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Building Decarbonisation and Sustainable Management of Energy, Water, and Consumption Patterns: Challenges, Opportunities, and Solutions

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To celebrate World Green Building Week (12 - 16th September) under the title of “Building for the Planet”, Emirates Green Building Council and The Centre of Excellence in Smart Construction at Heriot-Watt University, Dubai campus held a joint event on 13th September 2022 that was hosted at Heriot Watt University, Dubai campus. The event gathered leading sustainability professionals from both industry and academia to discuss four key sustainability issues that are of high priority in global sustainability agendas. These are namely:

- 1) **Building Decarbonisation;**
- 2) **Sustainable and Affordable Energy;**
- 3) **Sustainable Management of Water;**
- 4) **Sustainable Consumption Patterns.**

The roundtable discussions that took place during the event contributed to the creation of this paper, particularly through the participation of the moderators for each roundtable. The paper presents the outcomes and shared insights from the event in relation to the four themes of discussion.

Overview

According to Global Status Report for Building and Construction 2019 by International Energy Agency (IEA), the buildings and construction sector contributed significantly to final energy use and energy-related CO₂ emissions, accounting for 36% and 39% respectively. A significant portion of these emissions, approximately 11%, were the result of the manufacturing of building materials such as steel, cement, and glass, and nearly 28% are associated with the day-to-day operations like electricity or natural gas for heating, cooling, and cooking [1]. Reducing emissions from new as well as existing buildings through decarbonisation strategies is an essential step towards mitigating climate change and providing a more sustainable Built Environment. While it may appear that sufficient action is being taken, in reality, we have only scratched the surface and there is still a more substantial effort that needs

to be deployed..

It is also widely recognised that the current global energy mix continues to be dominated by fossil fuels, accounting for over 80% worldwide [2] and over 96% in the UAE [3]. According to the International Energy Agency’s (IEA) Net Zero by 2050 report [4], it is now possible to achieve carbon neutrality by 2050 due to the significant decrease in the cost of renewable energy sources. The United Arab Emirates (UAE) has also taken proactive measures towards this goal by setting an ambitious target to generate 44% of its energy from clean sources and to become the first Net Zero Gulf country by 2050 [5]. This is a clear indication of the UAE’s commitment to reducing its carbon footprint and transitioning towards a more sustainable future.

In terms of water challenge, and as stated by Antonio Guterres, UN Secretary-General, “Today, 40 per cent of the world’s people are affected by water scarcity; 80 per cent of wastewater is

discharged untreated into the environment, and more than 90 per cent of disasters are water-related”, as [6]. While some efforts are being made towards sustainable water management and ensuring a secure water supply, more work needs to be done to increase the efficiency of the water supply cycle in order to fully get back on track. Without a resilient, functioning water cycle for people around the world, environmental integrity as well as human health will continue be threatened and therefore a sustainable, and equitable future will remain unachievable. To achieve the goal of ensuring sustainable management, sanitation, and access to water for all by 2030 as outlined in Sustainable Development Goal 6 [7], the United Nations General Assembly has declared the period from 2018 to 2028 as the International Decade for Action through its resolution 71/222.. The goal is to enhance collaboration, partnership, and capacity building, and to stimulate action towards achieving the United Nations’ 2030 Agenda for Sustainable Development.

In terms of consumption, the demand patterns for goods and services in emerging economies are largely influenced by the country’s high-income levels and strong economic growth. According to the United Nations [9], it is predicted that the global population will grow by almost 2 billion over the next three decades, reaching a total of 9.7 billion by 2050, and potentially reaching a maximum of 10.4 billion in the mid-2080s. A growing population can have a significant effect on the demand for natural resources and energy. This is primarily due to the increased need for goods and services, resulting in higher pressure on raw material extraction and product manufacturing.

1. Building Decarbonisation

The Paris Agreement calls for limiting global warming to 1.5°C and reducing greenhouse gas emissions by 45% by 2030, with the goal of reaching net zero by 2050. [10]. With this deadline rapidly approaching, urgency towards it creates a huge challenge for accomplishing building decarbonisation. To overcome this challenge, building decarbonisation legislations, policies, building codes and regulations must be developed to guide market transformation towards decarbonisation for the benefits of all parties. while taking into account the financial burden that building decarbonisation can have on households and communities.

This includes implementing comprehensive laws and policies at the national and federal level, addressing current building regulations, and evaluating and measuring the cost-effectiveness of different options. Financials create an additional burden on the path of building decarbonisation, particularly the issues related to decision making and data linking such as finance data linking to sustainability performance. Unfortunately, the economics of building decarbonisation often determines its success, as investments in electrification, energy efficiency, and solar power

are often only accessible to those with higher incomes which triggers the issue of social inclusion in climate action.

