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Energy Efficiency in High-Rise Buildings in Desert Climates

Sustainability Research Paper

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The Gulf region has witnessed a significant increase in its number of skyscrapers over the past few decades. This trend of high-rise buildings in the Middle East can be mainly divided into two distinct phases. The first phase, from 1990 to 2000, was marked by the dominance of oil exploration and profits, which prioritised economic growth over energy efficiency. While the second phase was characterised by a shift towards sustainable design and greater awareness towards energy efficiency and financial savings associated with it. What are high-rise buildings? What kind of emissions are associated with them? Are there any challenges related to making high-rise buildings energy and resource efficient? How can the government and private sector play a crucial role in decarbonizing high-rise buildings?

SUSTAINABILITY RESEARCH PAPER

This research paper is part of a 12-month series published by the Al-Attiyah Foundation every year. Each in-depth research paper focuses on a current sustainability topic that is of interest to the Foundation's members and partners. The 12 technical papers are distributed to members, partners, and universities, as well as made available on the Foundation's website.

EXECUTIVE SUMMARY

- The Gulf region has witnessed a significant increase in the number of high-rise buildings, growing from 1 in 1995 to 300 in 2015.
- An upward concave trend is observed in embodied emissions as the height of a building increases.
- Cement and Steel contribute to 90% of the embodied emissions in a high-rise buildings. Space cooling represents up to 70% of energy use in Gulf region during summer.
- Implementing a whole-system energy efficiency approach in high rise buildings can significantly reduce embodied and operational emissions. The whole system efficiency approach consists of employing efficient building materials, passive building design, efficient equipment, and sustainable user behavior in high rise buildings to reduce its emissions.
- Reducing embodied emissions through efficient materials can be accomplished by selecting alternative materials like fly ash concrete, LC3 concrete and locally sourced materials.
- Passive building design techniques, such as shading devices, triple-glazed facades, and natural ventilation, can reduce cooling loads and energy consumption by 60% in high rise buildings.
- Adoption of district cooling systems and efficient chillers with low Global Warming Potential (GWP) refrigerants can reduce emissions and reduce peak loading in summers.
- In the observed case studies, efficient high-rise buildings had a life cycle of less than 10 years.
- Governments can implement building codes for high-rise buildings, consider whole lifecycle emissions in building codes, and promote research and development in building materials.
- Real estate developers can engage energy service companies (ESCOs) to retrofit their high-rise buildings, require environmental product declarations for building materials to reduce emissions and set their own decarbonisation targets.

The Gulf Region, Home to the Most New Skyscrapers in the World

The Gulf region has become the primary hub for the construction of new skyscrapers worldwide. This trend of high-rise buildings in Gulf countries can be mainly divided into two distinct phases: the first phase, from 1990 to 2000, was marked by the dominance of oil exploration and profits, which prioritized economic growth over energy efficiency. Consequently, super-tall structures emerged, with little consideration for energy conservation. These buildings featured towering facades adorned with transparent glass which relied on energy-intensive mechanical cooling systems and deviated from traditional cultural and geographical norms in their architectural design. Since 2010, a second phase has emerged, characterised by a shift towards sustainable design and greater awareness towards energy efficiency and financial savings associated with it. As a result, there has been a rise in the construction of super-tall buildings that incorporate natural ventilation, advanced shading systems, double-glazed panels, and efficient air conditioning systems (Ghabra et al. 2017).

According to the Council on Tall Buildings and Urban Habitat, there is no universal definition for tall buildings as their classification depends on contextual height and proportion within a specific geographical context (Tall Buildings, 2015). The function of tall buildings has evolved over time. While originally designed as office towers, they now serve a variety of purposes, including hotels, condominiums, shopping centres, and residential units. This diversification reflects changing demands and lifestyles in these regions and contributes to their appeal as tourist attractions. Skyscrapers offer opportunities for innovative designs within limited spaces and contribute to climate resilience. Initially, most tall buildings were developed in the United States, however, over time, there has been a notable geographical shift of skyscrapers towards Asian and Middle Eastern countries. In the last few decades, China, South Korea, Malaysia, Qatar, and other Gulf countries have witnessed rapid economic growth and have become focal points for new skyscrapers. This shift in development can be attributed to their growing economies, lifestyle changes and booming tourism, especially in Gulf countries. The Middle East has therefore experienced significant growth in skyscraper construction. In 1995, there was only one skyscraper in the Gulf region with a height exceeding 150 meters. However, by around 2015, the number had significantly increased to almost 300 (Tall Buildings, 2015). Most tall buildings in the this region are residential, and demand for residential high-rises has increased. For example, 56% of tall buildings in Saudi Arabia consist of residential units (Ghabra, 2017).

While tall buildings occupy less land and have a smaller footprint, their increased height and size require robust structural systems to withstand wind pressures lead to higher embodied emissions per unit area when compared with low-rise buildings (Mahgoub, 2011). With rising emissions and the residential sector being a major energy consumer in most Gulf countries, integrating energy efficiency measures from the planning to execution stages of high-rise buildings is crucial. Incorporating energy efficiency brings multiple benefits, such as reduced energy consumption, resource conservation, cost savings during operation, and the achievement of national climate targets, for instance, included in their respective Nationally Determined Contribution (NDC).

