies of growth.

Gotong Royong: Open Solutions for Public Crises

Micheala Chan *(Working Group on Climate Action (SDG13), WFEO YE/FL, London, UK)*

Gotong royong is a uniquely Indonesian, Malaysian, and Singaporean concept that refers to mutual aid and the sharing of burdens between community members. This spirit of community and neighborhood is essential for addressing the world's most pressing challenges, which are increasingly global in scope and impact.

By working together across borders and disciplines, engineers are uniquely positioned to drive the development of open-source technologies and tools, supported by robust anonymised open data sharing and greater technology transfer, to address some of the world’s most pressing challenges.

The COVID-19 pandemic has shown the power of global collaboration and technology transfer in addressing global challenges. As open sourcing becomes increasingly touted as a panacea, this presentation will examine this proposal and explore considerations that engineers must take into account in their work to solve public crises through open solutions. Technology is not a “one size fits all” solution and engineers must come together to ensure a sustainable and equitable future for all.

Advancing Zero-Energy Building Concepts in Europe

Milica Vujošević *(Chamber of Architects, Chamber of Engineers of Montenegro, Podgorica, Montenegro)*

The concept of zero-energy buildings has gained significant attention in Europe due to the growing urgency to combat climate change and reduce energy consumption. In recent years, European countries have implemented rigorous energy performance standards and regulations to promote sustainable building practices. These regulations, such as the Energy Performance of Buildings Directive (EPBD) and national building codes, set ambitious targets for energy efficiency and encourage the adoption of renewable energy systems. However, challenges remain in the implementation and enforcement of these regulations, and there is a need for continuous improvement and harmonization across European countries.

From the viewpoint of young engineers and architects, the pursuit of zero-energy buildings presents both opportunities and obstacles. They are at the forefront of integrating innovative technologies and design strategies to achieve energy-efficient and environmentally conscious buildings. However, education and professional development plays an important role in equipping young engineers and architects with the necessary skills and knowledge to contribute effectively to the zero-energy building sector. It light of this topic, interdisciplinary collaboration, knowledge exchange, and mentorship programs are important to foster the next generation of sustainable building practitioners.

By analyzing the legislative landscape and engaging with the perspectives of young professionals, the aim is to provide valuable insights into the current status, challenges, and future prospects of zero-energy building concepts in Europe. It will serve as a catalyst for discussions and knowledge sharing among researchers, practitioners, policymakers, and industry stakeholders, driving forward the sustainable built environment agenda in Europe.

The Role of Young Engineers in Advancing Engineering Tools to Address Issues that Confront Earth's Sustainability

Benedict Atta Poku *(Youth in Engineering, Ghana Institution of Engineering, Accra, Ghana)*

Africa has the youngest population in the world. The United Nation reports that 70% of sub-Saharan Africa's population are under the age of 30. Africa has an average age of 19.5 years. This is supposed to be a clear indication of an opportunity for growth within the region. However, the stark contrast is that, the world's youngest continent has the oldest leaders. A 29th January 2021 article published by R CEL stated that the average age of an African president is 62.

Young Engineering professionals within the continent are leveraging on engineering principles to propose solutions to poverty eradication, clean water and sanitation, affordable and clean energy, climate action and the likes, but the optimal approach is to include them in the decision-making process.

Engineering is a development tool able to accelerate our progress towards achieving the SDGs. Given the population dynamics, young professionals have a very important role in redefining the issues confronting the continent, proposing innovative solutions, and participating actively in the implementation of such solutions to address these pertinent issues. Given the apparent disconnect between the sustainable development issues on the continent and our strategy to assemble young engineering professionals and the appropriate tools to resolve them, Government boards, state agencies, political systems must develop a strategy to have a fair representation of young professionals in their leadership teams to enable them advance and deploy engineering tools to resolve these pressing challenges.

Empowering Young Engineers: Navigating the AI Era for Sustainable Development

Pan Li *(Executive Director, Big Data and AI Working Group, WFEO-CEIT, China Association for Science and Technology, Beijing, China)*

This speech delves into the intersection of artificial intelligence (AI), engineering, and the empowerment of young engineers in the context of achieving the Sustainable Development Goals (SDGs). It provides an overview of the AI landscape, with a specific focus on the recent advancements in Generative AI. While AI presents tremendous opportunities, it also raises concerns regarding ethics and governance.

The speech emphasizes the critical role of engineers in leveraging AI to drive progress towards the SDGs. By harnessing the power of AI, engineers can address complex societal challenges more effectively and develop innovative solutions. However, to fully realize its potential, it is imperative to address ethical considerations and establish robust governance frameworks.

Young engineers play a pivotal role in shaping the AI era. The speech outlines strategies for young engineers to prepare for this transformative era. Furthermore, it highlights how AI empowers young engineers by enhancing their problem-solving capabilities and offering new avenues for innovation.

The World Federation of Engineering Organizations (WFEO) recognizes the significance of AI in engineering and sustainable development, and aims to ensure that young engineers are equipped with the knowledge necessary to navigate the AI landscape responsibly and contribute to the achievement of the SDGs.

In conclusion, this speech emphasizes the need for young engineers to embrace AI as a tool for positive change. By fostering ethical AI practices, enhancing interdisciplinary and international collaborations and dialogue, and leveraging AI's potential, young engineers can become agents of sustainable development, driving progress towards a better future for all.

Working Group on Infrastructure Report Card (WGIRC)

Infrastructure Conditional Assessment of higher education institutions in South Africa IRC 2022

Lorato Ntsie *(South African Institution of Civil Engineering, Johannesburg, South Africa)*

In 2006, the South African Institution of Civil Engineering released its first Infrastructure report card, which assessed conditions of public infrastructure in South Africa. Further reports were released in 2011,2017 and 2022.

The higher education sector is managed by the Department of Higher Education and Training (DHET) which is sub-divided into public Universities (26) in each of the nine provinces, 135 registered private higher education institutions, 50 Technical and Vocational Training (TVET).

Higher education infrastructure in South Africa plays a crucial role in supporting quality education, research, and development. Over the years, the country has made significant efforts to improve and expand higher education infrastructure to meet the growing demand for tertiary education. According to the 2022 report, The universities, mostly located in urban areas, host 1.1 million students. The TVET colleges have 700000 students. Enrollments has increased significantly since the dawn of democracy in 1994 placing a huge burden on the existing infrastructure. The department introduced various frameworks and funding programes to expand and maintain the existing infrastructure. The efforts has beared fruits, with two new Universities and various TVET colleges currently under construction. The Covid-19 pandemic impacted the sector hugely, resulting in delays of expansion and funding for facilities management being re-directed to ICT requirements to enable online teaching. This paper aims to provide an overview of the current state and key considerations regarding the higher education infrastructure in South Africa, and further explore the possibility of digitizing the infrastructure database using Building Information Modelling (BIM) frameworks.

POSTERS

P 01

Discussion on Technical Route of Carbon Peak in the Field of Building Heating in Northern China

Zhangxi Zhang *(Shanxi Hai De Rui Energy Conservation Technology Co., Ltd., Changzhi, China),* ***Xiangkun Yang*** *(Shanxi Hai De Rui Energy Conservation Technology Co., Ltd., Changzhi, China)*

The buildings in northern China not only need to meet the needs of daily life and living functions, but also need to satisfy the needs of heating in winter. There is a large building scale in northern China, therefore, it is of great significance for the buildings in northern China to achieve the carbon peak. The main contents of this essay is as follows:

1. Potential analysis of energy conservation and carbon reduction in heating of buildings in northern China;

2. Discussion on the technical route of carbon peak in the field of building heating in northern China.

P 02

The viability of vegetable oil fuel

Ian F Thomas (I F Thomas & Associates, Williamstown, Australia)

Introduction

This work was initially prompted following the viewing of an ABC Television 'Catalyst' program in October 2004. The topic of the program was the use of vegetable oil to fuel a motor car by conversion into biodiesel. While viewing this, the author gained the impression that vegetable oil not biodiesel was being poured into the fuel tank and this prompted him to do the same with his own diesel utility vehicle. The author was in any case, unprepared to transesterify the oil into biodiesel as this process is quite dangerous and has caused many accidents in 'backyard' practice. A further prompting for this work was the near complete absence in the literature of on-road trial work done by others.

The compression ignition (CI) engine was invented by Herbert Akroyd Stuart in 1886 (Figures 1-4) and patented in 1890 following which 32,417 engines were manufactured over many years as the Hornsby-Akroyd Patent Oil Engine. They were produced in both vertical and horizontal form and used for stationary and portable purposes including an oil tractor and an oil locomotive. A higher pressure version was developed by Rudolf Diesel (Figures 5 & 6) and patented in 1898 which operated successfully on groundnut oil (Arachis hypogaea). Diesel foresaw the importance of vegetable oils as fuel when in 1912 he wrote *'the use of vegetable oils for engine fuels may seem insignificant today, but such oils may become in the course of time as important as petroleum and the coal tar products of the present time'*. He had the second motive to enable independent craftsmen and artisans to compete with large industry. This claim is perhaps better put in that *'he originally conceived the diesel engine as a facility, readily adaptable in size and costs and utilizing locally available fuels, to enable independent craftsmen and artisans better to endure the powered competition of large industries that then virtually monopolized the predominant power source – the oversized, expensive, fuel-wasting steam engine'*.

This work reviews the available literature on the use of vegetable oil fuels, addresses the findings of an on-road trial conducted by the author, describes available non-food oil producing species, estimates the availability of land for biofuel cropping, and approximates the number of lives which would be saved by using vegetable oil rather than other more dangerous fuels.

Informal on-road trials using 100% vegetable oil commenced on 23rd October 2004 and were temporarily interrupted on 19th November 2004 when the vehicle lost power in Hamilton, Victoria while on a journey from Melbourne to Bahgallah in the Western District of the state. Aside from this, these trials were successful over approximately 1000 km of both town and country driving and suggested viability of this fuel. Trials were restarted on 10th September 2005 after abandonment for a period during which time regular diesel fuel was used. Informal trials did not involve creating a vehicle log and are therefore not reported upon herein.

The on-road trials were formalised in association with RMIT University as the starting point for a post-graduate research degree study in environmental science on 7th March 2008. The trials were completed on 22nd January 2010. During the whole of this period, a detailed vehicle log was kept and used as the basis for trial findings. The trials covered 42,000 km using principally a 50/50 blend of conventional diesel fuel and waste vegetable oil. During the early period of performance of the trials, an extensive literature search was conducted in an effort to understand work done by others in this field. Most workers found that it was necessary to dilute the vegetable oil with conventional diesel fuel to reduce the viscosity of the blend. Trial findings were presented at the 5th International Conference on Sustainable Automotive Technologies (ICSAT 2013) held in Ingolstadt, Bavaria in September 2013 and published in the conference proceedings.

Given the extensive background of the author in process safety, loss prevention, workplace safety, road safety, incident/accident investigation and risk assessment, the next task in this work was to attempt an understanding of how much safer the world would be if vegetable oil was the only fuel used. Indeed a close second motivation to do this work was the fact that the high flashpoints of vegetable oils cause them to be safer by a large margin when compared with all alternatives. To assess this an evaluation of road accidents involving fire, fuel transportation accidents and accidents in fuel manufacture was conducted. A combination of UK and US road accident statistics are used to assist in understanding the impact of current fuel types.

Next, given that much of the research performed by others used food oils, the availability or otherwise of non-food vegetable oil producing species was considered in some detail. This part of the work was also prompted by numerous representations made to the author by his colleagues and references in the literature regarding the inappropriateness of *'taking food out of people's mouths'* by using food oil species as fuel. This part of the study commenced early in the on-road trial period and although this is an ongoing activity, it was completed for the present purpose in April 2014.

In the next part of this work, viability in terms of land availability for fuel production is considered in light of current and predicted world energy demands. Also addressed are the environmental and sociological impacts of using marginal lands for fuel cropping. The impact of our exponentially increasing world population upon a number of factors including the shortage of land for food and fuel production is also addressed. Species, land, social, environmental, population and safety aspects of this work were presented at the 6th International Conference on Sustainable Automotive Technologies (ICSAT 2014) held in Gothenburg (Göteborg), Sweden in September 2014 and published in the conference proceedings.

Of particular relevance given the domicile of the author, is the almost complete absence of studies of vegetable oil fuel in Australia. As far as the author is aware, there is only one other worker in this country who has presented papers on vegetable oil use at conferences and who has performed on-road trials. Given that Australia is considerably hotter and dryer than European countries *(eg annual average maxima Melbourne 13.5 to 25.9°C, South Germany -2 to +14°; annual average minima Melbourne 6.0 to 14.6°C, South Germany -7 to +7°C)*, it is considered appropriate to assess this kind of fuel in this country. Furthermore, there are many non-food oil-producing species which are either native to Australia or amenable to being grown here. There are vast areas where adverse impacts upon local populations and the environment are unlikely with proper consultation and environmental management.

Oil-producing plant species

Sixty five papers covering the period 1980-2014 have been reviewed which address the use of single-cylinder laboratory test compression-ignition engines, real vehicle engines, whole vehicles in the laboratory, vehicles on the road, stationary farm-pump/tractor engines and fixed engines for electricity generation in remote areas. Selected papers are also reviewed for example measuring effects on lubricating oils, establishing oil properties, developing a vegetable oil fuel standard, developing a test method for triacylglycerol contamination in fuels, viscosity modelling and studying emulsion stability.

In 73 instances, researchers worked with food oils such as Rapeseed (20), Cottonseed (14), Sunflower (11), Soybean and Peanut (5 each), Corn and food-sourced vegetable oil (4 each), Palm (3), Olive and Copra (2 each), Hazelnut, Rice Bran and Palm Kernel (1 each). In 43 instances, researchers worked with non-food oils or food wastes such as *Jatropha* (8), *Karanja* (5), waste vegetable oil (4), *Putranjiva*, Poon, Orange, animal fat and linseed (2 each), lard, chicken fat, Cashew Nut Shell, Camphor, Turpentine, False Flax, Neem, Cabbage Palm, Spanish Plum, Deccan Hemp, *Sapodilla*, Babassu, *Champaca*, Kokum, Soapnut and Pistacia (1 each).

To provide comparisons, some instances addressing other fuels are included such as Biodiesel (5), Hydrotreated Vegetable Oil (2), Shale oil and Diesel fuel/water/surfactant emulsion (1 each). Also addressed is research which has considered additives to improve engine power, to reduce exhaust emissions or to ensure that VO/diesel blends form stable emulsions. Examples are ethanol (6), methanol (4), hydrogen and diethyl ether (3 each), butanol (2), producer gas, liquefied petroleum gas, biogas, dimethyl ether, petrol, propanol, amyl alcohol, dodecanol, orangeskin powder and algae powder (1 each).

Between 60% and 65% of results show equal or improved exhaust emissions and engine performance relative to diesel fuel. Directionally acceptable exhaust emissions for which >80% of results are the same or better than diesel fuel, are achieved by Poon, Mahua, Neem, Coconut, Linseed, Soapnut and Soybean oils and by Lard. Other fuels for which 50% or more of emissions are the same or less than diesel fuel are Palm, Orange-Skin-powder/Diesel blend, Rapeseed, *Karanja*, Cottonseed, Ricebran, Corn, Cashewnut-shell/Camphor, *Putranjiva*, *Jatropha*, Waste Frying, Turpentine and False Flax oils and Animal fat and Chicken Fat. Directionally acceptable engine performance for more than a single result is obtained for Rapeseed, Cottonseed, *Jatropha*, Sunflower, *Karanja*, Soybean, *Putranjiva* and Corn oils. Single result acceptable engine performance is achieved by *Pistacia*, *Sapodilla*, Teitai, Hazelnut, False Flax, Deccan Hemp, *Pongamia*, Turpentine, Coconut, Soapnut, Orange-skin, Olive and Peanut oils and by Chicken fat and Lard.

Most workers report that the reasons for not using SVO are related to its high viscosity and injector and engine fouling. These can be offset by preheating and use of saturated oils. Several workers in particular Tippayawong, indicate that SVO may be used only in the short term and that longer term usage needs further investigation. Tippayawong also states *'Vegetable oils and their products appear to be obvious choices as future fuels and are of exceptional importance'*. Nabi cites Elbert and Kaiser, '*Considering overall energy, health, environmental, and economic aspects, vegetable oils could be the fuel of the future.'* Many claim that vegetable oils are viable in substantially unaltered engines provided that the oil concentration is not greater than 30% unless the fuel is preheated. Others are staunch advocates of the improved lubrication (lubricity) impacts of vegetable oil in improving the life of injector pumps, pistons, piston rings, cylinder bores and combustion chambers. Some claim an increase in PAHs (Polycyclic Aromatic Hydrocarbons) and others claim a reduction. The very low level of sulphur in vegetable oil is known to reduce sulphur oxide emissions but claims regarding other emissions relative to diesel fuel vary.