Fragmented and siloed value chains, where a supply chain is divided into separate, disconnected segments, with each segment operating independently of the others, can lead to inefficiencies and reduced value for all stakeholders. Therefore, stakeholders in this case are not able to share knowledge or resources, which can hinder their ability to improve efficiency and reduce costs. In addition to that, building decarbonisation costs and strategies are not yet coordinated across the whole life cycle of building, especially at the design stage, where carbon planning and management are yet to be integrated in green building design from such an early stage.

Studies revealed that pathways for green building performance-optimisation are better specified in early design stages [11]. It is also essential to apply Integrated Project Delivery (IPD) [12] approach, which is a fundamental approach to the theory of the “better, cheaper, and faster” through managing a construction project in a way that involves all stakeholders (building owners, developers, designers, and executors) working together cooperatively to optimise outcomes, increase value for the owner, reduce waste, and increase efficiency throughout the project lifecycle. This approach integrates people, systems, business structures, and practices to leverage the expertise and insights of all participants. Managing waste effectively is another challenge in the effort to decarbonise buildings, and sustainable waste management practices are vital to minimise the environmental impact of waste. This includes improving water and air quality and reducing greenhouse gas emissions.

Potential opportunities, focus efforts and solutions are available to support building decarbonization in the region. For example, new regulations need to be implemented and/or adjusted and put in action as well as initiating roadmaps for building decarbonisation.

In support of the UAE 2050 Net Zero Strategic Initiative, an updated version of the UAE’s second Nationally Determined Contribution (NDC) following the Paris Agreement was approved. The new document included a higher target for the year 2030 to reduce the greenhouse gas (GHG) emissions by 31 percent compared to the business-as-usual scenario, resulting in an absolute avoidance of 93.2 million metric tonnes of CO₂e emissions [13]. These initiatives would not be targeted and agreed on without a strong coordination in policies and strategies between the UAE government entities. Education and awareness also plays an important role in changing the opinions of customers, suppliers, and developers, as well as enshrining ESG through various channels like media sources, academia, and all other potential means of communication.

Conducting Life-Cycle-Analysis involves performing a systematic analysis throughout the entire life cycle of a product or service. This involves analysing all stages including the production, distribution, use, and end-of-life phases, as well as the upstream and downstream processes associated with these phases. For instance, the production of raw, auxiliary, and operating materials and the disposal of waste through methods like incineration must also be accounted for. Additionally, the impact of suppliers, transportation and waste management practices are taken into account during the analysis.

Regularly collecting and analysing data on a building's performance over its life cycle, as well as building stock labeling and benchmarking can help identify opportunities for improvement and cost savings and provide a basis for making informed decisions about investments in energy-efficient technologies and practices. There are several approaches to building stock labeling and benchmarking, including Energy Star, LEED, BREEAM [14], etc. Furthermore, making benchmarked green building data available for everyone is another tool for enriching the available resources for building decarbonization strategies. According to the 2020 Green Building Market Brief [15] published by the Emirates Green Building Council, the UAE has 63.96 million square meters of built-up area that meets local green building regulations or certification programs such as Estidama and Al Saafat. The brief also provides insightful information on the number of buildings in the region that have received international green building ratings, with 386 certified projects under the LEED system, equating to a staggering 5.9 million square meters of built-up area.

Building retrofitting with strategies that can be done in both short- or long-term basis, can significantly contribute to achieving greater energy and financial savings. According to Emirates Green Building Council's Advancing Deep Retrofits Report [16], a deep building retrofit involves a comprehensive analysis and revamping a building's systems as a single integrated unit, with the goal of reducing the building's energy use intensity, by at least 50% compared to its baseline energy use. Energy efficiency measures should be prioritised over renewable energy generation, if they are more cost-effective in achieving this reduction target.

Moreover, it is essential to promote and implement off-site and modular construction methods to reduce the carbon impact of a building and support its decarbonisation. This process entails prefabricating building components off-site and then assembling them on-site to form the final structure. Prefabrication in general and modular construction in particular entail several advantages over conventional construction methods, such as speed of delivery, enhanced quality control, and minimised

waste. Furthermore, modular construction is more efficient in terms of material and energy utilisation as components are accurately designed and fabricated to be easily disassembled and reused or recycled.