Energy Efficiency and Its Significance in High-Rise Buildings

Building emissions can be categorised into embodied emissions (associated with building materials) and operational emissions. In 2021, 28% of emissions were due to building operational emissions and 11% were from embodied emissions. Energy efficiency strategies in buildings can systematically reduce emissions throughout their entire lifetime. Overall, energy efficiency strategies can be broadly applied to building materials, building design (like passive design), building operation (using efficient cooling and lighting equipment), and sustainable behavioural practices by users. In general, the energy efficiency strategies employed in buildings can be effectively applied to high-rise constructions as well. It is observed that in high-rise buildings, there is a concave upward trend in building material-related emissions with an increase in height, making energy efficiency crucial in reducing the carbon footprint of the buildings (Gan et al., 2017).

Considering the importance of energy efficiency in building decarbonisation, close to 79 countries have established building energy efficiency codes (UNEP, 2022). In the Gulf region, specifically in Bahrain, Kuwait, Qatar, and Saudi Arabia, each country has developed its own building energy performance codes based on their respective geographical contexts. All these codes cover almost all building types, including residential, commercial, and high-rises. The only exception was found in the case of the Green Building Regulations and specifications for Dubai, which are not applicable to extremely tall buildings. The Jeddah municipality has proposed guidelines for tall building specifications and technical requirements after the construction of the 1000-meter-tall Jeddah Tower.

The objective is to create an integrated urban fabric with a distinctive skyline, featuring tall buildings that include vibrant public spaces and pedestrian zones. The guidelines aim to mitigate the impact on services, traffic, and the environment.

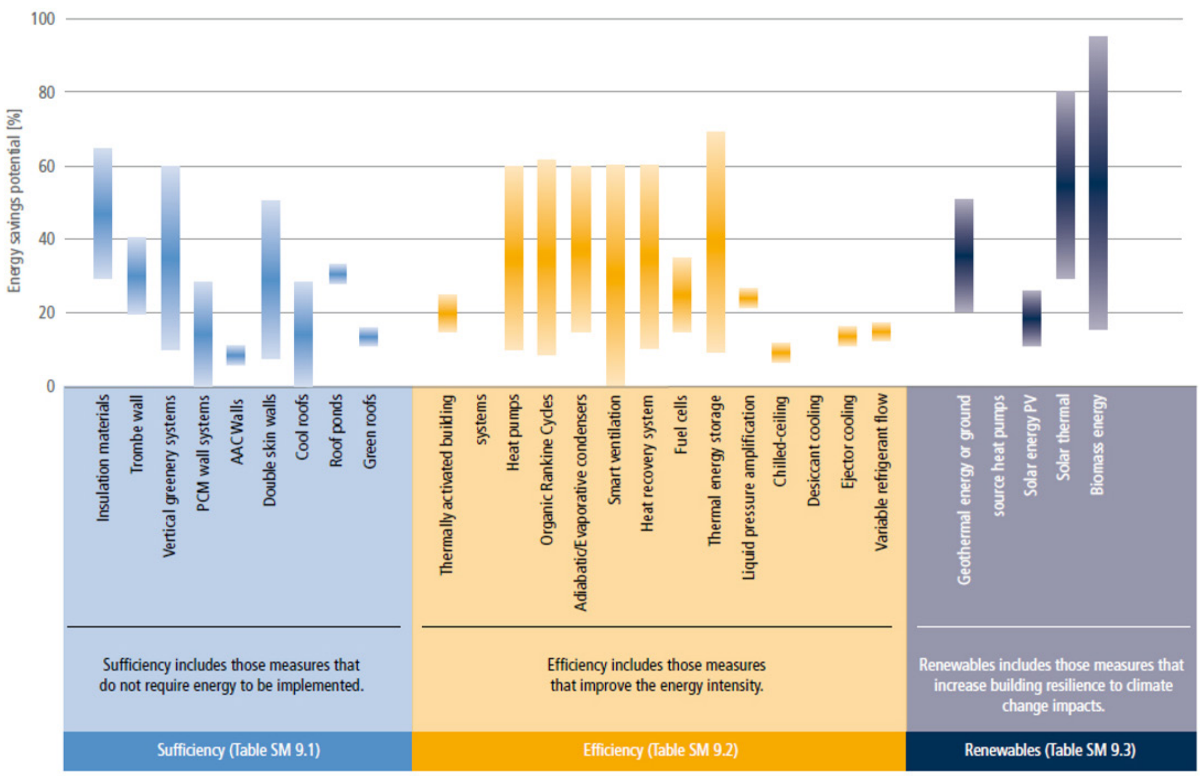
According to the Intergovernmental Panel on Climate Change's (IPCC) sixth assessment report of Working Group III, building decarbonisation can be addressed through three main strategies: sufficiency, efficiency, and renewables. Sufficiency focuses on implementing passive design strategies, efficiency involves adopting efficient technologies, and renewables refer to the use of renewable energy sources. An overview of the mitigation potential is depicted in Figure 1. The core principle of building decarbonisation is to reduce the perceived cooling and lighting needs through passive design strategies, meet these demands using efficient equipment, and then reduce operational energy by sustainable user behavior and building management system (IPCC, 2022).

All these strategies will be discussed in detail in the subsequent sections.

Efficient Building Materials

Buildings are responsible for 39% of global emissions, with operational energy use accounting for 28% of these emissions, while embodied carbon only accounts for 11%. However, with advancements in efficient technology and increased adoption of renewable energy, operational emissions are expected to decrease in the future, while embodied emissions are expected to contribute 50% of the emissions by 2050. Therefore, it is important to reduce embodied emissions during the building design and planning stage, as they become locked into the building (Amiri and Neshat, 2021).