In the U.S., portable vegetable oil generator sets for private use are available from 14.5 to 505 kVA. Researchers have principally addressed the use of low-volatility fuels (diesel, biodiesel and SVO) in CI engines which is the main thrust of this work. Some address the use of fuel-additives such as air-aspirated hydrogen, diethyl ether and dimethyl ether to boost engine power. Some have tested slurry fuels for example, using diesel fuel and orange-skin powder and diesel fuel with *Chlorella vulgaris* algae. A coal dust emulsion with diesel fuel has also been suggested as being feasible.

A breakdown of which countries are actively researching into the use of vegetable oil fuels is provided in Table 3 together with journal article references. More detailed appraisals of 37 selected papers are contained in Appendix 10.1. The Elsbett engine which was specifically designed to run on pure plant oil (PPO or SVO) is described in Chapter 1.

To function well, vegetable oil requires as low a viscosity as possible, must be liquid at all temperatures used, must not polymerise (solidify, dry) under conditions of use, must be free of extraneous solids, must be free of acidity and alkalinity and should have as high a cetane number and calorific value as possible Ideally, it would also be degummed.

My work concludes that straight vegetable oil blended 50/50 with diesel fuel is both viable and performed slightly better than diesel fuel alone.

More information is available from the author (ifta@ifta.com.au).

P 03

Possibilities of covering electricity consumption with renewable sources in Czech Republic

František Hrdlička *(Dep. of Energetics, Czech Technical University in Prague, Prague, Czech Republic)*

Aim

The Czech Republic currently has 8.36 GW of electrical power installed in lignite power plants. This lignite installed power an annual average cover approximately 40% of the power of meet the current needs of the Czech Republic. The decarbonization of electricity production in the Czech Republic assumes a rapid decrease in the use of coal by 2033. It is necessary to replace electricity production with other low-carbon sources. Environmental organizations assume the replacement of lignite with photovoltaic and wind power plants. This article examines this replacement option.

Methods

By evaluating the real data provided by the Energy Regulatory Office, the necessary increase in the output of renewable energy sources (photovoltaic power plants and wind turbines) is sought, which would enable the shutdown of coal-fired power plants.

A simplified solution shows the effectiveness of doubling the current output of wind and photovoltaic power plants.

The complex solution ensures a permanent output of 1 GW of wind power plants with high-capacity battery storage in the month of December.

Results and conclusion

The results show that doubling the current output of photovoltaic and wind power plants is insufficient for the production of electricity from lignite.

Achieving a continuous output of 1 GW by wind farms for one month means a disproportionately high investment cost for battery storage.

P 04

The future bioenergy potential of Australia

Ian Thomas (I F Thomas & Associates, Williamstown, Australia)

Introduction

Australia occupies the driest inhabited continent in the world. 70% of the mainland receives less than 500 mm/yr of rainfall. Direct normal insolation (MJ/m^2) for all of central Australia except for thin strips along the south coast, north coast and a slightly thicker strip along the east coast, is 23-27.5 MJ/m^2. The bulk of the thin strips have an insolation level of 18.5 MJ/m^2. The mainland contains ten deserts according to the definition of a desert as an area which receives equal to or less than 250 mm/yr of rainfall. The total area of these is 1,371,000 km^2 that is, 17.82% of the continent. Two other deserts located in Victoria are omitted from this list given that their rainfall is greater than 250 mm/yr. They are the Little Desert (1326 km^2, 480 mm/year) in the western Wimmera region and the Big Desert (1417 km^2, 200-300 mm/year) in the north-western Mallee region. The Big Desert adjoins the Ninety Mile Desert in South Australia.

Australia has a number of alternative fuels using facilities for example, 36 bioenergy power plants, 50 hydro-electric power plants, 37 wind farms, six solar-voltaic power plants, six seawater desalination plants, four experimental hot-rock geothermal projects and 13 biomass-to-energy case study sites. Much of Australia is protected as State and Federal parks and as Aboriginal reserves, including 17 world heritage areas. Between 14% and 15% of the country is presently described as being of 'minimal use' and it is this land which is of the greatest interest in the present context. Most is desert or semi-desert and it is this which will be investigated for cropping of arid-area-growing species, both glycophytes and halophytes. In addition, use of the southern coastal area may be considered where land is available for cropping of halophytes under seawater irrigation. Northern, tropical coastal areas may also be considered for cropping of oil-producing tree species such as *Calophyllum inophyllum*.

Principal soil types present in desert and dryland areas according to the Harmonised World Soil Database 2008 (HWSD), are Arenosols, Calcisols, Solonetz and Solonchaks. Arenosols *(Latin 'arena', sand)* are sandy without clearly delineated horizons and with little humus in the upper layer. They cover a large area of the central and western inlands of Australia. Calcisols *(Latin 'calix', lime)* also known as desert soils are calcareous soils with lime accumulation occupying wide tracts of western and southern Australia with lesser presences in the north of the country. Solonetz *(Russian 'sol etz', strongly salty)* soils are sodic with a 'natric' upper horizon containing more than 15% of exchangeable sodium and some clay in the sub-horizon. The largest areas of Solonetz are in the central-to-eastern inland with isolated patches in coastal regions of South Australia and Victoria and some presence in Queensland, New South Wales and Western Australia. Solonchak *(Russian 'sol chak', salty area)* or salt-marsh soils are pale or grey in colour located in narrow strips in central Australia and central to southern Western Australia. Soil classes using more commonly understood terms are also presented where, inland/coastal; dunefields/sandplains; calcareous sands; limestone plains; salt lakes and fringing saline alluvial plains, are of particular interest in this context.

Further evidence of the relative vastness of potential land areas available for growing halophyte or other arid-area growing species in Australia, are the presence of suitable floristic land types and vegetation groups such as *low shrublands*, *chenopod shrublands*, *low open shrublands* and *grasslands*. In addition areas of open taller growth where the groundcover can also comprise the desired species are *tall open shrubland*, *open woodland* and *low shrubland*. Of particular significance are areas of Chenopodiaceae (goosefoot, pigweed, saltbushes and buckwheats) which are a sub-group of the Amaranthaceae family which in turn, includes popular fuel oil halophytes Salicornioideae and Suaedoideae. Major floristic types are presented. Major vegetation groups are presented as a list and those groups pertinent to this study are shown as photographs and maps. Locations of some naturally occurring halophyte plant families are also presented.

In all, some 20% of the area of the country contains Saltbush, Bluebush and Samphire species and is amenable to utilisation for cultivating oil-producing halophytes such as Samphire spp and other non-halophyte arid-area-growing, oil-producing species. Some examples of the appearance of a range of Australian bushlands where halophytes and other arid area species grow or could be grown are presented.

Current status of fuels in Australia and economic factors are addressed by way of background. Also considered are Australia's major vegetation groups for which the author considers five to be appropriate for halophyte cropping amounting to 1,690,000,km^2 that is, 37.4% of the country.

A great deal of Australian land is naturally saline and even more has been rendered saline by adverse human activity. Soil salinity therefore, is a major factor when considering growing anything in this country consequently this is addressed together with soil sodicity and acidity. Almost of equal importance is the adverse impact of presence of introduced species generally termed 'weeds', therefore part of this work is devoted to this. Salt-tolerant and salt-loving species which grow naturally in this country in coastal areas and in arid areas are addressed, some of which are presented as lists and others as individual species with photographs.

A biogeographical study of Australia is presented and some of the issues faced by remoteness of potential fuel cropping areas are addressed.

Economics of biofuel production

This appraisal commenced with a review of a marketing paper which used an Australian biofuels case to clarify the interest, sense-making and adaptive marketing processes which were the subject of the paper. This led the author to other publications. An outlook for biofuels in Australia in 2007 shows production level for biofuels in 2005-6 when the market was rising, of 41 million litres for bioethanol and 16 million litres for biodiesel, a total of 57 million litres. This compares with petrol production of 19,050 million litres and diesel fuel production of 15,880 million litres for the same period. A significant negative factor in producing biofuels is the 60-70% of total costs being for feedstocks. The study predicts that new facilities being planned would be making bioethanol from waste starch, molasses, corn, sorghum and low quality wheat. The authors suggest that a next generation of bioethanol fuel production facilities will be able to use cellulosic feedstocks such as crop waste, wood waste and grasses. Brazil has been producing hydrous bioethanol (95% bioethanol, 5% water) since the 1970s which is used in engines modified for the purpose. They report the energy level of this fuel as 68% of that of petrol. Anhydrous bioethanol is also produced from the hydrous fuel by molecular sieving yielding a 99% bioethanol product capable of being used in unmodified engines. They report an advantage for biodiesel production in that it can be produced by any scale of facility such as by small groups of farmers using Canola or Mustard oil feedstocks. Australia sells both B5 and B20 biodiesel. There is some concern however that with small-scale production, variability of fuel quality and the potential liability associated with this, might reduce demand.

Halophyte supporting vegetation groups

There are five principal major vegetation groups (MVGs) where oil-producing species are considered to be capable of successful growth subject to their accessibility, climate, soil type, salinity, sodicity, means of irrigation, other land-uses, absence of potential to cause harm to the environment, and appropriate selection of species. Photographs and maps for each of these vegetation groups are shown. A table is also present, listing the land area of each of 23 sub-groups and the theoretically available land area for growing fuel crops. Maps of salinity in Australia are shown and maps showing worldwide salinity. Presence of acidity and sodicity in soils is also shown in maps as well as photographs of dryland salinity which once were good agricultural lands. Numerous maps and photographs of land-borne and water-borne halophyte species are presented and details of the percentages of land in Australia used for different purposes. The latter shows 54% is used for livestock grazing, 15% of protected areas and 15% of all-important minimal use land.

Conclusions

Australia is one of the most promising countries for the growing of vegetable oil producing species in particular, arid area growing species which are also salt tolerant. The desert areas although described as being cold in winter are amenable to growing species such as members of the Chenopodiaceae and Amaranthaceae families. The country comprises just under 18% of deserts which are largely unchanged and represent real potential. The climate of the country is so varied that many other species are able to be grown, some in northern tropical areas such as *Calophyllum inophyllum, Moringa oleifera* and *Milletia pinnata.* Others like *Ricinus communis*, grow and can be grown almost everywhere. Rengasamy describes the country as comprising 30% of saline, saline-sodic and sodic lands which are essentially amenable to the growing of halophytes. Kadereit suggests that this is nearer to 33% of the country, comprising saline soils in estuarine plains, coastal lagoons and salt pans. There is the beginning of serious consideration regarding the use and propagation of halophytes and other vegetable oil producing and fuel-biomass producing species in this country. Areas of land where experimental plantations and later full-scale production could be considered for growing fuel halophytes are demonstrated by reference to maps of existing major vegetation groups. In total an area of 1,690,000 km^2 which is 21.9% of the country could be available subject to constraints such as conservation and other land uses. Land use defined by a 2016 ABARES reference using a 2010-11 dataset shows that 14.54% of the country is 'minimal use' and described as comprising residual native cover. Adding the other ABARES category 'other minimal use' yields a theoretical total of 14.89% of land which may be considered available.

The detailed biogeographical assessment of available land in Australia shows that an area of some 6.5% of the mainland (499,687 km2 rounded to 500,000 km^2) could be used for halophyte cropping in areas which are both arid and saline/sodic. It is possible to add the percentage of salt-affected farmland to this as this land cannot be used for farming in its present condition and would be rehabilitated in time, by the use of halophyte cropping – a form of crop rotation. Equally, other substantial areas are available for example, the tropical north of the country is capable of growing oil-producing tree species such as *Milletia pinnata*, *Calophyllum inophyllum* and *Moringa oleifera*. Coastal saltmarshes above and below tide level are also substantial and can be used for farming numerous samphire species. Beach-cast and farmed seagrasses can also be harvested and processed to produce biofuels and a range of other biochemicals. These latter locations are addressed in part by Kriticos and by L.E.K. Consulting providing some indication of the extent of conservatism of the author's 500,000 km^2 proposal.

More information is available from the author (ifta@ifta.com.au).

P 05

A cross-domain cyber-physical system solution for residential housing, supply and multi-modal mobility to enhance social resilience

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In this work a cyber-physical system solution is proposed that combines the domains of residential housing, supply and mobility in order to strengthen social resilience continuously challenged by the environmental impacts of climate crisis, large scale natural disasters, global epidemics and human conflicts. A literature review on international scientific publications that address those topics, highlights the motivation to reassess modern societies view on infrastructure planning, construction and maintenance. Based on these insights a blueprint is drafted that realigns with major goals of the SDGs to mitigate the human footprint and strengthen resilience with a new level of circular economy. The main idea is to design container units that can potentially be used in a more flexible manner for the needs-based recombination of infrastructure cells that allow fast adaption to new volatile, dynamic conditions. Thus, individual resilience shall be fostered by the means of infrastructure dezentralization, promoting mobility and creating incentives for low entity level collaboration. With the rise of such infrastructure cells in combination with smart factories, a higher level of circular economy and collaboration shall evolve. The presentation and discussion of the proposal shall lay the groundwork for future prototyping. Thereby, technical requirements such as the use of BIM and software virtualization are highlighted. While this work presents a concept, not prototype results, it shall provide a reference point for future works, technical design improvements and critical reflectance on its social impact in regard to more conventional approaches.

P 06

Using the Smart Phone to enhance public participation for Smart Cities

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Citizens are the lifeblood of a city and it goes without saying how much their opinions matter with regards to smart cities. We're living in the smart age era -. Smart phones for instance have revolutionized how we interact.

One proposal is a city crowdfunding app that conveniently allows users to contribute towards projects of interest. This creates a sense of ownership. Feedback can also be quickly gathered and analyzed. Popularity ratings can be used to gauge uptake. Crowdfunding websites have done well in the past for big cities such as London. To boost participation from a wider representation of the city- the GIS coordinates can be automatically fed.

Another proposal is to have a competitive phone survey where proposals to solve public space problems can be effectively obtained through phone calls or texts. It gives a chance to reach many city residents and get their views within the shortest time possible. From which the best innovative ideas can be adopted. An advantage of this method as opposed to the app is more coverage in case of poor Internet connectivity. Public Space Ideas Competitions have been effectively before in big cities such as Sydney.

Another proposal is to use social media apps. Most of these social media apps have platforms which enable users to form groups or communities- where quick communication can be made. The option of Direct Messaging of Group/Page members can enable Group/Page admins of these forums to incorporate views/ ideas from silent introverts whose voice may go unheard.

P 07

Systemic innovation model for the design and construction of sustainable buildings in the Colombian Caribbean

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This research develops a systemic innovation model for the design and construction of buildings in the Colombian Caribbean, which allows analyzing the interests of the actors involved in the construction ecosystem and the achievement of the overall goal of sustainable cities and communities. A quantitative cross-sectional cohort investigation was conducted with a correlational-causal stage, describing the relationship of dependency and causality among the variables involved in socio-economic, political, and educational dynamics in the face of the challenges posed by sustainable construction. These variables include the existence of government initiatives for sustainability, the profile of stakeholders in the construction sector, the description of opportunities for access to investment capital, the level of stakeholder perception regarding sustainable development and environmental protection, the analysis of current environmental practices of construction companies in the Colombian Caribbean, and strategies for cities to adapt to new construction trends. This led to the proposition of an architectural and operational model that, from different organizational trends, generates changes in the conception and praxis in the field of knowledge of civil works with a social purpose. To achieve this, new trends in construction projects and the role of local governments in the design, implementation, and maintenance of sustainable urban development systems were examined. The study provides evidence in favor of the existence of conceptual dimensions associated with socio-environmental forces that shape the activity of stakeholders and the theoretical concepts associated with socio-economic growth and development based on sustainability.

P 08

Numerical model of the experimental BFB boiler using the SNCR method for NOx reduction

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Nowadays, to meet the applicable emission standards for conventional power plants, it is not enough to use a single reduction method thus it is necessary to use different technologies simultaneously. In the case of NOx, one of them is the SNCR method. Its main advantage is the possibility of relatively easy installation in existing sources because it does not require a radical reconstruction of the flue gas treatment process line. However, for optimum performance, the correct amount and location of the reagent injection point are crucial. The purpose of the presented research was to show that it is possible to determine the favourable location of injection points of reagent into the furnace of a coal-fired boiler, selected in terms of improving the efficiency of nitrogen oxides reduction.

A numerical model of an experimental 500 kW solid fuel boiler was created. When creating the model, emphasis was placed on the accurate mapping of the flow geometry of the boiler and the high quality of the computational mesh. Boundary conditions on nozzle inlet profiles were defined based on primary air-feeding system submodels. The validation shows that the model calculation results do not provide precise quantitative information about the flue gas composition. However, the model allows to identify the impact of the boiler configuration (such as the location of the reagent injection points or secondary air nozzles) on the course of the nitrogen oxides reduction process.