The use of alternative materials in construction, finishing, aesthetics, or furnishing can also contribute positively to the building decarbonisation through including supplementary cementitious materials, recycled or reclaimed materials, biomaterials, by-products and sustainable green materials such as geopolymers concrete [17], unprocessed bamboo, straw bales, and rammed earth [18]. These alternative materials are more sustainable and have a lower impact on the depletion of natural resources. They also have low or negligible GHG emissions, thus contributing to the development of a low carbon and more sustainable built environment.

2. Sustainable and Affordable Energy

Considering its climatic environment, with high solar radiation across the year, the UAE has a strong potential for solar energy capture, which is favourable to solar energy production in different forms, from large-scale like Mohammed Bin Rashid al Maktoum Solar Park with solar towers and Concentrated Solar Powers (CSPs), to decentralized individual rooftop photovoltaic (PV) installations. In fact, the UAE has been a pioneer in solar energy production among the GCC countries.

It already banked on this opportunity successfully over the last decade; the installed capacity of solar energy in the UAE before 2013 was nearly zero, whereas after 2018, it significantly increased to record more than 2500 MW in 2020, where all the installed solar energy generation capacity was from PV panels [19]. Moreover, it was reported that the UAE is in the process of building the world's largest single-site solar power plant in Abu Dhabi [20], which will be generating enough electricity to power up almost 160,000 homes across the UAE, as well as reducing more than 2.4 million metric tons of Abu Dhabi's CO₂ emissions per year – this is equivalent to eliminating 470,000 cars from the roads [21].

Despite the fact that solar energy is not completely devoid of carbon emissions (from the extraction of components, transportation, and waste at the end of life), it is evident that this is the main clean energy source that will prevail in the UAE. The main challenges in pursuing this transition further come from the scale and ownership of such renewable energy developments and their implementation.

At the small private consumer level, there is still a resistance to change, which is led by the idea that any development or improvement should be driven by economic reasons. This needs

to be countered by more public awareness campaigns. The electricity authorities can also help by simplifying the approval, installation, and connection processes. Moreover, to incentivize the owners, the government in charge of land management can establish energy performance ratings for buildings, which would be an indicator of rental rates. Further, for those who have installed solar PV systems, its maintenance requires regular access to the roof for cleaning. With more and more systems being installed, management companies could eventually roll out annual services, in the same vein as AC maintenance.

At the corporate level, which is the bulk energy consumption segment, many top-tier companies have clean energy usage ambitions. On the other hand, many are still very resistant. However, the market-leading companies with ample access to funds, such as Etihad [22] and MAF [23], do pursue their decarbonisation strategies at full speed because they believe in the benefits beyond their responsibility towards climate change; their popularity and valuation do improve, which in return will influence other top-tier private companies and build confidence as the government leads towards Net Zero.

UAE is rich in indigenous crude oil and is one of the main producers and exporters of oil in the world, however, the country is adopting clean and renewable energy options such as solar and nuclear power. The impact of this transition from an economic point of view is consistently evaluated since the country's economy relies mainly on oil. The main challenge that needs to be understood is that the population is expected to increase by 2050 [24], and therefore the energy requirements will also increase in the same proportion. The task at hand is then to plan, not for today's demand but for tomorrow's necessity, with support not only from the government but also from NGOs, to create road maps towards 2050; including how to improve building codes for new buildings and how to motivate or reprimand a lack of retrofitting of older buildings, will certainly help.

It is difficult to maintain a balance between funding large, utility-scale projects to supply power to the country and giving everyone the opportunity to generate decentralized power. A solution could be to adopt a royalty system, which is done in some parts of the world, where private generators (small and large) pay for every kWh produced. But for this to happen, it is paramount that solar electricity exports to the grid be legislated across all regions of the country. At the same time, the electricity authorities should increase the tariff on traditional electricity to counter overdesign (and therefore possible overconsumption) and incentivize the installation of clean sources.

On the legislation front, it is believed that, over the next decade, to stimulate decarbonization initiatives, the government will have

to issue new regulations on old buildings, to ensure that even corporations with lesser sustainable ambitions do incorporate clean energy usage. Finally, diversification could be considered, such as nuclear energy as well as offshore wind energy and clean hydrogen.

3. Sustainable Water Management

Decarbonisation of the water industry during treatment, transmission, and distribution is one of the challenges to be tackled. The water supply and wastewater treatment lead to huge greenhouse gas emissions due to water loss and inefficiencies of the urban water systems. Therefore, optimisation of life cycle of the water supply projects is essential, through, for example, water recycling or reuse. Furthermore, financial resources, data linking and availability, legislation, policy, water supply codes, regulations, and so on have not yet reached the desired level.