Figure 1: Overview of various strategies to decarbonise buildings (IPCC, 2022)



Around 100 billion tonnes of waste are generated every year due to construction, renovation, and demolition (UNEP, 2022). This waste not only has environmental impacts by ending up in landfills but also contributes to embodied emissions. In addition to conducting a thorough building design review to minimise materials usage, incorporating an efficient manufacturing process for building materials (such as concrete, steel, and aluminum), embracing alternative construction materials, utilising locally available resources, and promoting circular construction practices can greatly reduce the carbon footprint associated with buildings.

In high-rise buildings, particularly tall structures, the need to meet structural and wind load requirements often leads to a higher embodied energy per unit gross floor area compared to low-rise buildings. It is noteworthy that approximately 90% of the total embodied emissions in high-rise buildings stem from the use of cement and steel. To evaluate the impact of different building materials, simulations were conducted to compare the embodied carbon intensity of reinforced concrete buildings, composite buildings, and steel buildings. The results revealed that in a 50-story building, although steel building will lead to 50 to 60% overall weight reduction, the embodied carbon per gross floor area was consistently 25 to 30% higher than that of reinforced concrete and composite buildings. However, if 80% of recycled steel is used then its embodied carbon is the least amongst the three types of buildings that were compared in the analysis (Gan et al., 2017). The findings emphasise that concrete has the lowest embodied carbon footprint among the evaluated materials. Moreover, by adopting environmentally friendly alternatives such as fly ash concrete or CGBS concrete (based on Calcined Clay-Based Cementitious Systems), the embodied carbon in concrete can be further reduced. Limestone Calcined Clays Cement (LC3) has been shown to significantly reduce energy consumption by approximately 50% and achieve a 40% reduction in emissions compared to Ordinary Portland Cement (UNEP, 2022). Another example is from Bank of America tower in New York which considerably reduced its embodied emissions by using concrete with blast furnace slag (Zhigulina and Alla, 2018). These insights underscore the significance of material choices and recycling practices in minimising the environmental impact of high-rise buildings, aiming for more sustainable and resilient construction practices.

Passive Building Designs

The design of a building and its immediate surroundings play a crucial role in reducing energy consumption and emissions. Generally, passive design strategies aim to analyse factors such as orientation, wind flow, solar path to deploy strategies that maximise daylight utilisation and minimise perceived cooling needs. The impact of passive design strategies varies with geography and effectiveness. In a research project conducted in Saudi Arabia, various passive design techniques were evaluated for their effectiveness. The use of triple-glazed windows resulted in a 5% reduction in energy usage, while thermal insulation with a thickness of 25 mm led to a 15% decrease in annual energy consumption. Additionally, the installation of shading devices saved 6% in energy consumption, and implementing a green roof strategy showed the potential to reduce energy consumption by 8% (Al-Tamami, 2022). Passive building design effectively reduces the cooling load, which can then be efficiently managed with the use of active cooling devices.

Similar passive strategies can also be effective in tall-rise buildings. Simulation studies conducted in Qatar have demonstrated that implementing effective ventilation, shading, night cooling, and insulation can lead to energy use reductions of 60-70% in high-rise buildings (Mohamed Hassabou & Ali Khan, 2018). Passive design techniques such as double-skin facades can reduce heat input during summer and minimise heat loss during winter. To enhance insulation, triple glazing with argon-filled cavities can be used, although this comes with additional costs. An example of passive solar shading can be observed in the Al Bahr towers in the UAE, where solar shades attached to the façade actively track the sun's path, closing when the sun is closer and opening when it is further away. Another effective strategy is incorporating roof garden and vegetation in high rise buildings which can not only reduce cooling loads but also improve air quality and the well-being of occupants. In the Shanghai Tower, the sky garden serves as a buffer zone to reduce cooling needs and provide ventilation (Ali et al., 2023). Passive design strategies are cost-effective measures that yield significant energy and cost savings throughout the building's lifecycle. Therefore, incorporating passive building design in high-rise buildings from the project concept phase is essential to reduce operational emissions.