P 09

Kabd Sanitary Landfill

Hamoud Al-Zaubi *(Projects Engineering Consultancy, Kuwait, Kuwait),* ***Lana Ibrahim*** *(Projects Engineering Consultancy, Kuwait)*

Background

The Kuwait Municipality (KM) has initiated the Kabd Landfill Project (Project) in response to the need for an appropriate infrastructure for treatment and disposal of solid waste generated in the State of Kuwait. The Project had been designed utilizing the latest technology to treat municipal solid waste in Kuwait. The Project had been designed utilizing the latest technology suggestions (e.g. Waste to Energy) to treat municipal solid waste in Kuwait. As a part of suggestions, the Project also aims at generating alternative power sources which can be purchased and distributed by the Kuwait Ministry of Electricity and Water (KMEW).

Project Brief

The Project site located in the Kabd area, approximately 25 km south west of Kuwait City and will comprise of a number of integrated waste management services including sorting, treatment (e.g., using incinerators for the generation of electricity), and landfill disposal.

An area of approximately 500,000 m2 has been allocated for the Project and is intended to accommodate a WTE facility and its associated infrastructure next to it with a planned capacity of approximately 3,275 tons per day that will be subtracted from the total daily municipal wasted received to the landfill. The landfill area will be operated for 20 years. Based on the average personal daily waste generation in Kuwait, which is 1.5 kilograms per day per person, it is also expected that the capacity for the landfill will be approximately 32,386,926 tons will be disposed of in landfills at this facility.

Majority of the design information is therefore based on assumptions and focuses on evaluating different options to be considered for the landfill. The topography and geology of the site were identified as major contributors to the selection of the landfill location and design.

The Project was described based on the following typical landfill features:

- Lining systems
- Leachate management
- Landfill gas management
- Landfill capping

General Consideration

-Permitted waste

The following waste are permitted to be deposited at Kabd Landfill, any other wastes will not be accepted and will be kept in Quarantine area and will be transferred out of the landfill.

- Municipal solid waste
- Agriculture Waste
- Other non-hazardous waste
- Bulky Waste

The following wastes are not to be deposited at Kabd Landfill.

- Hazardous wastes
- Liquid wastes

- Construction and demolition wastes
- Tires
- Sewage

The following waste types are specifically excluded:

- Wastes which are inherently explosive.
- Wastes capable of burning unsupported at 40°C
- Wastes which are free flowing liquids within the range of ambient temperatures normally encountered at the site.
- Wastes, which react violently with water, or which react exothermically with water so as to produce temperature rises in excess of 10°C.
- Wastes having a temperature greater than 30°C, or 10°C above ambient temperature, whichever is the greater.
- Wastes, which are contained in pressurized containers, except for aerosol cans, which constitute an inherent component of a waste type, permitted to be deposited.
- Wastes containing more than 10 mg/kg mercury or hexavalent chromium.
- Wastes containing ferro and/or ferri cyanides exceeding 1000 mg/kg.
- Wastes containing predominantly free cyanides.

- Quantities

The total void space of Kabd Sanitary Landfill based on a waste body 750 m x 450 m in plan area at ground level and 15 m deep and 30 m high (45 m deep waste body|) is 11,502,000 m3. Assuming steady filling rates over a 20 year operational life (365 days/year filling) this equates to about 1,340 tonnes/day.

-Hours of operation

The site is expected to operate for 24 hr as approved by the Kuwait Municipality.

-Duration of activities

The site is designed to be operational for 20 years. 60 Days test run period should be operated before the actual run for the site.

-Potential Environmental and Social Impacts

In general, the environmental characteristics in terms of climate and meteorology, wind trends, waste generation and socio-economy are considered to generally consistent throughout the State of Kuwait. Specific details on environmental baseline conditions are presented within the vicinity of Kuwait City and the Project site (Kabd) have been presented where available including geology and topography, water resources and hydrology, air quality, noise, soil, terrestrial ecology, archaeology and cultural heritage and traffic

The potential occurrence and significance of potential environmental and social impacts arising from the Project has been assessed. To the extent possible, consideration has been given to design, construction, and operation of the Project although detailed information is currently not available. Generic information on design, construction, and operation impacts where relevant are presented. The assessment process has however focused on the aspects associated with the

Assessment results have demonstrated that key issues anticipated during the construction, commissioning, and operation phases include the following:

· Air quality & odor · Soil and Groundwater

· Noise · Waste Generation

· Terrestrial Ecology · Cultural Heritage / Archaeology

· Traffic · Socio-economic

The results of the risk assessment of the unplanned impacts during construction and operation associated with accidental spills showed the risk to be Low (Construction) and Medium (Operation).

After use plan

Choosing an appropriate after use for a landfill is critical to ensure successful restoration of the landfill site. the proposed after use should be determined during the FEED phase with some form of built in flexibility, in order to accommodate changes that will occur during the lifespan of the landfill.

The range of after use options includes:

- Nature conservation
- Informal recreation and formal sports
- Planting of hedgerows, shelterbelts, amenity and commercial woodland
- Preparation of soil for agricultural purposes
- Hard end uses such as roadways, buildings, car parks, yards

Design Consideration

The main principle of landfill design is to provide effective control measures to prevent or reduce possible negative effects on the environment, in particular: the pollution of surface water, groundwater, soil and air as well as the risk to human health arising from landfilling of waste.

The ground conditions, geology and hydrology of the site, and the location of the landfill, should all be investigated to provide sufficient information for site-specific design. Apart from the technical design requirements, environmental design requirements need to be considered such as: the nature and quantities of waste, protection of environmental media, leachate management system, gas control, water control, environmental nuisances, monitoring requirements and “after-use” plan.

The site layout should facilitate a practicable operation of the landfill. The preparatory works, which are site-specific, should be determined during the investigation phase. The landfill should be developed in a series of phases (cells that are separated by bunds and used progressively); this is because phasing will allow for progressive use of the landfill area so that construction, operation and restoration can occur at the same time in different parts of the site. Waste intake – which determines the size and lifetime and the sequence of operation of the landfill & waste type – will have to be considered during phasing.

The principal site infrastructures are:

- Access and traffic control;
- Arterial and temporary site roads;
- Parking area;
- Administration office, staff building and compounds;
- Waste inspection areas including radioactivity control;
- sorting area;
- splurge area;

- Civic waste facilities;
- Weighbridges;
- Leachate treatment plant;
- Landfill gas compound;
- Wheel cleaners;
- Site services;
- Quarantine areas;
- Material and fuel storage units; and
- Security / Reception.

-Capping Design and Construction

The principal function of the capping system is to minimize infiltration of water into the waste and consequently reduce the amount of leachate being generated. Cover material is also used for the daily and intermediate covering. Daily cover spreads over deposited waste at the end of the working day to control of nuisances such as windblown litter, odor, vermin, flies and birds. Landfills are required to contain wastes for many decades after closure of the site; therefore, it is necessary to have a robust capping system.

-Potentially polluting leaks and spillages of waste

There is a potential for leaks and spillages of waste or leachate which could have an adverse effect on the surrounding groundwater and surface water across all areas of the site.

Landfill Area

All waste should be contained within the lined area of the landfill cell. If a leak is identified in the landfill liner all practical actions should be initiated in order to minimize and repair the leak. This will normally involve removing waste in the close vicinity of the leak to expose the damaged liner and enable repairs to be undertaken the damage repair procedure should be set by the Contractor and should be mentioned in the emergency plan.

Groundwater and surface water monitoring data should be reviewed to determine the extent of the leak and contamination.

Waste recycling and waste destruction areas

Waste that is not disposed in the landfill area will be kept in a suitable container or on an area of hard standing with surface water catchment (the quarantine area) to prevent potentially contaminated run-off entering the groundwater or local watercourses. The Working Plan shall outline any treatment measures needed to allow run-off water to be discharged into any local watercourses.

Any waste spillages will be cleaned up as soon as possible upon discovery. Additional monitoring of local aquifers and surface water bodies may be required to monitor the effects of spillages.

Quarantine Area

Waste that is Hazardous or not permitted to be disposed in landfill area after the Sorting process will be kept in Quarantine area and shall be transferred out of the site by the specialized bodies depending on the type of the waste and after applying tests on the waste to determine the hazardous level of the material.

The Quarantined Wastes should be tested in Certified Laboratories Listed by KEPA, KM should be reported with a copy of All Tests Done.

Conclusions and Recommendations

The assessment of the operation related environmental impacts demonstrated that the planned and unplanned impacts were negligible and moderate respectively. The planned impacts are considered negligible due to their slight impact on the environment, despite the long operation duration of the Project. Furthermore, where the recommended mitigation measures are implemented, this will reduce the impact on sensitive receptors. Unplanned impacts are expected from the following;

generation of air emissions and damage to local ecosystems due to accidental fire; accidental fuel spillage and loss of containment and release to the environment of reusable; and recyclable materials.

The Environmental Management Plan and Environmental Action Plan details the recommendations and monitoring components that have been proposed to mitigate the impacts identified in the construction and commissioning and operations phase.

The following additional recommendations for the construction of the Project were identified in the impact assessment:

- Conduct a Traffic Risk Assessment (TRA) for the impacts to assess the local traffic and the anticipated congestion by the construction work
- Carry out a health risk assessment study which identifies the potential impacts to health resulting from the construction of the landfill. Suitable control measures and management plans will be developed based on this study.
- Ensure that all prior approvals are sought for any modifications on the landscape and land-use Undertake comprehensive environmental baseline studies (specifically terrestrial ecology) to identify environmental features that may be impacted by the construction works
- It is recommended that a detailed Social Impact Assessment (SIA) including stakeholder engagement be conducted for the Project prior to constructing the facility and following or during the FEED stage.

The following additional recommendations for the operation phase of the Project were identified in the impact assessment:

- Implement a noise impact assessment to assess noise emissions when the facility is operational, including the waste incinerators.
- Conduct an odor assessment including monitoring and modelling at a later phase of the Project e.g., following FEED.
- Carry out a TRA study for this Project. the impacts to the local traffic and the anticipated congestion are significant and therefore this needs to be assessed and the suitable management plans need to be developed and implemented.
- Conduct a health risk assessment study which identifies the potential impacts to health resulting from the operation of the landfill.

P 11

A simplified approach of designing the bearing capacity of a foundation on multilayer soil

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It is common for civil engineers to calculate the bearing capacity of a shallow foundation made on multilayer soil as one of a unique layer laid on homogeneous soil when the lower layers are at a depth of z≥3B. However, in the case when the width of the foundation becomes important this simplification is no longer applied. In the latter case, when the foundation is placed on a natural slope and its design remains a special case; typical examples are the foundation of offshore structures, silos, and electricity pylons. The actions of the structure such as its self-weight, the operating load, and the wind, must be transmitted to the ground in an economical and safe manner. The load under which the foundation soil undergoes shear failure is called the ultimate bearing capacity. It depends on the mechanical properties of the soil, the geometric and physical characteristics of the footing, and the nature and arrangement of the layers of soil in which the foundation is laid. The design criteria for foundations are presented in two main aspects. The first is to avoid ground failure (bearing capacity criterion) and the second consists of limiting settlements in the ground to admissible settlements.

Thus, as part of this work, the authors sought to propose an approach to calculate the bearing capacity of a shallow foundation on a multilayer sloping ground. In the literature review, most bearing capacity theories involve homogeneous soils assuming layer properties remain constant for bearing capacity analysis, and hence analytical solutions (such as bearing capacity theory) are matched with the experimental and numerical results. And, in the case where the properties of the soils vary with depth and the soil mass is sloping, most theories cannot be used and/or would not deal with the question; and the solutions using the analytical analyzes, which consider the non-homogeneity of the soil, are an approximate one and therefore the results are can be considered as imprecise.

This work presents an approach based on the analytical method. The results of this approach are compared to the ones from the numerical method, which helps to decide on the approach to use for the dimensioning of the foundation base. The analytical method is based on the classic equations taken in the best way of use coupled with the reduction factors then in a second phase the integration of the slope. Conditions for using the formulas and parameters are set depending on the terrain conditions. The second approach, the numerical method, is based on the use of software such as Plaxis 2D.

After comparing both aforementioned approaches, the analytical method gives acceptable values for low slopes β≤25 which are greater than the numerical values by at least 13%. For steep slopes β≥35, the analytical method is very limited compared to the numerical method, that is to say, it does not allow precise values of bearing capacity to be obtained. Both methods are very sensitive to variations in the layers' geometric and intrinsic parameters. Although the numerical method offers a wide range for analyzing the bearing capacity problem of sloping multi-layer soil, verifying the results in situ is appropriate.

In general, it was found that the bearing capacity of such a foundation depends on not only the cohesion intercept, the friction angle, and the thickness of the layers hi, but also on the ratio of the embedded depth and width and the slope angle β. Comparative good results were obtained for β value less than 25°, otherwise, the analytical approach was more accurate. In addition, the failure of sloping multi-layered soil was observed to occur as general shearing or punching. A quick check method was proposed to avoid such difficulty when deciding on the approach to be implemented for the foundation of multi-layers.

It is noticed that the stratification of a soil mass has an impact on the variation in the bearing capacity of a strip footing. Furthermore, the numerical calculation compared to the analytical calculation makes it possible to draw attention to the fact that the analytical approach does not take into account real fracture surfaces that occur on a mass of laminated flooring, which explains the difference observed between the analytical and numerical values of the bearing capacity.

A case study was applied to the calculation and dimensioning of the strip footing of a wall weight built in Kinsuka, in the DR Congo, as part of the project for the construction of a 220kV Kinsuka substation in Kinshasa. It was found on the one hand that not taking stratification into account during an analytical calculation reduces the bearing capacity by 25%, therefore undersized, and on the other hand, the omission of taking into account the stratification in the numerical calculation increases the bearing capacity by 11%, therefore oversizing.

The comparison of the two methods allows the auteurs to observe that: (i) the analytical method is reliable for low $\beta \leq 25°$, and the analytical values are higher than the numerical values by at least 13%, (ii) for average slopes $25° \leq \beta \leq 45°$, the two methods give very distinct capacity values with a difference of at least 44%, (iii) when the slope $\beta \geq 35°$, the numerical values are higher by at least 44% and remain almost constant for $h1/B \geq 2.5$ and $d/B \geq 3.5$, and (iv) when the upper layer is less compact than the lower layer, the numerical and analytical values of the bearing capacity vary in the same way with a deviation that decreases with the increase in the angle of 7%. In addition, it is shown that for the case where the upper layer is less compact than the lower layer, the bearing capacity is reduced by 47% with the increase in the thickness of the layer. Also, where the upper layer is more compact than the lower layer if the thickness $h1/B \leq 1.5$, there is a reduction of more than 75% of the bearing capacity, one can note a punching of the lower layer, furthermore, it increases with thickness by at least 80%.

P 13

Natural filtration of septic soak away water for construction and garden watering purposes in in Zimbabwe: A case of Nyabira peri urban settlement

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This study unleashes the temporally solutions to the construction and garderning water shortages in the upcoming suburbsIn most peri urban and even urban environment no one thinks about the utilisation of greywater from houses and this result in families forking out extra monies in purchasing water for construction, toilet flushing and gardening. However availability of water has its own challenges to most households in the upcoming suburbs in Africa and in Zimbabwe.

The study also established that most of the water used in the households is being drained into the ground and further contaminating ground water, yet it can be used for construction and garden watering if correctly directed to harvesting infrastructure with natural filtration. An experiment was carried out in the peri-urban settlement of Nyabira were the researcher dug a protected well 3 m away the temporally septic as a soak away to drain and preserve grey water for re use during construction. The study established that most families' waste considerable income in purchasing water loads for building yet an average of 200 litres per day is being collected for re use. A group of youths have started their pre cast wall project using the same water from one household, cutting costs and lives of youths have been transformed at no water cost. The study therefore recommends that all houses with mini septic tanks to create harvesting tanks to reuse the water suitably thereby recycling the precious liquid.

Key words: Grey water; soak away, septic tank, construction.

P 14

Engineering Education & Continuing Professional Development

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Around the globe, nations prioritize the creation of advanced technological communities and the advancement of civilization goals. The crucial role of engineers in this development necessitates continuous education. This article delves into the intricate relationship between engineering education and professional development, with a focus on the evolution of engineering from analog to digital and manual to automated. Additionally, it provides an in-depth explanation of CPD and discusses the key factors that contribute to the establishment of a successful engineering education environment, such as economic and educational considerations, obstacles, Industry 4.0, training, and experience.

What is CPD? CPD is a way to continuously learn and refresh person's knowledge, whether it be through practical or theoretical means by using all various opportunities. It is important to stay updated with the latest technological developments. CPD is achieved by utilizing both practical and theoretical learning methods. Neglecting one of these methods can have a negative impact on the process and results of CPD. The acquisition of theoretical knowledge is a fundamental aspect of education that enables students to comprehend the standard framework not only as a theoretical concept but also as practical knowledge that can be enhanced and refined based on learning circumstances. The theoretical learning process incorporates three essential terms: education, pedagogy, and andragogy, which refer to preparing, developing, and understanding the practices and methods that instructors can use to educate adults using all available sources of knowledge. Conversely, practical learning involves on-site work, applying theoretical knowledge to practical tasks, focusing on enhancing personnel skills through hands-on activities, and staying engaged with events. It facilitates self-learning by enabling a deeper understanding of the entire work process and solving existing problems. Practical learning provides an efficient way to comprehend theory and exchange information through teamwork.