These challenges, however, are able to provide a path for huge opportunities to start a much needed shift towards low-carbon, low-energy, as well as climate resilient urban water services. Drinking water and wastewater industries can potentially reduce their carbon footprint as well as other direct and indirect greenhouse gas emissions (such as methane and nitrous oxide) that are related to the wastewater treatment and discharge, through implementing energy efficiency measures. This allows the utilities to improve their service to the public, reduce their operational costs, and, at the same time, protect the environment.

In addition, there is a huge need to educate people and raise their awareness about water related topics, especially water usage optimisation and water reuse. According to data from the United Nations [25], the United Arab Emirates has one of the highest per capita water consumption rates in the world, with an average of 550 liters per person per day. Education and awareness to reduce water consumption are the responsibility of schools, universities and colleges, media, NGOs, governments, as well as water industries and suppliers, and all other stakeholders. If proper education is embraced and implemented, this can lead to a substantial decline in water consumption, including irrigation and landscaping, resulting in a reduced need for desalination.

Again, as in all other sectors, engagement of all stakeholders throughout the whole lifecycle of the water industry is a fundamental approach that yields fruitful outcomes. For example, this could easily address the need to integrate water tanks in buildings into the design and operation of the wider water distribution network. Moreover, when it comes to greywater reuse, research has found that the perception of greywater reuse was closely related to the application of the reused water

as most users prefer not to reuse greywater for activities that involve personal contact [26]. Public perceptions are essential to consider before implementing a specified method. Further, through extensive contributions from both technical and non-technical experts, a comprehensive assessment of greywater characteristics can be delivered before choosing the most appropriate method of treatment, as well as the most appropriate end use or application, thus reducing the over-reliance on the freshwater resources for non-potable uses.

Setting new regulations and updating the code of practice in the design and operation of water distribution networks, and conducting leak management measures and procedures are other potential solutions. Additionally, advanced technology in the field of water supply and sanitation, such as smart water grids using sensors and data analytics [27], the Internet of Things (IoT) for embedded programs [28], and Unmanned Aerial Vehicles (UAVs), also known as drones [29], and many other technologies can significantly enhance water resource management by decreasing the excessive use of fresh water, controlling and monitoring water pollution, mapping water bodies, measuring water quality, and monitoring water usage. Further, there is a need for developing new Intensity-Duration-Frequency (IDF) curves that take cloud seeding and climate change into consideration [30], and using AI to improve water management, such as predicting water demand, optimizing water allocation, and detecting water-related problems [31].

4. Sustainable Consumption Patterns

As the population increases, there is a corresponding increase in the demand for things like food, shelter, and clothing, which requires the production and distribution of these items. This, in turn, requires the use of raw materials. Another factor that can contribute to an increased demand for materials and energy is the rise of the middle class, which is a result of higher GDP [32] in emerging economies. As more people become part of the middle class, they tend to have more disposable income, which they use to purchase a wider range of goods and services. This can lead to an increase in consumer spending, which can drive up the demand for raw materials. Urbanization is another factor that can impact the demand for material resources. As more people move to cities, there is a greater demand for things like housing, transportation, and infrastructure, which requires the use of materials and energy. Additionally, cities tend to be more resource and energy intensive than rural areas due to the concentration of people and the need for things like heating and lighting. This can put additional strain on resources and energy systems.

Another challenge that impacts sustainable consumption of resources and increases consumption is the market pressure

through various strategies that companies use to influence consumer behavior and encourage people to purchase more products or services. These strategies may include many ways such as aggressive advertising, credit card facilities, and consumer loans, which are designed to grab the attention of consumers and persuade them to buy a particular product or service. These make it easier for consumers to make purchases, even if they don't have the cash on hand to pay for them upfront.

In fact, the linear economy model, often referred to as the "take, make, use, and discard" model, is still applied at a large scale. This model is based on the idea of taking resources from the environment, using them to make products, consuming those products, and then discarding them when they are no longer needed. Unfortunately, this is characterized by a focus on short-term convenience rather than long-term sustainability. Therefore, there is a lack of Extended Producer Responsibility (EPR) and externalisation of environmental cost of product that is often not accounted for.

Further to look at, is the material-product logistics that involves the movement of raw materials, intermediate products, and finished goods from one location to another through various modes of transportation and through different stakeholders. One of the main issues in material-product logistics is accountability and transparency. From the extraction of raw materials to the production and sale of finished goods, materials may be moved through different countries, making it difficult to track and assign responsibility for any issues that may arise, and to assure whether the products have been ethically and sustainably produced.