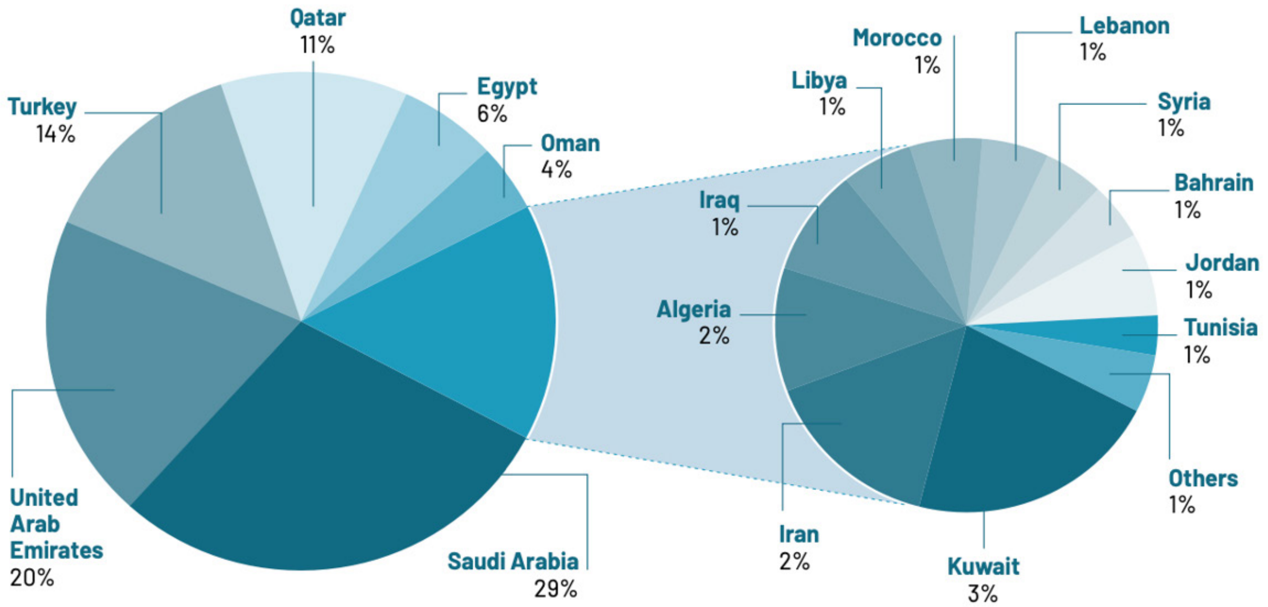
Efficient Equipment

The widespread use of air conditioning (AC) units is increasing globally, with approximately 2 billion units installed. This growth is driven by rising temperatures and urbanisation (Guidehouse, 2022). In the Middle East, where temperatures can reach up to 50°C, the reliance on AC for extended hours is evident. This is reflected in the region's higher average electricity consumption compared to the global average. Space cooling in the Gulf region accounts for approximately 60% to 70% of the total energy use, especially during the hot summers when the demand reaches its peak.

The MENA region contributes to 7% of the global AC demand, and it is projected that the AC market will continue to grow with a compounded annual growth rate (CAGR) of 8.1% (Guidehouse, 2022). As shown in Figure 2, countries like Qatar, Saudi Arabia and the UAE constitute more than 50% of the AC stock in the entire MENA region.

In high-rise buildings, cooling is mostly centralised and provided by chillers situated within the building or by district cooling systems. Using energy-efficient chillers that comply with low global warming potential (GWP) refrigerants can save operational energy and mitigate emissions. Deploying super-efficient cooling systems that utilise low GWP refrigerants like propane (R290) can be highly beneficial. Compared to traditionally used hydrofluorocarbon (HFC) refrigerants like R410a, R290 has a GWP that is 2000 times lower.

Figure 2: AC stock share in MENA region (Coolup, 2022)

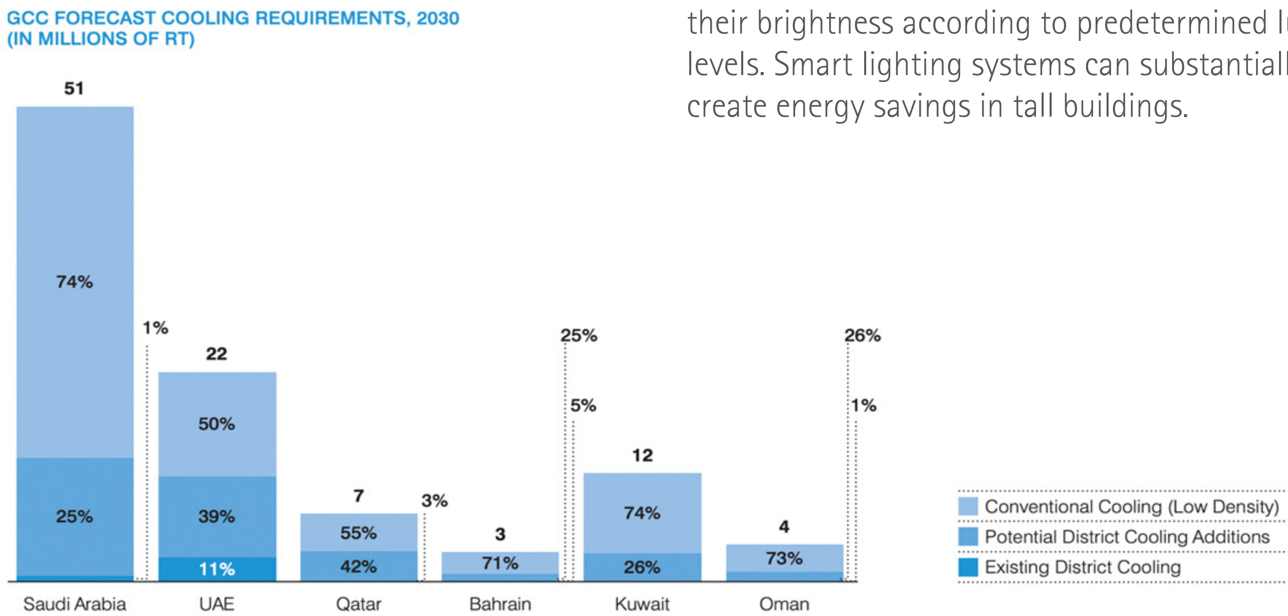


By utilising efficient space cooling equipment with low GWP refrigerants, not only can the indirect emissions resulting from electricity consumption be reduced, but also the direct emissions caused by refrigerant leaks during installation, servicing, and disposal.