The field of engineering has undergone significant transformations over time, culminating in the current age of innovation. In the 19th century, mechanical engineering expanded to include labor-saving devices such as the sewing machine and the mechanical reaper. As the century progressed, small-scale laboratories grew into large-scale production facilities. Today, experienced and qualified engineers play an indispensable role in shaping the world's development by driving the design and manufacture of products, innovation, and services that enhance human life. Therefore, it is imperative to create an environment that fosters engineers and improves their critical thinking, creativity, and curiosity. Many engineers receive training from graduation and continue to update their knowledge through on-the-job training to keep up with global developments and the latest advancements in equipment and programs, which includes the following:

- Computer Aided Design (CAD): is a design-related technology that focuses on the development, modification, and optimization of designs. It is mostly used to create 3D models. (e.g., CATIA, Power Shape, SoildWorks, and AutoCAD)
- Computer Aided Machining (CAM): is a computer-assisted manufacturing method that involves, plans, and controls the production process. CNC machines use CAM codes. (e.g., 3 Axis Milling Machine, 5 Axis Milling Machine, and CNC Lathe)
- Also, 3D printer: FDM 3D Printer. and SLA 3D Printer.
- High Accuracy Cutting Machines: Laser Cutting Machine and Wire Cutting Machine.
- Computer Aided Engineering (CAE) helps engineers to do the analysis of the CAD to create product in these parameters: temperature, pressure, component interactions, and applied forces.

With the advent of digital technology, skilled personnel in engineering and manufacturing processes have become indispensable. In the past, these processes mainly focused on product-based approaches that involved designing, problem-solving, and finding solutions. However, with advancements in technology, they have shifted towards technology-based approaches such as the Industrial Internet of Things, Big Data Analytics, Artificial Intelligence and Machine Learning, 3D Printing, and Virtual Reality. Traditional tools and analog drawings have been replaced by digital programs utilizing advanced equipment, which allow workers to finalize tasks with less effort, time, and more successful outcomes. Learning and education have facilitated this digital transformation, which has been influenced by the advancements in engineering. This has led to the emergence and gradual development of new approaches and patterns of learning and education, further contributing to the development of engineering concepts and theories. As learners and students become involved in ongoing projects, their learning skills are enhanced through observation and comparison of project results and outcomes. Increased interaction with projects also creates more opportunities for the creation and development of a scientific environment for continuous professional development.

In the contemporary world of rapid industrialization, it is imperative to establish an environment that nurtures knowledge and supports the growth of highly skilled engineers. Thus, it becomes essential to create an atmosphere that fosters self-directed learning and encourages professional development. This is a top priority for those responsible for establishing an environment that facilitates engineers' creativity, productivity, and innovation.

A conducive environment for engineers is founded on a variety of principles. First, creating clear goals, objectives, and a motivating environment is crucial. The company's managers should clearly define the objectives so that engineers can comprehend the company's strategic direction and carry out the defined objectives since motivation plays a crucial part in boosting performance and productivity. Second, it's crucial to communicate in a clear and consistent manner. All engineers should have free access to information, including updates on market conditions and company changes. Engineers should also update managers on new technical advancements and test outcomes. This information sharing between parties makes it easier to meet objectives and get around any roadblocks. Thirdly, it is critical to develop and use accountability techniques to guarantee that project assignments are correctly understood and carried out. A “Product Development Management System” (PDMS) is the best way to establish accountability and manage performance. Design reviews that are conducted as part of this organized process are targeted at accomplishing design objectives and requirements. Every design review considers a benchmark where a particular document should be authorized before moving on to the project's next stage. Employing PDMS enables businesses to generate designs more consistently and with fewer revisions. Employing PDMS enables businesses to generate designs more consistently and with fewer revisions. Fourthly, it's critical to continually assess and enhance the working conditions for engineers to promote innovation, productivity, and creativity. Additionally, one of the major strategies for improving staff members' skills and credentials is to support and highlight engineer accomplishments. Engineers should be praised for their initiative, successes, and failures, and managers should reassure them that they will be rewarded. Employees that take the initiative will always perform better in their jobs and inspire activities like designing. Finally, there must be realistic planning and project execution; thorough planning by appropriate staff for project components such as cost, schedule parameters, resources, staff, material, and time will reflect in the quality of the output and reduce risks. By adhering to these guidelines, we may establish a setting that supports professional growth and self-learning, allowing engineers to realize their full potential.

The ongoing automation, digitalization, and integration of numerous technologies in the manufacturing and industrial sectors are currently referred to as "Industry 4.0" and described in that context. It represents the development of engineering and industrial education and includes a number of elements:

- ü The Internet of Things (IOT) is the concept of connecting physical items and machines to the internet to enable remote data interchange and equipment control.
- ü Gathering and analyzing a lot of data to improve the way projects are done.
- ü Using artificial intelligence and machine learning, tasks may be automated, maintenance needs can be predicted, and overall production efficiency can be increased.
- ü Cloud computing makes it easier to access data and software remotely and encourages data storage.
- ü Using immersive technology, Augmented Reality (AR) and Virtual Reality (VR) can improve engineers' skills in a variety of ways, including training, maintenance, and design processes.
- ü By decreasing errors and guaranteeing excellent quality, using innovative manufacturing techniques like 3D printing for rapid prototyping and integrating robotics and automation to streamline operations ranging from assembly to logistics can dramatically improve production processes.

Reverse engineering can therefore be viewed as a scientific illustration of CPD. Reverse engineering and CPD both make use of cutting-edge tools and ongoing learning. In order to develop new things or results, they also call for the use of critical thinking, the discovery of knowledge from multiple sources, and the mixing of various cultures. Reverse engineering entails redesigning, replicating, mimicking, reproducing, and improving existing objects without using blueprints, which goes beyond just accepting offered ideas or evidence. Instead, it entails dissecting a project's component elements to gauge comprehension. The growth of broadening abilities and knowledge is the essential component of reverse engineering. To encourage creativity and innovation, engineers must use their imagination. They should actively look for hints and data that can serve as a creation guide. Engineers should adhere to the following three steps to improve their abilities:

1. Master the skill of gathering evidence and examples, then evaluating if the object warrants further investigation.
2. By comparing the provided data and learning from examining amazing cases, discover how to leverage and convert existing data into one-of-a-kind items.
3. By enhancing the provided metrics, recognize the qualities and requirements for the project, which will aid in the improvement of engineers' performance and self-evaluation.

Reverse engineering is a software application that focuses on hardware, machine code, and cutting-edge machinery and equipment. Through the use of RE, hardware and software may now be used together in a seamless manner to carry out activities that were before impossible. The categorization of various computer subroutines into the proper functional categories is another aspect of reverse engineering. The classification aids in comprehending the goal of the program. It is crucial to keep in mind, though, that this procedure is time-consuming and, depending on the intricacy of the software might take anything from a few hours to a few weeks. The following list of cognitive and practical steps is part of how RE operates:

First, the process of “information extraction” entails acquiring and examining all accessible data regarding the thing that will be reverse engineered. This entails figuring out how the bits of information go together as well as using pertinent equipment and software to separate the components.

Second: “Modeling” abstracts all the gathered information into a conceptual model, explaining the functions of each component within the overall structure. The purpose of this step is to take specific information from the original object and abstract it into a general model that can guide the design of new objects or systems.

Third: “Review” is the process of examining the model to determine whether or not the original thing has been realistically abstracted.

In conclusion, the engineering sector relies heavily on caution and constant learning. Engineering requires a variety of skills; they cannot be confined to theory alone. These skills include critical thinking, imagination, exploration, data collection, design, creation, and an open-minded approach to progress. These elements set the stage for knowledge and production, which have an impact on human life. Additionally, there is a chance to improve knowledge and manufacturing that influence and shape human existence with the rise of Industry 4.0, which aspires to develop smart factories. Moreover, this change has the ability to increase efficiency, lessen waste and errors, stimulate inventive business models across many industries, and develop a highly qualified engineering workforce.

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Implementing Building Information Modelling in the Ministry of Public Works of Kuwait: Investigating the Barriers and Proposing a Framework

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The Ministry of Public Works (MPW) in Kuwait contracts and subcontracts with private companies to carry out the majority of government projects. By enabling remote access to information, particularly for mega-projects, the implementation of Building Information Modelling (BIM) into their conventional procurement management system will entirely transform the construction business. This study aims to investigate why BIM is not being used in MPW building projects despite its advantages. To determine the benefits and barriers to successfully deploying BIM in projects, qualitative interviews with important MPW stakeholders were undertaken. According to the report, there are no substantive barriers to BIM implementation, and the pilot project that has been implementing BIM has shown benefits in communication, budget estimation, and information sharing with fewer iterations. However, a lack of support from senior management, a reduction in cadre and workers, no specialized budget, the mindset of experienced engineers that adhere to the traditional design-bid-build (DBB) procurement process which encourages conflict rather than collaboration, and the need for more awareness of BIM in circularity posed significant challenges to implementing BIM in MPW. To address these challenges, a framework for integrating BIM into the MPW tender process has been proposed and validated through semi-structured interviews with tender managers. BIM is a valuable tool for the global need for sustainable buildings for Kuwait's Vision 2035 and for meeting the Sustainable Development Goals (SDGs) established by the United Nations.

Keywords: BIM, MPW, framework, Sustainable Development Goals SDGs, stakeholders.

1. Introduction

Construction projects in Kuwait involve a significant number of resources and stakeholders. Effective communication and data sharing among multidisciplinary stakeholders are essential to prevent errors, conflicts, and resource wastage. The Ministry of Public Works (MPW) in Kuwait is responsible for executing most government projects through contracting with private firms and subcontractors. In traditional tendering, the selection of subcontractors is often based on the lowest price offered as contractors aim to maximize profits. However, this approach can result in client dissatisfaction and eventual profit loss (A. Olanrewaju et al., 2022). BIM can transform the traditional procurement management approach employed by the MPW as it facilitates access to information, particularly for large-scale projects, and aids in waste reduction through its modeling and design capabilities. BIM enables digital twin representation of the building and its components as well as multidisciplinary stakeholder collaboration throughout the project life cycle. BIM has been adopted in many developed countries, and it has become a fundamental requirement in the procurement (Olanrewaju et al., 2022) process for public projects. Despite this potential, Kuwait still faces limitations in adopting BIM highlighting the need, for a framework to integrate into construction projects.

This study conducted a qualitative analysis by interviewing key stakeholders in Kuwait MPW to identify challenges and benefits in BIM implementation. The proposed framework aims to provide a practical guide for BIM implementation in the Kuwait MPW Design-Bid-Build (DBB) procurement process.

2. Definition, Benefits and Barriers of BIM in Construction Industry

BIM is a digital representation of the physical and functional characteristics of a facility that supports decision-making processes throughout the building life cycle, from inception through design, construction, and operation (Eastman et al., 2011). BIM includes 3D models with added intelligence, allowing users to manipulate and visualize a building's components and systems and simulate their performance (Arayici et al., 2011). BIM also allows the integration of different design and construction disciplines, enabling better coordination and communication among project stakeholders (Mahamid et al., 2017). Additionally, BIM facilitates an efficient evaluation of contractor design details, against project requirements. This enables the assessment of bidders based on their life cycle costs and benefits rather than solely focusing on the tender price (Gehner, 1997).

Implementing BIM can provide advantages, such as enhancing communication and collaboration among project stakeholders reducing construction expenses minimizing mistakes and rework, and expediting project delivery. Additionally, it contributes to waste reduction and supports construction practices (Azhar et al., 2012). Furthermore, BIM assists, in managing the construction process by providing a visual representation of the project's progress and highlighting potential schedule delays (Eastman et al. 2011).

Disputes among parties often occur in the AEC industry, where BIM features can greatly assist in addressing legal issues and mitigating disputes effectively. Legal concerns related to BIM shall be addressed by adopting contract agreements establishing standardized procedures along with a dedicated BIM execution plan (BEP), and creating a common data environment. Barriers to the implementation of BIM include a limited understanding of its potential advantages, the expenses associated with its adoption the availability of skilled personnel, and the absence of a standardized approach to its implementation (Abbas et al., 2016). Additionally, resistance from those accustomed to construction methods, inadequate support from management, and reluctance, among experienced engineers to embrace new working practices can present considerable challenges when it comes to implementing BIM (Azhar et al., 2012).

3. Methodology

This study was based on a qualitative approach to accomplish the objectives, as shown in Fig. 1. A literature review was conducted to understand the current state of BIM implementation in the construction industry in Kuwait. Semi-structured interviews were conducted with key stakeholders, including client engineers, tender managers, contractors, and consultants, to identify challenges and opportunities in the design-bid-build (DBB) procurement process. A proposed BIM framework was developed, including guidelines, procedures, and execution plans. The framework was evaluated using the MPW project as a case study to assess its effectiveness in improving project delivery, collaboration, and innovation. The interviews provided insights into the perspectives of stakeholders on BIM as a waste reduction tool, identifying benefits, challenges, and potential for future improvement.

4. Analysis and Findings

4.1. Participants Responses

The client, contractors, consultants, and tender manager's opinions on the DBB procurement process are all reviewed. Clients emphasised the dependability of the procedure while accepting the possibility of subpar results. The benefits of competitive bidding were acknowledged by the contractors, but they also acknowledged difficulties in accurately anticipating costs while maintaining quality standards. Consultants raised the possibility of disagreements resulting from changes in design and unanticipated additional work.

The consultant provided ideas for thorough instruction and assistance in Kuwait MPW procurement. The development of training initiatives that cover the fundamentals of BIM software and workflow, the recruitment of qualified trainers, the promotion of active participation through various learning modalities, the

provision of ongoing support beyond the training phase, the provision of on-site assistance during implementation stages, the promotion of collaborative spaces, and continuously gathering feedback to improve are some of these.

Stakeholders in the construction industry have varying perspectives on BIM, along with associated benefits and challenges.

Benefits

Challenges

4.2. Proposed Framework for Implementing BIM in Kuwait MPW

The proposed framework for implementing BIM in Kuwait MPW simplifies the BIM domain by identifying meaningful concepts and their interconnectedness. Kuwait MPW should adopt an integrated BIM framework based on the conventional DBB delivery method and employ the lowest bid procurement process to enhance the tender process. A well-defined scope for BIM integration is crucial, with MPW outlining acceptance criteria for contractor-supplied information.

4.3. Validation

To get information on the BIM framework, including guidelines, BEPs, PEPs, Model Management Plans, training methodology, and performance evaluation mechanisms, semi-structured interviews with tender managers were undertaken. The effectiveness of BEPs and PEPs, the viability of BIM Model Management Plans, the practicality of adopting BIM guidelines, and the impact of training programs on skill improvement were all questions that stakeholders were asked. After that, the information was examined utilising qualitative research techniques in order to confirm or improve the BIM framework's elements. Through this iterative approach, the organization's goals, objectives, and practical realities are effectively reflected in the final BIM framework, ensuring successful implementation and successful project outcomes.

5. Conclusion

In order to improve communication, data exchange, and project efficiency, this research study investigates how Building Information Modelling (BIM) might be integrated into Kuwait's Ministry of Public Works (MPW) construction projects. The adoption of BIM in MPW projects has been difficult because of issues such as a lack of senior management support, lack of experienced BIM personnel, and adherence to old processes. BIM has the ability to revolutionize traditional procurement management and waste reduction. The integration of BIM into MPW's tendering procedure is offered in a comprehensive framework, illustrating both its applicability and its potential to transform project management. The study emphasizes the significance of BIM for sustainable buildings in Kuwait's Vision 2035 and the Sustainable Development Goals of the United Nations, encouraging responsible expansion in the construction industry.

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The greater safety of vegetable oil fuel

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Introduction

The inherent safety of a fuel is governed by its flashpoint which for liquids is the temperature at which they spontaneously ignite and for gases, is their boiling point. While lower flashpoint fuel engines are easier to manage, we in the western world seem intent upon using ever more dangerous fuels moving from petrol to liquefied petroleum gas (LPG), compressed natural gas (CNG), liquefied natural gas (LNG) and finally to the most volatile gas of all, hydrogen. The current sustainable fuel initiative here in Australia is to use so-called 'green' hydrogen. This fails to recognise that the lower the flashpoint is, the more dangerous the fuel is. Hydrogen has the lowest flashpoint (boiling point -253℃) and the highest flammability range (4-75%) of all potential fuels such that its use is likely to cause more deaths than current fossil fuels.

Adoption of vegetable oil fuel despite its 10 to 20-fold higher viscosity than petrol will reap a large reward in inherent safety. Vegetable oil flashpoints are generally in the range +100 to +300℃ (cf petrol minus 43℃). Straight diesel fuel and, biodiesel which is made from vegetable oil are in-between with flashpoints of 52-82℃ and 100-170℃ respectively. Vegetable matter can also be burned directly albeit wasteful, or processed into ethanol which involves extra cost.