Lack of consumer awareness about the environmental impact of products can also contribute to resource depletion and pollution. One of the main reasons for the lack of consumer awareness about the environmental impact of products is a lack of information. Many consumers are not aware of the full lifecycle of a product, including how it is produced, how it is transported, and how it is disposed of. This lack of information makes it difficult for consumers to make informed decisions about the products they purchase. Not to mention the lack of transparency from companies, where some companies may not disclose information about the environmental impact of their products or may present information in a way that is misleading or confusing to consumers. Here comes the urge to develop Environmental Product Declaration (EPDs) [33] for more products, which are documents that transparently describe the environmental performance or impact of a product or material throughout its lifespan.

Add to all the aforementioned challenges, the difficulty to find sufficient availability of locally manufactured products, especially

in the GCC countries, due to less industries and agricultural production, as agricultural production is important for providing a range of raw materials for the manufacturing industry.

However, there is a wide range of solutions that can be implemented to address the above-mentioned drawbacks and challenges towards more sustainable consumption patterns. First, is to make locally manufactured sustainable and green products available at large scale and competitive pricing, and use standardised labeling for sustainable and green products to make consumer visibility and understanding of such products easier.

One of the most used instruments for influencing sustainable consumer choices is voluntary labeling which has expanded to more products and countries in recent years. The most viable labels are those where environmental or social claims are verified by a third party, including governments and non-governmental organisations, such as in the EPDs where carbon footprint as well as other environmental impacts of a certain product are reported. Nutritional labeling of food items, including processed foods, should also be made mandatory for retail products as well menu-based food items and food from Genetically Modified Organisms (GMO). To avoid wastage, retail stores should have a policy for near expired items and fresh foods items. A further issue to be addressed is encouraging and regulating the hospitality sector to use more locally produced food items on the menu.

Second, raising large-scale consumer awareness about sustainable consumption through multiple media channels can create a cultural shift away from existing consumer habits, such as promoting new models in purchasing by sharing and renting of products, wherein the supplier bears responsibility for maintaining the products and taking them back when products are no longer needed, to subsequently be refurbished or put to another use. Moreover, educating youth on sustainable resource consumption is essential as they will represent a large share of the millennial population considering Sustainable Consumption as a subject matter in the educational curriculum. Also, encouraging customers through giving incentives for buying green products can be considered.

The government can also support sustainable consumption in several ways including enforcing policy and frameworks to promote sustainable consumption and finding alternative energy sources that are affordable and accessible for all to have an accelerated transition away from fossil fuels. This should go in line with public-private partnership (PPP) frameworks in promoting sustainable industries and production facilities within a country, to reduce reliance on imports of such products, through government aided investments and incentives

such as providing promotions and government subsidies for entrepreneurs and SME's that develop sustainable products in order to encourage and sustain small-scale manufacturers.

In addition, promoting and securing funding for research and development in environmentally compatible products to be manufactured within the country. Also, governments can support in developing sustainability rating criteria to regulate and control environmentally harmful products, setting minimum environmental standards below which unsustainable products will not be allowed to be in the market, and increasing energy, water and waste tariffs for residential, commercial and industrial facilities. This also applies to making green procurement and sustainable supplier selection a mandatory process for government organisation's and large corporate's procurement process.

There are many other approaches or solutions that can drive sustainable consumption behavior if implemented and followed, such as considering sustainability throughout the entire value chain of a product from design to disposal, promoting technologies that can be used by agricultural producers, manufacturers, and end consumers to create a sustainable flow of materials and items, and encouraging corporate sustainability reporting by companies to inform consumers of their social and environmental values and practices beyond the sustainability characteristics of their individual products which are usually covered by labeling.

Such information disclosure is now one of the main mechanisms by which consumers are informed of the environmental and social conditions under which products have been produced. Institutionalising Sustainable Consumption can help combat market irregularities and empower consumers to make better choices and take legal action towards sustainability. It also protects the health and safety of consumers.



Conclusions

Implementing sustainable management of water and energy, supporting sustainable consumption patterns, and implementing building decarbonisation are all critical for achieving a more sustainable and environmentally-friendly future. By taking responsible actions in these areas, which are many as mentioned earlier in this report, we can help to mitigate the negative impacts of human activity and promote a more sustainable future for all through reducing the carbon emissions associated with the construction and operation of buildings, using energy and water resources in a way that meets the needs of current generations without compromising the ability of future generations to meet their own need, and through changing the way in which people consume goods and services.

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