Integrating space cooling controls with building management systems can help optimise energy usage by utilising occupancy sensors. Air handling units and pumps can incorporate variable speed drives to improve the overall system efficiency. Additionally, using heat recovery wheels can extract heat from exhaust air to reduce the cooling load. Absorption chillers, powered by waste heat, can also reduce operational emissions. For example, the 48-story New York tower 247 m high uses a natural gas-powered absorption chiller with a low GWP refrigerant and variable speed drives for pumps, fans, and motors to minimise energy consumption (Ali et al., 2023). Similarly, the 1 Blight Street tower in Sydney, which is 28 stories high and 120 meters tall, uses a hybrid trigeneration plant to generate electricity, heating, and cooling. This plant relies on natural gas-powered absorption chillers and solar-powered cooling to increase energy savings and reduce peak loads. The height of high-rise buildings increases embodied carbon, but it also provides an opportunity for innovative solutions, such as integrating wind turbines on the top floor to harness high wind speeds. The Shanghai tower incorporated smart wind turbines to power the upper floors with wind energy. The Bahrain World Trade Center, with a height of 244 meters, has two wind turbines that generate 1100 MW of electricity per year to power the office spaces (Ali et al., 2023).

District cooling is another viable and promising option, especially in Gulf countries with high-density populations, where cooling demands can be aggregated and supplied through district cooling systems. District cooling offers significantly lower system losses, has a lower environmental impact, and is cost-effective compared to individual air conditioning units. It is estimated that by 2030, if 30% of the cooling energy requirement in the Gulf region is met through district cooling, it could mitigate 30 million tonnes of CO_2 emissions annually (PwC, 2012). Figure 3 illustrates the existing and potential share of district cooling in the Gulf countries. As highlighted, UAE, Saudi Arabia, and Qatar have significant potential for district cooling. Close to 25% share of the world's total district cooling exists in the Middle East. And Qatar has executed the world's most extensive integrated district cooling system with a capacity of 450 MW (Insightace analytics, 2023).

Figure 3: Existing and potential district cooling in Gulf countries (Strategy&, 2012)



Other renowned district cooling projects include the Knowledge Oasis Muscat in Oman and Saudi Aramco Dharan complex (Tabreed, n.d.). Although district cooling has potential in the Middle East, there are substantial time and cost investments associated with these projects. Half of the upfront cost is associated with the distribution networks, and there are additional costs related to the installation of the central system and laying pipes to the clients. The upfront cost and planning setbacks hinder the widespread adoption of district cooling. However, the rising cooling demand and the optimised performance, and control of district cooling make it a safe bet in the Middle East, considering the rising temperatures and increasing residential housing demand.

Apart from cooling, lighting accounts for 10% to 25% of the total electricity consumption in tall buildings, depending on the building types and load requirements (Ali et al., 2023). Using efficient lighting solutions like LED lamps integrated with occupancy sensors can reduce energy usage. Advanced shading controls can harvest daylight savings, and outdoor lights can be equipped with daylight sensors to adjust their brightness according to predetermined lux levels. Smart lighting systems can substantially create energy savings in tall buildings.

Vertical transportation systems consume 5% to 10% of the energy in buildings. Elevator technology has been improving its energy efficiency through technological advancements. Regenerative technology, for example, can store energy while the elevator descends and reuse it during upward operation. Similarly, variable speed gearless technology can help recover and cut energy use by 50% (Ali et al., 2023). Destination-oriented elevator systems optimise the transportation of people by communicating seamlessly to understand each passenger's destination, grouping them together, and reducing time and energy consumption.

Energy efficiency in cooling, lighting, and vertical transportation can go a long way in reducing energy usage of high-rise buildings throughout their lifetimes. However, without proper maintenance and servicing, operational efficiency can decrease over time. Therefore, it is recommended to carry out energy audits, along with regular servicing and maintenance checks to optimise the performance of the system.

Integrating Smart Building Management / Sustainable Behaviour Nudges for Consumers

Aside from technical considerations, the behavioural aspects of consumers also play a significant role in optimising energy usage. Raising consumer awareness about their energy consumption and encouraging sustainable practices, along with the integration of smart devices, can effectively manage energy demand. Cost-effective building management systems and automation systems have a notable impact on improving efficiency by optimising the performance of building systems and incorporating energy-efficient solutions in high-rise buildings.

According to the International Energy Agency (IEA), behavioural interventions have the potential to reduce global emissions by 4% (IEA, 2021). One example of a behavioral nudge is the integration of home energy reports (HERs) in consumer electricity bills. HERs leverage data analytics and behavioral science to enhance utility customers' understanding of their energy usage, empowering them to actively adopt more efficient practices in operating their devices, thus playing a vital role in emission reduction. Previously, well-designed behavioral practices like HERs have resulted in worldwide energy savings of up to 33 TWh (AEEE, 2019). Similarly, educating homeowners on achieving thermal comfort through optimal air conditioning usage, rather than excessive cooling, can significantly reduce energy consumption while ensuring occupants' well-being. Encouraging tenants to increase the air conditioning temperature during summer can effectively decrease energy usage. India launched a public campaign to encourage users to set their air conditioners at 24 degrees Celsius or above in order to achieve optimal thermal comfort.

Case Study of a Hotel in Qatar

A case study conducted on a 9 stories hotel in Qatar with 4500 m2 simulated the impact of energy efficiency strategies and renewable energy (RE) strategies on energy consumption and emissions reduction in commercial buildings. The study revealed that by integrating passive building design strategies, energy consumption can be reduced by 7.4%. Furthermore, incorporating behavior change strategies such as goal setting, social comparison, feedback, and campaigns resulted in energy reduction ranging from 3.1% to 16% when combined with the use of smart sensors (Moujahed, 2022).