A study of accidents which have occurred at manufacturing plants around the world and of road-accident statistics involving fuel fires in the period 1910 to 2014 is presented. These accidents continue, for example, at Philadelphia Refinery in 2019 and Pemex Refinery in 2022. The study shows that of 616 accidents, natural gas caused most of the explosions followed by petrol, propane, butane, solvents, dust, LPG, kerosene, ethylene, acetylene, hydrocarbons and crude oil. Natural gas also caused the most deaths. The worst events in terms of deaths per explosion are those involving pipelines, roads, and large scale occupied premises. To prevent this, it is reasonable to suggest that the wisdom of distributing gases by pipeline, using volatile vehicle fuels and gas supply to multiple occupancy premises, should be questioned. Of countries studied, the US has the highest number of events and of deaths given that its data is more readily available internationally. In contrast, the only event listed for North Korea is one which remained unreported for a considerable period and where help from other countries was initially declined. The author concludes that based on a world population of 7.7 billion, if all fuel was replaced with vegetable oil, the potential for loss-of-life saving would be in the range 5507 to 7255 persons/year. Bar charts showing the number of explosions, number of deaths and number of deaths per explosion in the period 1910 to 2014 are presented in the poster and in the full paper.

A fundamental part of the logic of this work, is to determine the viability of straight vegetable oil (SVO) in order to gain the improved safety that will result. SVO can be used in both fixed and automotive engines. Presently, the world contains around 900 million vehicles with another 60 million new vehicles being produced each year. It is estimated that approximately two-thirds of the world's oil output goes to transportation. Of this, 54% is diesel fuel used in diesel engines. It is these compression ignition engines which are capable of using SVO fuel as first shown by Herbert Akroyd-Stuart in 1890 and by Rudolf Diesel in 1897. To achieve the aim therefore, requires first that all engines are compression ignition engines and then that all fuel is SVO. The advantage is in the flashpoints of SVOs being so much higher than all other fuels. I show the relative flashpoints of various fuels.

From this, it is evident that vegetable oils have considerably higher flashpoints than any other fuel type. That a high flashpoint is important in reducing the likelihood of fire is common knowledge and should be taken as read. The German standard for Rapeseed oil DIN 51605 (crude degummed rapeseed oil) requires

that the flashpoint be not less than 220°C. Biodiesel (fatty acid methyl ester) according to DIN 14214 must have a minimum flashpoint of 101°C.

Summary

This work attempts to explain the potential reduction in loss of life using SVO by referring to data on the occurrence of unconfined vapour cloud explosions (UVCE) and other explosions involving fuel and fuel like substances which can occur when volatile fuels are being manufactured or stored. These events although devastating are relatively rare. More common fires in fuel and fuel-like manufacturing facilities are small localised fires, tank fires, bund fires, crude oil tank fires not involving boil-over, crude oil tank fires involving boil-over and so-called boiling liquid expanding vapour explosions. Also more common are fuel transportation accidents. The author has to date, not sought statistics for these other events. This appraisal is limited to assessing explosions and vehicle fires. However, some information about crude oil tank boil-overs and fuel transportation fires has been obtained and is summarised.

Of the flammable gas fuels, hydrogen is considered the most dangerous in view of its very low flashpoint (-253°C), large flammable concentration range (4-75%) and low ignition energy (0.011 mJ @ 25°C). An escape of hydrogen almost invariably catches fire. Hydrogen is presently the most vigorously pursued alternative fuel in view of its so-called environmental 'friendliness'. A release of hydrogen inside a tunnel could be devastating as indicated by Wu. This analysis however shows that flammable gases and flammable vapours which are heavier than air are considerably more dangerous than hydrogen. This is likely to be because hydrogen moves rapidly upwards from its release point therefore localising the damage area to that reached by flying debris. The rate at which hydrogen escapes upwards is 131 m/s/s. It is 14.4 times lighter than air. An added disadvantage for hydrogen is that along with helium it is the only element which leaves the planet after escaping into the atmosphere, by exceeding Earth escape velocity (11.2 km/s). Whether this escape rate is balanced by or exceeded by the planetary influx of hydrogen caused by the solar wind and in compound form in meteorites and cometary debris is unclear. However, knowingly allowing activities which deplete the planetary mass, should perhaps be reconsidered.

I have studied and summarised 616 accidents in the period 1910 to 2014. Whilst conventional diesel fuel is not without risk especially if it becomes involved in a fire which is already underway, few of the accidents listed involved diesel fuel or combustible liquids which are similar to diesel fuel. It should therefore be clear now to the reader, that the more volatile the fuel is, the more dangerous it is and the greater risk there is of accident. Consequently, any initiative which reduces the presence of these kinds of fuels particularly their availability to the general, untrained public, should be encouraged. In Australia, Europe and the developed world generally, the opposite is happening as we move as a result of pressure from both the private sector and from governments, towards more and more volatile and dangerous fuels. It is hoped that this work will assist in reversing this trend.

Explosions keep happening with high and low loss events occurring in a cyclic manner. Generally, the greater the confinement the greater is the extent of harm caused, with the exception that some of the most devastating explosions occur in the open air as so-called unconfined vapour cloud explosions. With munitions designed to be harmful, the confinement is of the explosive material in its casing. With mines and tunnels, it is the nature of those places which causes confinement. In houses, offices and any form of building, the confinement is the building itself. In the open air, the change from deflagration (burning) of a cloud of vapour to a detonation (explosion) depends upon the extent to which obstacles are encountered as the flame-front progresses. The change from deflagration to detonation occurs when the flame velocity reaches and then exceeds the speed of sound.

Natural gas caused most of the explosions followed by petrol, propane, butane, solvents, dust, LPG, kerosene, ethylene, acetylene, hydrocarbons and crude oil. Natural gas has also caused the most deaths but

this time followed by agricultural chemicals such as ammonium nitrate, LPG, petrol, propane, dust, solvents, LNG, propylene, diethyl ether and TNT. The greatest number of deaths per event were caused by diethyl ether, followed by TNT, agricultural chemicals, LNG, propylene and LPG.

The number of explosions is highest for factories, followed by houses, road events, pipeline accidents and rail accidents. The number of deaths is highest for factories, houses, schools, rail and road explosions. Worst for deaths per event are schools where one case caused a very high number of deaths (March 1937, New London, Texas, 450 deaths), followed by factories, theatres, rail, prisons, flour mills, road events and hotels.

Although factories have the most events and cause the most deaths, I show that the worst events in fact, are those involving pipelines, roads, and large scale occupied premises. To prevent this, it is reasonable to suggest that all forms of fuel transportation should be reconsidered. It suggests that reticulation of gas to premises other than single, on-ground premises where any lacking in safe practice by the occupier, will only affect those present in the one premises rather than affecting whole blocks of flats or tenements, should also be reconsidered.

The US has the highest number of events and of deaths by a long way. However, this alone does not suggest that this country is less responsible rather, it shows that its data is more readily available internationally. In contrast, the only event listed for North Korea is one which was initially undisclosed for a considerable period and offers of help from other countries was refused. The event however appears to have been so large that the country acceded to allowing access to the International Red Cross. It was not until much later that North Korea publicised what had happened.

The total number of deaths caused by accidents analysed is 11,466 (111.3/year). This compares with the 1985 established ILO figure of 22,898 deaths in 25 years from 1969-1993 (915.9/year). This analysis defines these deaths as caused by disasters with non-natural triggers, further categorised as ‘accident, technological accident or fire’. Clearly the latter figure should not be used in the present context. However if ILO is correct in its analysis, the higher figure provides a glimpse into the totality of deaths which are likely to be caused per year from all fire-related causes. Neither of these figures will allow for non-reporting and the reluctance of many countries to publish at all. Openly reporting, analysing and learning from accidents when they happen is the only way to ensure that they do not recur or at least, to minimise that recurrence.

My conclusions are (i) If the whole world used non-volatile, high flashpoint vegetable oil fuels as opposed to very volatile current fuels and even more volatile fuels being considered, a life-saving in the range of 5223 to 6879 persons per year would be realised by preventing explosions and vehicle accidents involving fire alone. Greater saving would be realised by also preventing other fire accidents which have not been analysed here. Although it is likely that there is insufficient land available presently to achieve this extent of vegetable oil use, it is justified as a goal on safety grounds.(ii) There would be fewer deaths associated with all aspects of fuel handling namely, manufacture, transportation, storage, reticulation and use. Even the unlawful practices of stealing fuel from leaking pipelines and of breaching the pipeline to facilitate theft, would cause less loss of life if the fuel was not so volatile. (iii) It follows from this analysis that as well as changing the fuel type used for automotive and fixed facilities, certain fuels should not be reticulated at all and high pressure natural gas should not be permitted to be reticulated to dwellings which are in multi-storey apartment complexes.

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Manufacturing Sustainability through Process Design & Repurposable Engineering Approach

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It is well known Manufacturing leaves a huge carbon footprint, not just in the end product alone, but the fabrication of tooling used in manufacturing also takes up a considerable portion as each generation of the product requires its custom tooling.

The **aim** of this is to reduce the footprint of tooling or manufacturing process through a much more sustainable process design or re-purpose-able engineering approach in tooling design.

These **approaches** can be through a modular design system where components can be replaced independently, a fungible design where tooling can be used throughout multiple generations of products or able to harvest and retrofit its components into new tooling, repairable by design where the system is designed for easy to repair instead of replacement, tooling-less process design where designing a process that doesn't require tooling but changes through programming script to customize the process and changeable when new changes is required.

The **result** of such design successfully achieves a significant cost saving of 82% in tooling cost. This approach of process design and tooling design philosophy will inherently reduce manufacturing footprint in tooling fabrication, lowering manufacturing cost and achieving a much more sustainable future.

P 19

Enhancing Electrical Conductivity and Evaluating Heat Generation in Multi-Walled Carbon Nanotube-Incorporated Cementitious Composites

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In this study, multi-walled carbon nanotubes (MWCNTs) were incorporated into cementitious composites to enhance their electrical conductivity and evaluate the resulting heat generation from electrical flow. Achieving proper dispersion of carbon nanomaterials in conductive cementitious composites is a crucial but challenging task. To address this, noncovalent functionalization of MWCNTs was carried out using melamine, followed by sonication to ensure effective dispersion within the mixing water. The specimens consisted of 50 mm cubic shapes with embedded copper plates serving as electrodes. The electrical resistance of the developed conductive cementitious composites was measured, and changes in surface temperature over time were observed using a laser thermometer and thermal imaging camera. The MWCNT inclusion amount was varied as the main experimental parameter, ranging from 0.5 wt.% to 2.0 wt.%. The experimental results confirmed that the developed conductive cementitious composites exhibited electrical conductivity at the semiconductor level. Furthermore, it was observed that specimens with MWCNT contents below 1.0 wt.% showed an increase in the maximum heating temperature as the MWCNT inclusion amount increased. However, for inclusion rates exceeding this threshold, a relatively poor dispersion of carbon nanomaterials resulted in a decline in both the maximum heating temperature and heating rate. Consequently, the developed conductive cementitious composites have the potential to efficiently transfer the heat energy generated by Joule's heat, induced by the application of electrical energy, to the cementitious composites. This technology holds promise for various applications, including road de-icing.

P 20

Digital twin for machine design

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Introduction

The concept of the digital twin (DT) is to create a virtual informational construct, that is an individual entity. This entity would be a twin of the embedded information in the physical system. The idea of DT is to be linked with the physical system through all four phases of the product lifecycle: the creation of the product, production, operations, and disposal of the product. Nowadays there is a question if there will be one digital twin for the whole product lifecycle or if there will be one DT for every step, which can "live" its own life after the product has moved to the next phase, and the old DT can be used for further development and research.

The majority of research effort does not cover all of the product cycle but only focuses on its phases. The majority of the focus is on maintenance (the support/use stage), in the second place there is the completion of the machine, and the design of the machine is in third place. This study focuses on the design part of the lifecycle.

Creation of Digital Twin for Design

Ansys has recently introduced the Twin Builder software. This software mainly consists of three parts. The first Build phase is for model and reduced-order model (ROM) creation which is created by running a large number of simulations on the created model. The ROM is able to react almost in real time. In the second phase of Twin Builder, the results from the model are verified and optimized to match the real machine. The third phase involves connecting the DT to the real machine and creating a functional mock-up unit, or stand-alone application. The design DT would use the proposed ROM created from collected data from real machines and information during the period of machine operation. The DT would help to detect design flaws related to the operating load of the machine, which is usually unknown to the machine manufacturer.

Another possible approach to designing a design DT is to use a combination of multiple SW platforms. In this study, the combination of Adams View software for multibody dynamics simulation (MDS) and Ansys Workbench for finite element method (FEM) calculations is presented. These software platforms are further linked via Matlab (Simulink). The volumetric model is imported into Adams View software, where the boundary conditions of the model are specified. Output from these simulations are forces acting on parts of the machine. These data are exported to the Ansys Mechanical and used as input data for the stress and strain FEM calculation of the examined parts. The Matlab software not only works as a linkage between both simulation programs but also as a user interface.

Data Collection

Acquiring data and information about the machining forces is a HW-intensive activity. The forces acting on the workpiece can be read by a dynamometer, which is a relatively expensive device, and adding another object to the machine's workspace may be undesirable because of its reduction. Without these devices, the components of the machining forces must be estimated.

One of the possible ways to obtain information about the cutting force waveforms consists of using an accelerometer and measuring the spindle motor currents. Another way of obtaining data on cutting force waveforms was investigated by Pham. His paper compares the measured data using a dynamometer with

data obtained indirectly from machine drives and spindle currents. This method has yet to be verified and is unlikely to be as accurate as accelerometer measurements, but could be an easy source of relatively accurate information.

The Use of DT for Machine Tool Design

By using DT for the entire product lifecycle, it is possible to collect data for the entire phase of its use. In the development part of the cycle, the creation of DT of possible machines can lead to a more efficient use of future machines. Manufacturers can focus more on individual customer problems so that they don't produce machines that may be under-dimensioned for specific customer needs. Which can lead to rapid wear and tear or damage to the machine in the long term. Otherwise, the machine may be over-dimensioned, and the customer will never use the machine to its full potential. This leads to a higher price of the machine which may be bested by competitors. By being able to modularly assemble the individual parts of the machine (bed, table, stand, spindle, motors, etc.), the manufacturer can offer customers a customized machine where the problems mentioned above would not occur. For such considerations, it is necessary to introduce a new sales model where customers are willing to share operational data.

Conclusion

This study suggests using different DTs for every phase of the product lifecycle and to creation of DTs for milling machine designing. The DT of the CNC machine used in the design part of the product lifecycle can undergo simulations of machining based on data from the real machine in the workshop. These simulations can provide a better look at part usage. Design DT can provide help for decision-making in design and helps to prevent the usage of over- and or under-dimensioned parts. This approach would lead to “tailor-made” machines that can withstand their work properly. The next step in this work is to focus on the collection of information about the forces on the machine, create a model of the MCV 754 milling machine, and verify the force and stress waveforms on the machine.

P 21

Using Markers to Refine GPS Positioning for Augmented Reality Warehouse Navigation

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When picking inventory from outdoor warehouses we encounter several problems, including locating the destination and determining the shortest route to sub-targets. One technology that could help the user during the localization and navigation process is augmented reality. This technology allows 3D virtual artefacts to be displayed in the real environment, in this case for example, navigation elements or a visual representation of the target. There are already various commercial solutions available for use in navigation, but their application in general warehousing is unique. In the case of outdoor warehouses, GPS technology can be a great benefit. However, this technology has positioning inaccuracies. For the optimal implementation of a navigation system, the GPS position needs to be found as accurately as possible. We investigate one option for achieving GPS positioning accuracy by using markers. Once the position of the observer is refined, the position of the digital artefacts is also refined. First, the inaccuracy without corrections is experimentally measured within the proposed technical solution, then the optimal size and rotation angle of the marker is experimentally determined. The output is then a mathematical model that determines minimum marker sizes, spacing, and rotation angles based on the aisle width of the outdoor warehouse.

P 22

IoT Feedback System for Analysis and Optimization of Human Motion Sequences

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In this work the concept and prototype results of an IoT feedback system for the monitoring, analysis and optimization of human motion sequences are presented. With an aging population in Europe and growing generations of digital natives, new ideas are required to encourage sport activity across all age groups. According to public available studies such as from OECD, compliance with WHO recommendations for appropriate exercise could potentially mean a substantial relief for public healthcare systems. In many disciplines, the approach of gamification has become a proven tool to attract attention and keep up motivation as it strongly appeals to the human mindset. Since fitness is one of the most common sports activities, digital solutions that offer the possibility to compare one's own sports performance to an anonymized group data may appeal not only to professionals but to all performance classes. Digital solutions in combination with smart textiles applied to sport clothing and equipment can capture, collect and visualize user data for that purpose. Furthermore, digital solutions may help to prevent avoidable sport injuries. Indeed, the majority of accidents that lead to injuries in sports can be traced back to incorrect behavior and insufficient technical skills. On the other hand, digital solutions may provide useful biomedical data in combination with historical data from sport activity for telemedicine treatment. The presented prototype in progress combines smart textiles as sensors, IoT-edge devices, wireless data transmission and artificial intelligence in an automated process from data capture to visualization as a cloud service.

P 23

Mining to sustain food and provide education, a business model case study from Korea in 1930s and 1940s, potential application to indigenous mining communities

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As the era of ESG is emerging, the importance of the socioeconomic impact of mining operations is emphasized. Today, mining operations have been the target of criticism for their adverse impacts on the local community, notably on the following themes: income inequality, inadequate education opportunities, and a lack of collaboration with the local community, which may pose a potential risk of conflict.

The purpose of the case study is to highlight the business model of 'Daedong Mining Corporation' in Korea, which was a native-owned company during Japanese annexation in the 1930s and 1940s. Its slogan and corporate philosophy were "farmers are landowners, miners are mine owners". Its key functions were to fund the following: the establishment of a fee-free engineering college; the establishment of a publishing business that eased access to books in an effort to lift the literacy rate; the purchase of farming land, offering cheap lease fees for local farmers to ensure a self-sustaining food supply; continuous donations to local communities to lift farmers from poverty; and the consequent donation of its wealth to farmers and educational institutes when it was dismantled in 1943.

Although its dream to establish a sustainable business model to help build "society where all working people prosper together" was short-lived, its efforts to collaborate with the local community to improve food supply, reduce social inequality, and provide engineering education opportunities is a good case study to apply for modern mining companies to overcome potential conflicts with remote indigenous and local communities.

P 24

Breakthrough in water from air technology

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Abstract: The humanitarian Foundation SANAKVO promoted the development of a new AWG technology allowing extraction of humidity from the air to obtain pure drinking water by a low-tech and low-cost method. As the water in the air can never be exhausted, this technology could be a game changer to the worldwide problems of accessing pure water everywhere, even in deserts.

The technology is based on the absorption of water vapor into glycerol and its recovery in a sandwich-like membrane structure. Using the principle of membrane distillation (heated by solar or electric heat), it provides a condensate of pure drinking water. It allows water generation in a very sustainable procedure. Its proof of concept in an arid setting was established on the Isle SAL on Cape Verdes (2018).

Meanwhile, very simple, electric home units have been developed. They allow decentralized water production everywhere. The cost of water from them depends on the local cost of electricity. Units producing up to 30 l water per day are paid for in several months. In solar water fields, the water cost is close to tap water costs. The water yield is 5 l/m2/day.

Partnerships are needed for the implementation of this technology all around the world.

Aims

Design and develop low-cost fabrication for solar and home units.

Assist manufacturers in up-scaling production globally.

Background

Traditional sources of water are or will be soon exhausted. International organizations warn, that water crises will increase to almost catastrophic dimensions in the next decennia. There is an urgent need to find new sources of water to prevent water deficiency with catastrophic consequences for humanity.

Water vapor present in the atmosphere contains unlimited amounts of water because it is continuously replenished with water vapor coming from oceans by winds. Therefore water humidity might be an unlimited and eternal source of pure water if efficient technologies will be developed (1).

Actually known methods for getting water from air humidity are inefficient, complex and expensive. Therefore there is un urgent need to find more efficient technologies. For two decencies we have concentrated our research and development just for finding of such a new technology. We are convinced that we have finally succeeded in it.

Results

Our new two steps technology.

The technology consists of two steps: Absorption of water vapor into a convenient absorber and release of absorbed water out of it. Both steps can run separately. In this way it optimal to absorb air humidity at night when the relative humidity is the highest and release water by solar heat during the day. We use liquid absorber glycerol which can be easily transported by pumping. Pumping is easy, cheap, well regulated and requires only very little energy.

Glycerol is efficient, stable, of low cost, widely available in large amounts and nontoxic. It is food and non toxic. It is also non polluting and highly thermally stable up to 300°C. It has high capacity for water because it can bind multiples of its volume of water. It absorbs humidity even down to 10% relative humidity.

First step: Water vapor absorption.

Concentrated glycerol is pumped on the top of an absorption structure. This structure is formed by pleated textile (for ex. cotton fabric or towel). The towel bands are fixed on simple holder for ex. a pleated garden fence wire. This is inexpensive and easily bent. The structure is opened so that air can easily circulate inside and water vapor has a good contact with by gravity flowing glycerol.

Second step: Generation of pure water.

Water containing glycerol is pumped into a thin sandwich structure formed by an thin sheet of Al foil and selective membrane letting only vapor to pass through but no liquid. Water vapor condenses to pure water on the surface of condenser. Water obtained is very pure without use of filters (2).

Conclusions

This technology is the lowest-cost water-from-air technology (parts and materials for a home unit are <$100 and even lower for solar modules.)

Easy fabrication steps using well-established processes and common materials.

Productivity is in a range of 10 to 30 l/day in electric home systems and 5 l/day/m2 water per day in solar systems, both depending on air humidity.

Future Work

The Sanakvo Foundation will work toward facilitating spreading the technology on a global scale.

Establishing of continuous production of sandwiches and heat exchangers to decrease production costs and allow a large scale production technology worldwide.

Determination of life-time of the system and of its parts.

Calculation of water costs on different places of use.

Acknowledgements

Pavel Lehky and coworkers wish to acknowledge sponsors of Sanakvo and Lambda Instruments company for all support provided over many years.

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P 25

Losses and waste from the fruit and vegetable industry – food waste

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Very often, food losses and wastage arise at every stage of production, and mainly at the consumers. The most serious problem is the waste generated in distribution, households and catering, as it is mostly already processed, ready-to-eat products. It is estimated that more than 5 million tons of food ends up in garbage cans in Poland each year, with about 3 million tons of waste generated directly at consumers. It is also estimated that an average of 3.9 kg of food was thrown away per week in households, about 35% of this was waste that was generated during food preparation (peelings, shells, husks), and about 8% inedible parts (bones, stems, coffee and tea grounds), it follows that as much as 57% of the waste generated is wasted food.

The most commonly discarded products are bread (49%), fruits (46%), processed meats (45%), vegetables (37%), yogurt (27%), potatoes (17%), and milk (12%). FAO experts estimate that the global annual loss of food produced in the world is about 20% of oilseeds, meat and dairy products, 30% of cereals, 35% of fish and as much as 40-50% of root crops, fruits and vegetables.

The large amount of waste and at the same time fruit and vegetable waste is not only a waste of food, but also a major threat to the environment. On the one hand, significant environmental resources such as farmland and water are used to produce food; on the other hand, unused food, during decomposition, contributes to increased greenhouse gas emissions.

P 26

Prevention of another 1974 UK Flixborough disaster

Ian F Thomas (I F Thomas & Associates, Williamstown, Australia)

Introduction

At 4.53pm on Saturday 1st June 1974, there was a massive Unconfined Vapour Cloud Explosion (UVCE) of cyclohexane at Flixborough, Lincolnshire UK. 28 people were killed and 36 injured. The plant owned jointly by Dutch State Mines and the UK National Coal Board known as Nypro Ltd, produced caprolactam a cyclic amide, by the catalysed air-oxidation of hot liquid cyclohexane to produce a mixture of cyclohexanone and cyclohexanol known as Ketone-Alcohol or KA oil. The cyclohexanone was purified and then converted firstly to the oxime and then to caprolactam. Caprolactam is an intermediate in the production of polycaprolactam, known as Nylon 6.

On the preceding Friday, there was insufficient nitrogen available to run across the weekend so in order to continue production, the oxygen sensor which injected nitrogen if the oxygen level got dangerously high, was deactivated. The reaction took place in a cascade of six reactors and number five was out-of-service for repair, so a temporary pipe was installed connecting the two adjacent reactors. Each reactor was joined to the next by a 28-inch bellows unit. The temporary 20-inch pipe was connected at each end to the adjacent bellows unit.

Much investigation followed the event and all articles I have seen, address the inadequacy of the temporary pipe which was blown off. However, my investigation conducted and first published in 1993, denied any weakness or inadequacy of support of the temporary pipe assembly and instead, advocated that an explosion in the preceding reactor occurred and blasted out through the pipe, blowing it apart.

The part of the plant involved in the accident was the cyclohexane oxidation unit, for which cyclohexane and air were the feedstocks and KA oil was the product. Reaction with fire regularly occurred inside the reactor train and resulted in the production of so-called ‘black KA’. If there was no control over the all-important oxygen level I suggest that the ‘reaction-with-fire’ could have become an in-reactor explosion in one or more of the five reactors, finding an outlet in the form of the 4-6 temporary pipe joint. Had this pipe not been present, a worse event involving explosive rupturing of one or more reactors may have occurred.

I believe that a large memorial should be constructed on the site. All there is presently, is a small memorial in the Flixborough churchyard.

Reactions in the cyclohexane oxidation unit were:-

cobalt octanoate catalyst, a temperature of 155˚C, a pressure of 125psig

cyclohexane (C6H12) + oxygen (air) = cyclohexanone (CH2)5CO + cyclohexanol (C6H12O)

Unreacted cyclohexane was also present and this was separated by distillation and recycled.

In another plant on site the reactions were:-

cyclohexanone + hydroxylamine sulphate ((NH3OH)2SO4) = cyclohexanone oxime (C6H11NO) + H2SO4

cyclohexanone oxime (C6H11NO) + H2SO4 + NH3 = cyclohexanone oxime (C6H11NO) + (NH4)2SO4

Beckmann rearrangement using oleum (concentrated sulphuric acid) followed thus

cyclohexanone oxime (C6H11NO) + H2SO4 = caprolactam (a cyclic amide (CH2)5 C(O) NH

At another premises, the caprolactam was polymerised to form Nylon 6, thus:-

ring-opening polymerisation at a temperature of 533◦K and in the presence of nitrogen, N2

caprolactam + N2 = Nylon 6, polycaprolactam, [(CH2)5 C(O) NH]n

Caprolactam is a lactam of caproic acid (hexanoic acid, (CH3)4COOH) where 'lactam' is a name derived from 'lactose'. It is a seven-membered ring with the formula (CH2)5 CO NH.

An amide group CO-NH is formed by reaction of an amine group (NH2) and a carboxyl group (COOH)

How can we prevent this in future

From the foregoing it is evident from others that one must not introduce temporary pipework without thorough engineering first. Better still, wear the reaction delay and repair the damaged reactor properly. However, my view is that the far greater message of this accident, is under no circumstances, de-activate an oxygen sensor for such a dangerous, high temperature, high pressure reaction. Do not proceed until sufficient emergency nitrogen is available. Black KA is infinitely better than what actually happened.

More detail

Surprisingly I didn't become interested or knowledgeable about this accident until several years later and published my first paper on the subject in 1993. In 2011 my wife Joan and I were able to visit the site and also to meet with and stay with Dr Keith Gugan and his wife Beryl in London. He is the author of the book 'Unconfined vapour cloud explosions', published by the Institution of Chemical Engineers (IChemE) and George Godwin Limited in 1979. Subsequently he and I co-authored a paper entitled *'Official incident reports, can they be relied upon – Flixborough'*, presented as part of the proceedings of the APCChE/Chemeca int conf, Vol 2, 133-140, 27-29Sep93.

Professor Frank Lees' critique of others

The late Professor Frank Lees whom my wife and I were able to meet and dine with, using wine glasses etched with the Piper Alpha oil platform (Professor Lees was part of the Board of Enquiry into the disaster), stated in the third volume of his book 'Lees' Loss Prevention in the Process Industries', 3rd Ed, Elsevier Butterworth Heinemann, Vol 3, 2005; A132 Coode Island 1991 p1/63; A2.9 Critiques, Flixborough, Appendix 2, pp2/17-2/18, as follows:-

The Flixborough inquiry has been the subject of a number of critiques which have centred mainly on (1) the form of the inquiry; (2) the examination of the hypotheses; (3) the design of the plant; (4) the management of the plant and (5) technical issues. These include those of R L Allen (1977b), Mecklenburgh (1977a), R King (1990) and I Thomas & Gugan (1993) and the mainly technical discussions of Gugan (1979) and V C Marshall (1987).

King gives a detailed description of the plant and its operation, and diagrams showing the original plant and the modified plant, Mecklenburgh, King and Thomas & Gugan argue that the legal format is not conducive to elucidating the facts abourabout technical issues. The question is discussed in detail in Chapter 27. With regard to the examination of hypotheses, Thomas & Gugan argue that the possible role of explosive reactions described by Alexander (1990 b,c) was insufficiently explored. With regard to the 8 inch pipe hypothesis, while accepting that the enquiry devoted considerable effort to exploring it, they are critical of the arguments used in dismissing it.

Thomas & Gugan rehearse various aspects of the 20 inch and 8 inch pipe hypotheses. Aspects of the 8 inch pipe hypotheses are also discussed by Marshall.

King gives an account of his own hypothesis that there was a pressure rise in Reactor No 4 due to the evolution of water vapour from water present in the reactor. He also gives the background to the removal

of the agitator from Reactor No 4. King is critical of the conclusion that the crack in Reactor No 5 was due to nitrates in the cooling water, the finding of a DSM report. He quotes an HSE source to the effect that the reactor vessel drawing specified a maximum thrust on the 28 inch stubs of 9 te, whereas at normal operating conditions the thrust was 38 te. He suggests that the nitrates found were from cooling water sprayed on the already-formed crack.

The design of the plant is also criticized by Marshall, who argues that it would have been better to not use gravity flow involving the 28 inch pipe connections but pumped flow which would have allowed the use of much smaller diameter pipes. With regard to the operation of the plant, King is critical of the decision to remove the agitator from Reactor No 4, which, among other things increased the hazard from water accumulation in the vessel.

Thomas & Gugan point to the facts that the plant was shut-down to deal with leaks and was then restarted because 'the leaks cured themselves'; that the oxygen trip was disarmed; the production was continued even though there was a shortage of nitrogen; and that the plant was started up again after the failure of Reactor No 5 without inspection of the other reactors.

One technical issue discussed by King is the thrust exerted by unrestrained bellows on the system to which they are connected, which tends to be underestimated. Lewis gives some estimates of the size of the release. He states that the inventory of the cyclohexane oxidation unit exceeded 120 te. Re-examination of the reactor section at a pressure of 8.6 bar shows that it had an inventory of 230 te with another 150 te in the attached distillation sectinsection at 14.7 bar. He also discusses the problem of determining the efficiency of the explosion compared with TNT. Estimates were made from long-range effects and from medium range damage surveys, and both point to a TNT equivalent of 15-20 te. There were major difficulties however, in fitting TNT curves to the Damage observed. The TNT efficiency is difficult to assess, depending as it does on the estimate of the mass within the flammable region and on the blast curves used.

Gugan gives a detailed discussion of certain particular damage effects. They include crushing of a vessel, from which he estimates an overpressure of 0.76 MPa (110 psi); damage tpoto drain covers for which his estimate is 1 MPa; and bending of a reactor agitator shaft and deformation of lamp standards. He suggests that in general the analysis of the damage relied too much on the effects of overpressure to the neglect of influence of impulse and dynamic pressure.

Marshall regards the vapour cloud explosion at Flixborough as of particular interest in that it is the best documented and most studied case, and is thus an exemplar. He gives a detailed analysis of the estimates of overpressure made from the damage effects, treating separately those in the near and far fields. The results show wide scatter, and he concludes that it is peculiarly difficult to estimate the energy release of such an explosion from damage.

Professor Lees' own appraisal

This covered 18 pages of the third volume of his book at Appendix 2. While too etaileddetailed for me to include herein, I list his sub-headings as follows:-

A 2.1 The Company and the Management

A2.2 The Site and the Works

A2.3 The Process and the Plant

A2.4 Events prior to the explosion

A2.5 The Explosion – 1

A2.6 The Investigation

A2.7 The Explosion – 2

A2.8 Some lessons of Flixborough

A2.9 Critiques

Conclusions

I am of the view that there is another factor in the causing of damage which is addressed at some length in my minor thesis entitled 'Determination of the geometry, TNT equivalence & damage potential of an explosive vapour cloud' produced in 1982. This exists in records of Environmental Engineering at Melbourne University and is soon to be published in the International Journal of Forensic Engineering (IJFE). In it, I established damage radii for overpressure alone, for a number of different effects such as death, cuts from flying glass, minor building damage and building collapse. I mention often, that damage in an event is also caused by falling objects, flying objects, being crushed and the like. At Flixborough the event was so massive that much of this would have applied. I am particularly concerned that the bent 20-inch pipe photographed on the ground not so much bent as completely doubled-up on itself, has caused many to consider the insufficiently restrained pipe and perhaps reliance upon bending as found, when hitting the ground. I say quite possible but more likely the result of explosive force from within the reactor stream.

I am also concerned regarding statements that the oxygen sensor described as the 'trip' being disabled was deliberate and was to enable production to continue across the weekend even though there was no emergency nitrogen available. Unless statements about the oxygen sensor being disabled are in some way incorrect, I consider there to be no doubt as to the principal cause of this event.