Therefore, it is evident that passive design strategies have the potential to effectively reduce the perceived cooling demand and, consequently, the associated indirect and direct emissions from air conditioning. The exact mitigation potential of passive design strategies depends on various factors, such as the specific strategies employed, building type, outdoor climate conditions etc. These factors collectively influence the effectiveness of passive design in reducing energy consumption and emissions in the cooling process.

Case Study of Capital Market Authority (CMA) Tower, Saudi Arabia

The CMA Tower, located in the King Abdullah Financial District in Saudi Arabia, stands at a height of 385 meters with 80 stories. The extreme outside climate poses a challenge for the design, as the intense solar radiation received can increase cooling needs.
To overcome this challenge, the design incorporates solar shading, photovoltaic solar collection, façade lighting, and an innovative façade access system.

The tower features a triple-glazed insulated glass curtain wall with an array of glass fins connected to a gantry for shading. The integrated facade design aims to effectively control shading and optimise solar heat gain while also providing ample daylight.

In order to effectively reduce energy consumption and travel time in elevators, the implemented system features two elevator cabs travelling independently within the same shaft, with one cab positioned above the other. This design offers several advantages, including a reduction in the number of shafts required and minimised travel time during elevator journeys. Furthermore, the roof of the CMA Tower is equipped with a solar PV array that generates 400,000 kWh of electricity. The sustainable design strategy of the building aims to achieve LEED Gold certification, indicating a high level of energy efficiency and environmental performance (Soto & Al-Shihabi, 2015).

Case Study of the International Renewable Energy Agency's (IRENA) Headquarters

IRENA established its headquarters in Abu Dhabi, which is a 6-storey building, occupying a 32,000 m2 complex with a special focus on conserving energy and water. The building achieved Four Pearl certification, which is the highest certification in the UAE for non-energy, water, and carbon efficiency (IRENA, 2015). The project deployed the following energy efficiency strategies and their corresponding impact:

- **Building Materials:** The project employed a green supply chain and locally sourced materials, including recycled aluminum, steel, and cement. This approach aimed to reduce embodied emissions.
- **Passive Building Design:** The building incorporated passive design principles, resulting in a 64% reduction in energy usage compared to typical buildings in Abu Dhabi. This design focused on optimising natural lighting, ventilation, and insulation to minimise reliance on mechanical systems.
- **Efficient Space Cooling:** A heat recovery system was implemented, extracting energy from exhaust air to pre-cool fresh air. This approach helps reduce the energy required for cooling. Additionally, the project included a charging station for electric vehicles, promoting sustainable transportation.

Overview of the Technical, and Financial Challenges of Implementing Energy Efficiency Measures

The implementation of energy efficiency strategies in high-rise buildings faces various technical and financial challenges. One such challenge involves the necessity to acquire the skills and training required to effectively deliver, maintain, operate, audit and manage low carbon buildings. To successfully execute energy-saving projects on a large scale, such as building retrofits or new constructions, a skilled workforce is crucial to ensure high-quality work at a reasonable cost.

The country may also encounter hurdles in implementing and enforcing energy efficiency policies, mainly due to their limited capacity, testing laboratories and knowledge which are necessary to implement standards, labels, and building codes.

Financial obstacles to developing high-rise buildings can manifest in different ways. Retrofitting and constructing new buildings with green certification incur additional expenses that developers must bear. The initial high capital cost serves as a significant barrier to building new high-rise houses and also discourages building owners from retrofitting the existing high-rise structures. Additionally, households from low-income communities may lack the purchasing power to afford financing options for retrofitting in high-rise buildings. The overall upfront costs associated with energy efficiency can impede the development of sustainable tall buildings.

Price Increase vs. Savings of Operational Costs – What Would Be the Payback Period?

Deploying energy efficiency strategies in high-rise buildings may come with initial costs. However, successful case studies of efficient buildings have demonstrated that these investments can offer attractive payback periods. For instance, the implementation of building energy codes in Bahrain is projected to yield a payback period of around two years (Elnabawi, 2021). In a simulation study conducted on a high-rise residential building in New York estimates that integrating passive building strategies can result in a payback period of under three years (Fxfowle, 2021). In the USA, a study by NREL estimates that in high-rise buildings, the payback period for efficient building materials is less than ten years (Leach et al., 2021). Considering a lifetime of at least fifty years, the payback period can be achieved in less than one-fifth of the time. These examples highlight the potential for cost recovery and long-term savings through building energy efficiency measures. Especially in the Gulf region, with economies of scale and the creation of aggregated demand for efficient super-tall structures, the payback period can be further reduced.

Discussion of Opportunities for Overcoming These Challenges

The Gulf region has shown a growing focus on energy efficiency, evident through the implementation of energy efficiency plans and renewable energy initiatives, as well as increased collaboration within the region. However, in comparison to European countries, the driving forces behind energy efficiency in the Gulf region have been primarily influenced by sustained economic and lifestyle changes, rather than explicit policy changes aimed at energy efficiency and environmental concerns. However, a shift in paradigm has become more apparent recently, with countries like Qatar, Bahrain, and others setting net-zero targets. It is crucial for both the government and private sector to align and collaborate effectively to lead this transformative change. Leveraging technological advancements and available resources in building materials, employing integrated whole system passive design, and the scalability of efficient technologies like district cooling can be harnessed to drive the high-rise building stock towards zero carbon roadmap.