More information available from the author (ifta@ifta.com.au)

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The Westgate Bridge Collapse – a chemical engineer's view

Ian F Thomas (I F Thomas & Associates, Williamstown, Australia)

Introduction

Westgate Bridge dimensions are 2580 m overall length; 37 m width and 847 m of box-girder construction, the remainer in concrete. The all important Pier 10-11 span is 112 m long. The main cause of the collapse has been to do with people … pompousness and looking down on Australians by the British; putting the workers' huts beneath the 2000 tonne 10-11 span which dropped 50 m into Yarra River mud; and the use of 'buzz' expressions like K-Plates (splice-plates) and Kentledge (ballast).

More detail

Ahead of the collapse, Chief Erection Design Engineer Tim Sewell and John Holland, the proprietor of John Holland Constructions were walking through the completed east-side 14–15 span and together felt that something was not right. As a result John Holland demanded to meet with the designers and require that they signed off on their design and erection procedure. Otherwise he said he would call his men off … they signed.

There was loud and clear warning. In particular the collapse of the box-girder constructed bridge over the Cleddau Ddu River in South Wales, then known as the Milford Haven Bridge. In fact now, the river upstream of the constructed bridge is the Cleddau Ddu and the downstream part which connects with the sea is called the Milford Haven. Milford Haven itself is on the north bank of the Haven, further to the west.

The long, wide, deep estuary of Milford Haven divides Pembrokeshire into two parts. The distance by road from Neyland on the north shore to Pembroke Dock on the south is 28 miles. Prior to the construction of the bridge the former County Council operated a ferry service between the two shores, able to carry up to 24 vehicles and 250 pedestrians on each trip. In the mid 1960's with the growth of the city of Milford Haven as a major oil port capable of handling the world's largest tankers, it was decided to replace the vehicular ferry service with a bridge and a new road, which unlike the ferry would be available on a 24 hour basis.

Sir Alexander Gibb & Partners and Freeman Fox & Partners were appointed jointly as consulting engineers to design the Cleddau Bridge and a smaller bridge over the Westfield Pill. The new roadworks and the two bridges provided a highway link between the southern and northern towns of Pembrokeshire and between the oil refineries located along both shores of the Haven.

The contract for building the Cleddau Bridge was awarded in September 1968 to A.E. Farr Limited with Horseley Bridge and Thomas Piggott Limited as sub-contractors for the steelwork. The contract of £2.1 million was to be completed by March 1971. On 2nd June 1970 some 21 months into the contract a 60 m cantilever collapsed on the south bank, tragically resulting in the loss of four lives. The construction of the bridge recommenced in 1972 with the first of the new box units to replace those damaged being erected in October 1972 some 28 months after the collapse. The Westgate Bridge was also designed by Freeman Fox & Partners and the section of box girder between Piers 10 and 11 collapsed on 15th October 1970, only four months and thirteen days after the Welsh bridge.

Mr Tim Sewell who after retiring was a professional and valued colleague, described to me in detail, the weakness of the design, how he and construction chief John Holland were unhappy about it and also provided me with many otherwise unpublished photographs. The late Professor Noel Murray of Monash University Civil Engineering Department and Professor Raphael Grzebieta then of Monash University Accident Research Centre (MUARC) have also had many discussions about the accident and both I and I hope our

profession have gained by it. Professor Grzebieta and I often meet now as members of the Forensic Engineering Society of Australia Incorporated (FESA Inc) which is connected to Engineers Australia (EA). We are also both sub-editors of the International Journal of Forensic Engineering (IJFE).

The otherwise unproven method of construction employed was to join each section of the north half-box together on the ground and then to raise it up by lifting at both ends. The same was done with the south half-box. First to observe a problem with Span 10-11 were the construction workers whose task was to bolt the two half-boxes together noticing a large buckle in the transverse bolted joint of the north side half-box. When engineers were made aware of this in particular Jack Hindshaw who later died in the collapse, they posed a solution to add eight large concrete blocks weighing 25 tonnes (Sheer Force Engineering says 25 tonnes; Noel Murray says 56 tonnes) onto the buckle to 'press it down'. This was unsuccessful and so the next step was to undo the bolts to allow the added weight to press the plates together, then to re-drill and re-bolt them. One of the construction workers who survived, later described the bolts which were initially of a rusted-steel colour, changing in colour to blue which he and his colleagues knew was serious, then ordering all of the men off the bridge. As is now known, the whole of Span 10-11 fell and took many workers with it including as understood engineer Jack Hindshaw. Also as is regretfully now known, the 2000-tonne span fell not only 50 m down onto the Yarra River mud but also onto the workers 'smoko' hut where many were present.

My 2004 reports

At a conference of the Risk Engineering Society in 2004, I presented a paper entitled –

So long after the event – has the Westgate Bridge collapse been properly explained. This is a joint paper with the late Professor Noel Murray.

It addresses the collapse, the rescue, the Royal Commission report, the bridge, its critical parts and some of the terminology used, principle causes of the collapse, the novel method of construction, the cause of the buckling, the K-plates, the significance of concrete capping, the lack of calculations, outer web buckling, live loading of the piers, unease with the structure, the changes made to the bridge after the collapse, why span 14-15 east did not collapse, the mode of collapse and the current bridge and associated maintenance considerations.

.Also in 2004 I presented a paper with the same title at the International Conference of Maintenance Societies (ICOMS). I quote some parts of it as follows:-

The responsible parties were the Lower Yarra Crossing Authority, World Services, Maunsell, John Holland, Freeman Fox, and the Labour Unions.

It is inconvenient and unusual that the Royal Commission report does not contain conclusions or recommendations as such. Rather they are dispersed throughout the report. Once found, they are valuable. The bridge is one of a number of modern cable-stayed box girder bridges present in various countries. At the time of its design Westgate differed from other bridges in having the longest span. Other longer span bridges have been successfully built since.

The elevated approach roads (viaducts) were constructed of reinforced concrete resting on concrete piers. It is only that part of the bridge which was to span the river which was to be a steel box-girder. This also was to rest on six concrete piers 10, 11 and 12 on the west side and 13, 14 and 15 on the east side of the river. The girder comprised a series of trapezoidal steel boxes each 52ft 6ins long, bolted together transversely. The full 10-11 was constructed in two halves known as north and south half spans.

By using a box girder across the river, the weight to be suspended was considerably less than if concrete had been used and it was possible to construct the bridge with a minimum of disruption to river traffic.

That is, it was not necessary to build a temporary support structure in and across the river. By virtue of its low weight, the box girder section was able to be suspended or stayed by a series of steel cables running up over a single tower on each side of the river. These cable stays are large rectangular bundles of steel wire ropes wrapped in a water-repellent, fire resistant and rust-preventive binding in-turn, clad by a rectangular wooden framework and finally also clad with steel sheathing.

There are only three such cable stays on each side of the river and these are located centrally along the length of the bridge. They are protected from traffic and from damage by railings and by the various coatings already described.

The steel boxes were made of high-yield (strong) steel plate comprising the deck plates, base plates, inner webs and sloping outer webs. All of the stiffening structure was located inside the boxes and comprised a series of massive cross-beams beneath the deck plates, vertical diaphragms and longitudinal bulb-flat stiffeners. The bulb-flat steel section comprises a flat plate forged to include a lump or bulb on the inner, non-attached edge. The bulb-flat stiffeners were continuous within the length of each box and were installed at regular intervals along the underside of the deck plates, the upper face of the base plates and the inner face of the inner and outer web plates.

Eight half-boxes were spliced together on the ground using splice-plates and high-tensile friction grip bolts, to form the complete northern half-span. The southern half-span was constructed in the same way. Such extensive use of bolts rather than welds followed lessons learned from the King Street Bridge collapse in 1962. Here, localised heating during welding of the high-yield steel plates which had not been preheated, led to brittle fracture. The Lower Yarra Crossing Authority was mindful of this.

The method used to join the longitudinal bulb-flats was significant. To allow space for the transverse splice plates, all bulb flat stiffeners were stopped short of the end of each face of the box. In addition to the fact that the bulb flats were not continuous, neither therefore did they abut each other. The gap was therefore bridged with a single piece of flat plate attached by four bolts to each bulb flat.

More information is provided in my full papers and from the author (ifta@ifta.com.au).

P 28

Biomimicry for Sustainable Building Technology: Nature's Blueprint for Environmental Resilience

Tony Ndung'u Munene *(Engineering, University of Nairobi, Nairobi, Kenya)*

In an era marked by the urgent need for sustainability and environmental resilience, biomimicry emerges as a captivating and transformative concept within the realm of building technology. This study undertakes a comprehensive exploration of biomimicry's potential to revolutionize the construction industry, advancing its sustainability goals. The aim of this research was to delve deeply into the multifaceted world of biomimicry, uncovering how it can provide innovative solutions for addressing the pressing challenges of resource depletion, energy consumption, waste generation, and climate change adaptation.

To achieve this aim, an extensive literature review was conducted, focusing on key terms such as biomimicry, sustainability, biomimetics, nature-based solutions, and climate change. The research primarily centered on ProQuest and Google Scholar, allowing access to a wide range of scholarly articles, research papers, books, and case studies that shed light on the intersection of biomimicry and sustainable building technology.

The study's findings provide compelling evidence that biomimicry represents a paradigm shift in the construction industry. Rather than relying solely on cutting-edge technologies, sustainable solutions can be found by turning to nature for inspiration. One of the most striking examples of biomimetic design is showcased in the East-gate Center in Zimbabwe. This architectural marvel draws inspiration from termite mounds, mimicking the intricate convection current mechanism used by termites to regulate temperature and air circulation within their mounds. In a similar vein, the East-gate Center employs a ventilation system that harnesses the principles of natural airflow, with cool air entering at lower levels and rising to the top, where it is released through strategically placed vents. This biomimetic approach not only ensures a comfortable indoor environment but also significantly reduces the need for energy-intensive mechanical ventilation systems, leading to remarkable energy savings and a reduced carbon footprint.

A deeper exploration of biomimicry reveals a wealth of possibilities and opportunities for sustainable building technology. The natural world, with its eons of evolutionary refinement, offers a vast repository of solutions that can be harnessed for human benefit. Take, for example, the lotus leaf, renowned for its self-cleaning properties. By examining the microscopic structure of the lotus leaf, researchers have developed self-cleaning coatings for building materials, reducing the need for chemical cleaning agents and promoting a more environmentally friendly approach to maintenance.

Furthermore, the study of spider silk has inspired innovative materials for construction. Spider silk is known for its exceptional strength and flexibility, qualities that are highly desirable in construction materials. Researchers have made significant strides in synthesizing spider silk-like materials that can be used to create stronger and more durable building components, with the potential to revolutionize the construction industry.

Biomimicry extends beyond materials and structural design. The natural world also offers insights into efficient systems and processes. For instance, the intricate social organization of ants has inspired algorithms for optimizing building energy management systems. Ant colonies efficiently allocate tasks and resources, and by mimicking their decision-making processes, building systems can be fine-tuned to minimize energy consumption and maximize efficiency.

In addition to energy optimization, biomimicry holds promise for water management in building technology. Organisms like the Namib desert beetle have evolved unique mechanisms for harvesting water from

the air. Researchers are exploring ways to replicate these mechanisms in building materials, potentially enabling buildings to capture and store water from the atmosphere, particularly in arid regions.

Furthermore, biomimicry can address the pressing issue of waste management in construction. Nature excels at recycling and repurposing materials. By studying natural processes, such as decomposition and nutrient cycling, the construction industry can develop innovative ways to reduce waste generation and promote circular economies.

The integration of biomimicry into building technology does not come without its challenges. It requires a shift in mindset and a commitment to interdisciplinary collaboration. Architects, engineers, biologists, and materials scientists must work together to translate natural principles into practical design and construction solutions. Additionally, education and awareness initiatives are vital to promote biomimicry's adoption within the industry.

In conclusion, this study underscores the profound and multifaceted potential of biomimicry in advancing sustainability within the building sector. Nature's blueprints, honed by millions of years of evolution, offer a trove of solutions that can address the construction industry's most pressing challenges. By closely emulating nature's design principles, biomimetic solutions hold the promise of a more sustainable future, characterized by resource efficiency, reduced energy consumption, and minimized waste generation. As we navigate the complexities of environmental resilience and confront the realities of climate change, biomimicry emerges as a beacon of hope, guiding us toward a harmonious coexistence with the natural world.

P 29

Assessing the Potential Benefits of Implementing Kenya's Sustainable Waste Management Bill of 2021

Catherine Wairimu Maingi *(Resident Engineer, House and Homes Developers, Nairobi, Kenya)*

Kenya, like many other developing countries, faces significant challenges in managing its waste effectively. The exponential increase in population, urbanization, and industrialization has come with an increase in waste generation, with the existing waste management systems struggling to keep up. Our country produces around 22,000 Tonnes of solid waste per day. We only manage to collect 60% of it and this ends up either in open dumpsites or burnt in non-compliant kilns or even open fires. What we don't collect ends up dirtying our rivers and clogging our drains.

Acknowledging the need for a comprehensive approach to this pressing issue, the Kenyan government introduced the Sustainable Waste Management Bill on 12th May, 2021. The Sustainable Waste Management Bill of 2021 is a comprehensive legislative framework aimed at addressing these challenges and promoting sustainable waste management practices in the country. This bill promised the closure of open dumpsites, the expansion of the market for recycled products, incentives for waste management companies and made it compulsory to separate garbage into organic, dry and special waste ahead of collection from homes and businesses amongst other policies.

This essay examines the potential benefits that Kenya can derive from implementing the bill including environmental conservation, public health improvements and economic opportunities. By analyzing these advantages, it becomes evident that the implementation of the Sustainable Waste Management Bill has the potential to transform Kenya's waste management sector and contribute to the country's overall sustainable development.

1. Environmental Conservation

One of the key benefits of implementing the Sustainable Waste Management Bill is the preservation and conservation of the environment. The bill emphasizes waste reduction, recycling, and the promotion of circular economy principles. By reducing waste generation and promoting recycling, Kenya can minimize the amount of waste going to landfills and incinerators, thus reducing greenhouse gas emissions and mitigating climate change. Furthermore, the bill encourages the adoption of clean technologies and practices, such as waste-to-energy initiatives and composting, which can contribute to a cleaner and healthier environment.

This bill promises to shut down illegal dumpsites. Did you know that Kenya does not have a single land-fill? In their place, we have dumpsites. A landfill is a site which is properly planned and developed utilizing engineering principles to ensure protection of the environmental and the quality of life of the human beings in the surrounding regions; while, dump sites are randomly available places where waste is simply thrown. The Dandora dumpsite is Kenya’s largest dumpsite. It opened in 1975 and was declared full by public health officials in 2001. It is still in use over two decades later despite a court ruling on June 16th 2021 ordering its closure within six months. The Dandora dumpsite receives over 2,000 tons of waste a day. Because they are not engineered to keep the waste safely, dumpsites have a range of significant environmental impacts, including:

- Soil Contamination: The indiscriminate dumping of waste at these sites leads to soil contamination. Hazardous chemicals and pollutants from decomposing waste can leach into the soil, rendering it infertile and unsuitable for agriculture or other land uses.

- Water Pollution: Rainwater percolating through dumpsites can carry pollutants, heavy metals, and toxins into nearby water bodies, contaminating groundwater and surface water sources. This contamination poses risks to aquatic ecosystems and can affect the health of communities dependent on these water sources.
- Air Pollution: The decomposition of organic waste in dumpsites generates methane, a potent greenhouse gas, and releases foul-smelling and toxic gases into the atmosphere. These emissions contribute to air pollution, affecting local air quality and public health.
- Biodiversity Loss: Dumpsites often lead to the destruction of local ecosystems and habitats as they expand. This can result in the displacement or loss of native plant and animal species.
- Deforestation: In some cases, dumpsites may require clearing of forests or other natural areas to accommodate the increasing volume of waste. This deforestation further contributes to habitat loss and exacerbates climate change.
- Land Use Conflicts: The presence of dumpsites can lead to conflicts over land use, as nearby communities may need the land for housing, agriculture, or other purposes, but it remains unusable due to contamination and health concerns.
- Disease Spread: Poorly managed dumpsites can serve as breeding grounds for disease vectors like flies and rats. These vectors can carry diseases that pose health risks to nearby communities.
- Aesthetic Degradation: Dumpsites are often unsightly eyesores that can negatively impact the aesthetic appeal of an area, discouraging tourism and economic development.

2. Public Health Improvements

The implementation of the Sustainable Waste Management Bill can also result in significant public health improvements. Waste, if not properly managed, can become a breeding ground for disease vectors such as rodents and insects, leading to the spread of diseases like cholera, typhoid, and malaria. By improving waste handling and disposal practices, the bill can help reduce these health risks. Moreover, the bill advocates for better handling of hazardous waste like electronic waste and medical waste, which pose significant health risks if mishandled or inadequately disposed of. By providing guidelines for the safe handling and disposal of such waste, the bill can prevent exposure to toxic substances, thereby safeguarding public health.