The potential of green bonds can be explored as a means to generate funding for sustainable high-rise projects. The high-rise residential properties can benefit from low-premium mortgages specifically designed for availing efficient buildings. Financial incentives targeting energy-efficient equipment can also drive demand for more efficient devices in high-rise buildings. For instance, Italy offers a 50% tax reduction for high-end equipment, while the UK provides a reduction in VAT for certain appliances, encouraging their widespread adoption (Tomy, 2022). By incorporating sustainable green public procurement practices, emission reductions can be achieved in high-rise buildings of public institutions.

The Role of Large Real Estate Companies in Promoting High Efficiency Skyscrapers

There is a growing demand for high-rise residential units, especially in Saudi Arabia with long-distance views towards the city and the sea (Ghabra, 2017). Apart from this people are becoming increasingly aware of climate change, and sustainability has become a crucial factor when renting or buying homes.

According to a recent survey conducted by BCG among 8,000 respondents in the Gulf region revealed that approximately 71% of individuals were aware of climate change, and 56% expressed a strong desire to transition towards a sustainable lifestyle (BCG, 2021). This presents a strong motivation for real estate building developers to invest in efficient, state-of-the-art high-rise buildings, which is a win-win situation for building owners and tenants. Tenants can save energy, while landlords can benefit from state-of-the-art technology with a long lifespan. Similarly, retrofitting existing high-rise buildings is also beneficial, as the payback period is observed to be less than ten years, as seen in above mentioned case studies.

Energy service companies (ESCOs) play a vital role in retrofitting existing real estate properties, as they can install efficient systems in buildings through energy performance-based contracts. The ESCO model has been successful in countries like China and India, effectively reducing building emissions and operational costs (Tomy, 2022). In the Gulf region, Etihad ESCO aims to jumpstart the creation of a viable Energy Performance Contracting (EPC) market for ESCOs by performing building retrofits, increasing the penetration of district cooling, building the capacities of local ESCOs in the private sector, and facilitating access to project financing (Econoler, 2021).

The real estate sector has the potential to take the lead the decarbonising of high-rise buildings and therefore contribute to the net-zero targets of various Gulf countries. A notable example of this is the recent launch of the net-zero accelerator by Lodha Development Group in India. Lodha Group aims to achieve carbon neutrality in their real estate ventures by 2035 (Lodha, 2022). With a significant number of high-rise residential units in its portfolio, Lodha has already developed over 60 out of the 150 tallest buildings in Mumbai. To accomplish its carbon neutrality goal, Lodha is implementing a comprehensive whole-system approach to decarbonise their building stock consisting of high-rise residential units. They are focusing on several areas in their efforts:

Efficient materials and construction: The accelerator engages with industry leaders and stakeholders to influence and control supply chain emissions by prioritising greener materials in response to growing demand.

Passive design: By adopting an integrated design approach and implementing passive design features, energy efficiency can be achieved by minimising the need for additional energy. This involves conducting performance analysis, utilising best design strategies, and selecting performance materials.

Ultra-efficient equipment: Through economies of scale, the accelerator aims to overcome barriers to efficiency and achieve the highest possible efficiency levels for equipment. Initially, the focus will be on cooling systems, which are significant contributors to emissions during the operational stage of built environments.

Green financing: The accelerator explores opportunities in green financing options that support the transition to sustainable practices. These financing options act as valuable tools to enable the necessary business models and collaborations across various technical focus areas.

Setting similar targets by the Gulf real estate actors for high-rise buildings can significantly reduce their emissions. Additionally, publishing yearly Environment, Social Governance (ESG) analysis, along with comprehensive evaluations of current energy consumption and emission reduction targets, can enhance accountability and transparency. This enables the sector to transform its high rise building stock towards sustainability and demonstrates a public commitment to environmental responsibility.

Recommendations to Government and Private Stakeholders for Implementing Energy Efficiency Measures

To decarbonise high-rise buildings, it is imperative that the government sector takes the lead and pushes for regulations that cover high-rise buildings and support their implementation. The government can also provide incentives or support for retrofitting existing high-rise buildings. The high-rise building managers should conduct regular audits and maintenance, and align their strategies to incorporate energy-efficient practices. In this regard, here are some recommendations for both the public and private sectors:

1. Building energy efficiency codes and MEPS: Implementing building energy efficiency codes for residential and commercial high-rise buildings, and regularly updating them, is crucial to promote higher energy performance. It is important to update the Minimum Energy Performance Standards (MEPS) for cooling appliances like chillers and Variable Refrigerant Flow (VRF) systems, as they account for over 60% of electricity consumption during peak summer periods in the Gulf region (Guidehouse, 2022).

2. Strong compliance mechanism: Alongside regulations, a robust compliance mechanism should be in place to monitor and ensure transparency of standards. Real estate companies could be asked to voluntarily report their energy savings and sustainability measures from high-rise buildings to the government to enhance accountability and transparency.

3. Environment Product Declarations (EPD): The real estate sector, with its high-rise building stock, can drive the demand for efficient buildings. They can hold suppliers accountable by requesting EPDs that mention the lifecycle emissions of materials like cement and steel. This would make the supply chain greener and more accountable. Such practices can reduce the embodied emissions that occur during construction. Additionally, real estate companies can seek the assistance of energy service companies to decarbonise their existing building stock. This would enable landlords to sell their rooms at a higher premium while consumers enjoy a more sustainable and energy-efficient living experience.