3. Social Well-being

Effective waste management practices can enhance the overall social well-being of Kenyan communities. The bill emphasizes the importance of public participation and awareness in waste management processes, promoting community involvement and ownership. Through education and awareness campaigns, the bill aims to change the perception of waste and to instil a sense of responsibility among citizens. Additionally, improved waste management infrastructure, such as waste collection points and recycling centers, can enhance the overall cleanliness and aesthetics of communities, leading to improved livability and quality of life.

4. Economic Opportunities

The Sustainable Waste Management Bill of 2021 holds tremendous potential for Kenya's economic growth and environmental sustainability. By prioritizing waste management practices, the legislation aims to mitigate pollution, foster a circular economy, and create new business opportunities. This section will delve into the diverse business opportunities that are likely to emerge if Kenya successfully implements the bill. Below are some of the various opportunities that entrepreneurs can harness to drive economic development while addressing environmental challenges.

1. Waste Recycling and Resource Recovery; A key focus of the bill is promoting waste recycling and resource recovery. This initiative opens up vast business opportunities for entrepreneurs. Establishing recycling plants that specialize in materials such as plastics, paper, glass, and metals can transform waste into valuable resources. These facilities can generate revenue through the sale of recycled materials to industries that require these inputs. Additionally, entrepreneurs can explore innovative recycling technologies, such as advanced sorting and material recovery systems, to enhance efficiency and maximize resource extraction. By investing in recycling infrastructure, businesses can contribute to waste reduction and resource conservation while creating employment opportunities. For example, a company by the name Taka Taka ni Mali in partnership with Kajiado County has launched an innovative application that allows waste collectors to be connected directly to households and collaboratively manage the waste in a manner that increases its value. Waste that is segregated at source has more economic value than that which is not segregated. More than 500 households have subscribed through the application to have waste collectors collect and transport their waste to the dumpsite where it is further segregated, processed and sold to buyers such as Mr. Green Africa, a recycling company that sells pre-processed recycling materials. The application has attracted more than 35 waste aggregators who make a living from the waste. The waste is sold between 20–50 Ksh per kilogram depending on the type (plastic, aluminum, glass or paper).
2. Composting and Organic Waste Management; The bill emphasizes the importance of proper organic waste management, presenting significant business prospects in the composting sector. Establishing composting facilities can convert organic waste, including food scraps and agricultural residues, into nutrient-rich compost. This compost can be sold to farmers and gardeners as a sustainable alternative to chemical fertilizers which tend to harm the soil and water bodies. This transition to organic fertilizers can also contribute to sustainable agriculture, improving soil fertility and crop yields. Furthermore, entrepreneurs can explore the production of biogas from organic waste through anaerobic digestion. Biogas can be used for electricity generation or as a clean cooking fuel, offering both economic and environmental benefits. By venturing into composting and organic waste management, businesses can contribute to soil health, reduce greenhouse gas emissions, and create a circular economy model.
3. Waste-to-Energy Solutions; The implementation of the Sustainable Waste Management Bill presents an opportunity for businesses to tap into waste-to-energy solutions. Technologies such as anaerobic digestion and incineration with energy recovery can convert waste materials into renewable energy sources. By establishing waste-to-energy plants, entrepreneurs can generate electricity or heat from waste, contributing to Kenya's energy diversification goals. Additionally, these ventures can explore partnerships with local communities, municipalities, or private entities to ensure a sustainable supply of waste feedstock. Implementation should also consider adopting environmentally friendly practices, such as effective emissions control and ash management, to mitigate potential negative impacts. Waste-to-energy solutions not only address waste management challenges but also provide economic benefits by reducing dependence on fossil fuels, creating jobs, and potentially contributing to the national grid.
4. E-waste Management and Recycling; With the proliferation of electronic devices, the proper management of electronic waste (e-waste) is a pressing concern. Implementing the Sustainable Waste Management Bill creates opportunities for businesses to establish e-waste collection centers and recycling facilities. These ventures can safely handle e-waste, extract valuable metals and components, and recycle them for reuse. By doing so, entrepreneurs contribute to environmental protection by preventing hazardous materials from polluting the soil and waterways, while also reducing the need for resource extraction. Additionally, businesses can explore partnerships with electronic manufacturers to implement sustainable product design.

5. Job Creation

The 2021 bill also presents an opportunity for job creation and improvement of some existing roles. By promoting waste segregation, recycling, composting, and waste-to-energy strategies, the bill can pave the way for new businesses and industries. For instance, the recycling industry can provide jobs for thousands of Kenyans, from waste collectors to recycling plant operators. In addition, the bill encourages the establishment of producer responsibility organizations, which will be responsible for managing the waste generated by their products. This can lead to the growth of new sectors, such as waste collection and recycling services. Moreover, the organic fertilizer produced from composting can boost the agriculture sector, creating more jobs and contributing to food security. Moreover, the bill also provides for the establishment of a Waste Management Fund, which can be used to finance waste management projects and initiatives. This fund can act as a catalyst for innovation in the waste management sector, encouraging the development of new technologies and solutions that can create even more jobs and contribute to economic growth.

Conclusion

While the implementation of the Sustainable Waste Management Bill offers numerous benefits, there are challenges that need to be addressed before it can be implemented successfully. These challenges include financial constraints, limited technical capacity, and behavioral change among the population. However, these issues can be overcome by means of sensitization and partnering with NGO's that are geared towards sustainable waste management. With a little effort, it is evidenced by this abstract that the Sustainable Waste Management Bill is the key to a cleaner, healthier and wealthier Kenya.

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Life in my eyes in the past, present and future

Sepehr Hasanzadeh Forushani *(Personal, Tehran, Iran)*

I am not an engineer. I am a teenager, a ninth-grade student.

I want to say, dear engineers, who design and build cities with modern, gigantic and large constructions, do we teenagers see in your design? Are your design criteria suitable for us?

As an engineer, what kind of city do you consider for a teenager?

I and many of my peers do not understand these cities because they are not according to our wishes.

These are mostly cities that are designed and built for adults and it will be suitable for us when we grow up and become their age so that we can use them.

I would love to contribute to your future engineering. Life in the future of these cities and the planet is ours.

The environment and nature are being destroyed. In the future, we need a big transformation for life on earth.

We need to think about life on earth and beyond the planet and the solar system. I tell you we are not ready for it yet.

P 31

The importance of the involvement of young engineers in the Peruvian national development through the National Committee of Young Engineers and Future Leaders

Jose Antonio Diez Torricelli *(Comité Nacional Joven Ingeniero y Futuros Líderes, Colegio de Ingenieros del Perú, Lima, Peru),* ***Victor Caballero Rugel*** *(Comité Nacional Joven Ingeniero y Futuros Líderes, Colegio de Ingenieros del Perú, Ucayali, Peru),* ***Paul Alfonso Morales Luque*** *(Comité Nacional Joven Ingeniero y Futuros Líderes, Colegio de Ingenieros del Perú, Arequipa, Peru)*

The National Committee of Young Engineers and Future Leaders of the Peruvian Engineers Association has had a significant positive impact on the engineering field in the country. Through its initiatives, the committee has fostered the development of young engineers and focused on building their technical capacities.

One of the initiatives is the Young Engineer Project Contest, which aims to recognize engineering projects carried out by young engineers oriented towards achieving the United Nations' Sustainable Development Goals (SDGs). This contest provides a platform for young engineers to showcase their innovative and sustainable solutions to real-world problems.

Moreover, the committee has implemented a mentoring program that seeks to guide young engineers in their professional development with the support of experienced professionals. This program provides the opportunity for young engineers to learn from seasoned professionals and gain insights into the industry.

In addition, the committee hosts dialogue tables that bring together engineers, policymakers, and other stakeholders to address problems in Peru and identify how engineering can contribute to solving these problems. One of the most outstanding events that the Committee has hosted was the Workshop for integral improvement of neighborhoods, disaster risk management, and transport-oriented development in Lima and Callao. This initiative is led by the Peruvian Environmental Ministry, and we involves different municipalities and other public organizations

Overall, the National Committee of Young Engineers and Future Leaders is making a significant contribution to the development of the engineering field in the country from the perspective and active participation of young engineers.

P 35

Female civil engineer in road project design

Myriam Diavita (ACGT (Agence Congolaise des Grands Travaux), Kinshasa, Congo, the Democratic Republic of)

Introduction

Women have always been offered or generally relegated to second-class positions in science, technology and all areas of engineering. Some have been suffered prejudice without ever having had the chance to try. However, recent studies have demonstrated not only the equal scientific potential of women and men, but also the recognition of their contribution in the engineering industries.

Women make valuable contributions to technology and have different approaches to problem solving than men. It has already been established that men and women have different thought processes and approaches to problem solving. Reports have shown that women tend to have a better multi-step approach to problem solving than men, and are more oriented towards organization and teamwork.

Every day, millions of people rely on roads to commute to work, transportation of goods and travel to new destinations. Roads are vital for the quality of life and economic development of any country. They play a key role in our society and facilitate both national and international trade, as well as provide better access to health care, jobs, education, and other important services.

Each road is unique and requires a customized approach to meet sustainability and safety requirements.

The design of a road project consists of geometric roadway design which can be broken into three main parts: alignment, profile, and cross-section when combined they provide a three-dimensional layout for a roadway and the geotechnical part which include the different layers (foundation, base, sub-base) based on the traffic.

Road/highway engineers must consider all the different factors and find the optimal solution to create a road that meets the needs of the community.

The design of a road goes through four steps, among others:

- 1st step: Site investigation
- 2nd step: Data analysis and road design
- 3rd step: Development of the quantitative and cost estimate
- 4th step: Preparation of the study report

1st step: Site investigation

Site investigation consists of gathering all the data necessary for the design of a road which is carried out on the site (field or area of the project), but certain information can be supplemented by documentation (rainfall, geological maps, satellite images). During the field trip, several engineers will be deployed on site to collect all information specialized information.

1.1. Collection of road data

- The traffic flow
- Measure the width of the existing roadway or track
- Names of villages and towns by which the road crosses
- Identifying all the turns and curves on the road
- The nature and height of the bank embankments (left and right)
- Important references and mandatory crossing points

- Vegetation, trees to be felled
- Identifying all the damages of an existing road such as potholes, erosion, washouts, etc.

1.2. Hydraulic data collection

- The existing drainage network by identifying all the sanitation works by taking their dimensions and conditions (lined or unlined ditches, buses, culverts, collectors, water trickles, etc.)
- Identify high and low points
- Identifying the outlets to receive the drained water.

1.3. Site investigation on bridges

- Identify and inspect existing structures, taking into account their characteristics such as the type of structure, width, span, air draft
- Identifying locations requiring the construction of new crossing structures.

1.4. Geotechnical investigation

- Determine the nature and bearing capacity of the soil in the location
- Identifying quarries and borrow deposits of loose and rocky materials.

1.5. Collection of topographic data

- Carry out topographical surveys of the road construction site from the initial kilometer point to the final kilometer point.

1.6. Mapping of the project area

- Carry out the mapping of the entire project area.

1.7. Environmental impact study

- Analyze the environmental impacts of the project.

2nd step: Data analysis and road design

Road design and dimensioning are based on international technical standards that define the requirements to be met by the road and all associated infrastructure, such as bridges, drainage systems, etc.

Assessing road usage is one of the most important parts of the planning procedure. A road that supports heavy commercial vehicles, such as semi-trucks, must be straighter to accommodate the limits of the vehicle. These roads must also be tougher than streets that are tailored to low traffic with lighter vehicles, which will affect the building process.

Design guidelines must take into account the intended speed limit, the types of vehicles that will use the road, the slope it is built on, any view obstructions, and stopping distances. Only with the proper application of these guidelines can a team of engineers plan a roadway that is safe and comfortable for drivers.

The data collected during the site investigation is compiled and analyzed to arrive at a suitable design specific to each project. All specialized work teams provide input to road engineers to enable them to assess the cost of the road to be built.

The use of standards and software is very important and useful for the dimensioning of the road.

2.1. Factor affecting road alignment

1) Need of traffic

2) Purpose & class of road

3) Obligatory points

4) Curve

5) Gradient

6) Sight distance

7) Number of drainage crossing

8) Railway & river crossing

9) Obstruction

10) Formation of bed

11) Earthwork

12) Lengthy straight route

13) Availability of labour and materials

14) Aesthetical aspect

2.2. Types of road construction methods

The pavement is the part of the road that carries the traffic, and has a set of layers or material placed over the natural ground (subgrade). The pavement layers spread the load of the vehicles so that it does not exceed the strength capacity of the subgrade.

The challenge for an engineer during the construction phase and design phase of a road is to select the right material and layer thicknesses so that the pavement will be serviceable for the full design life. The strength of road paving is based or designed on the types of vehicles the road will carry or support.

The following are the different types of pavements:

- Rigid pavements: When rigid pavements are constructed, a reinforced or unreinforced in-situ concrete slab is laid over a granular subbase. Loads are supported by the flexural strength of the pavement, which acts like a stiff plate, transferring the load over a wider area of subgrade. Concrete roads are a rigid road paving type, and there will usually be joints in the concrete to control cracking.
- Flexible pavements: Flexible pavements typically have multiple layers, often with road asphalt making up surface layers. With flexible pavements, wheel loads are transferred by particle-to-particle contact of the aggregate through the unbound granular layers. The pavement is supported by and protects the subgrade below the pavement. Asphalt roads are constructed using flexible pavement. Bituminous pavements are also flexible.

3rd step: Preparation of the preliminary estimate of the cost of construction of a road

The cost of road construction may greatly vary depending on a few factors including the roads standards, topography, soil conditions and others.

As the methodology and system used during the road constructions in all over the world obeys some standard norms, it is not hard to estimation the general construction cost if the factors remain constant.

3.1. Preliminary estimate of quantities

The preliminary estimate of quantities is an evaluation of the quantities of all the work based on the measurements indicated on the plans and drawings used for the construction of this work in order to obtain an estimate.

3.2. Quantitative and cost estimate

The quantitative and cost estimate is the document by which it is possible to estimate the cost of the work for the completion of a construction work. Price evaluation is the second phase and final step for the final

creation of a quote. This process makes it possible to accurately calculate the amount necessary for the construction of the road using the quantities evaluated in the preliminary estimate of quantities.

The quantitative and cost estimate for a road includes the following items:

1) General Item

- All the temporary installations required for the operation of the worksite during construction (fencing, cranes, networks, traffic routes, storage and prefabrication areas, etc.).

2) Site Preparation and Clearance

- Dismantling bridges, culverts and other existing structures (demolition)
- Clearing of grass, felling of trees, removing roots
- Stripping of the surface soil

3) Earthworks

- Cutting
- Backfilling
- Purging and backfilling of sloughs
- Backfill adjustment and platform compaction
- Sidewalk construction
- Estimate of value-added for transporting materials

4) Pavement Works

- Sub-base course
- Base course
- Surface course
- Impregnation layer
- Tack coat
- Estimate of value-added for transporting materials

5) Drain works

- Earthworks for drainage structures
- Cleaning of gutters, circular culverts and slab culverts
- Construction of gutters
- Construction of slab culverts
- Installation of circular culverts
- Construction of gutters

6) Structural Works

- Maintenance and repair of existing bridges
- Construction of new bridges

7) Signaling and equipment

- Horizontal, vertical and retro-reflector signs
- Milestone

- Speed bumps
- Borders
- Parking areas

8) Public lighting

- The installation of night lighting in public places to illuminate the road.

9) Related works

- Rockfill
- Protection of unstable slopes and stabilization of slopes
- Construction of retaining walls

4th step: Preparation of the technical report on the road construction study

The technical report on the road construction study is the document that contains all the information on the design of the future road to be built.

It includes the presentation of the project area, the technical details of the project, the various calculation notes for the dimensioning of the pavement structure, bridges, drainage structures, and so on.

Data compilation of site investigation, the road's linear diagram, the vertical and horizontal alignment of the roadway, cross-sections of the road, detailed plans of bridges and slab culverts are also supplied.

Conclusion

Designing road projects requires well-coordinated teamwork. Introducing a gender balance to science, technology and engineering not only creates a stronger complementary team, but also leverages what diversity has to offer. Problems will be tackled from all angles, and skills will be leveraged to strengthen teams. To address current development issues in the fields of science, technology and, above all, construction, the best solution is to foster complementarity rather than competition between the sexes, and increase the representation of women in the construction sector.

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Empowering STEM women and inspiring kids for STEM fields in Switzerland

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Since 1991, the Swiss Association of Women Engineers (SVIN) is a national organization that advocates for the interests of highly qualified and motivated women professionals in the fields of science, technology, engineering, and mathematics (STEM). The SVIN is committed to supporting women in technical professions, to breaking down traditional role models and to inspire more young women to become engineers.

The SVIN pursues the implementation of its goals in particular through its projects in its core areas. The labour market programme “Kultur-Wegweiser” works in close cooperation with management and employees of technology-based companies for greater gender equality in career opportunities in STEM industries. The young talent promotion program “KIDSinfo” gives primary school pupils and their teachers the opportunity to approach the technical and scientific fields in a playful and interactive way and provides children at an early school level with a positive image of engineers and potential role models.