4. Research and development – Academic institutions in collaboration with the private sector could research into alternative building materials in the context of the extreme climate of the Gulf region. The government can also consider setting up production processes for these alternative construction materials like green steel, LC3 cement etc. This would help in developing a whole ecosystem to supply sustainable, locally sourced building materials for the high-rise buildings in the Gulf region.

5. Training workforce: A skilled workforce is necessary to handle equipment, conduct building audits, and integrate smart devices in green buildings. Therefore, the government should introduce skill development and training courses in green building technologies and HVAC system.

6. Climate change awareness: To ensure sustainable practices among building users, real estate managers of high-rise buildings may consistently educate them through various means such as workshops, visual cues, home energy reports, and energy-saving tips. The integration of smart devices can further optimise energy consumption. Encouraging friendly competitions, organising workshops, and holding events on significant environmental days like Earth Day, Environment Day, and World Overshoot Day can foster a sense of environmental responsibility, especially among the younger generation. Additionally, governments can contribute by introducing climate change awareness programs into the school curriculum. An example of such an initiative is the UNDP's Climate Box, which employs interactive quizzes, games, and reading materials to educate students about climate change. This program has already benefited more than 50,000 students across eight countries (UNDP, 2018). Engaging young minds can play a crucial role in implementing sustainable behavior interventions among building users, leading to a reduction in operational energy issues in various types of buildings, including high-rises.

7. Stakeholder engagement: Effective coordination and cooperation between public and private stakeholders, along with research and development institutions, will greatly contribute to analysing policy gaps and introducing suitable regulations, policy measures, and green financing options to decarbonise the building stock in the Gulf region.

In the Gulf region, where hot desert climate and a thriving economy prevail, the construction of high-rise buildings has experienced a significant surge. These centralised high-rise structures have been adopted as an effective solution to meet the rising demand for comfortable, secure, and operationally efficient spaces for tenants. However, this increased reliance on high-rises has resulted in escalated energy consumption, particularly for cooling purposes, leading to higher emissions. Given the growing significance of climate change mitigation and the net-zero targets set by Gulf countries, it becomes imperative for high-rise buildings to embrace a comprehensive, whole-system approach to energy efficiency. This approach aims to reduce both operational and embodied emissions associated with these tall structures.

The whole system approach consists of employing energy efficiency in building materials, passive design, efficient equipment, and sustainable user behavior that can significantly reduce both embodied and operational emissions of high-rise buildings. Additionally, the incremental cost of achieving these savings is relatively low, with a payback period of less than 1/5th of the building's lifetime. This makes energy-efficient high-rise buildings attractive for developers and tenants, as tenants can reduce their operational energy use, and landlords can benefit from state-of-the-art design. The desert climate also presents a unique opportunity to harness abundant renewable energy resources like solar and wind. By integrating solar and wind farms within high rise building structures could enable buildings to function as self-sustaining entities with net-zero energy consumption.

Challenges exist in terms of upfront costs exists especially for the district cooling systems that typically power high-rise buildings. Retrofitting high-rise buildings has been slow, and energy service companies (ESCOs) can play a vital role in implementing energy efficiency measures through performance-based contracts. Proper maintenance, regular service checks, and energy audits are necessary to ensure the ongoing energy savings and performance of any high-rise building.

Government regulators in the Gulf region can play a major role in decarbonising high-rise buildings by implementing building codes specific to high-rise structures, including lifecycle emissions considerations alongside operational emissions. Strong compliance mechanisms should complement these regulations. The government can support the development of emission-less processes for cement and steel, which constitute more than 90% of embodied carbon, and invest in training programs for skilled workforce. The real estate sector can take the lead by closely coordinating with the government and setting sustainability targets for its high-rise buildings. Making environmental product declarations mandatory can ensure suppliers provide materials with lower embodied emissions.

In conclusion, innovative high-rise buildings, with the support of the government and private sector's decarbonisation efforts, can complement the net-zero targets of the Gulf region.

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Green hydrogen can help decarbonise hard-to-abate sectors like refinery, steel and heavy duty transport and the chemical industry. The Gulf region is well positioned to establish itself as a hydrogen hub as it has cheap and abundant renewable energy resources and is located in the vicinity of major hydrogen consumption centres like Europe and Asia.

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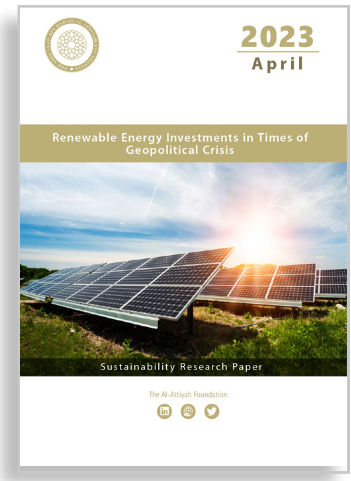

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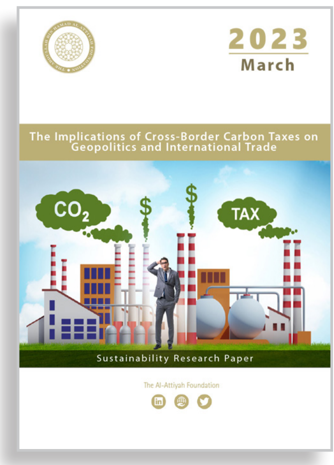

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