The Role of Residential Energy Efficiency in Shaping the Energy Transition in Saudi Arabia: Key challenges and initiatives

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Abstract

This paper discusses a crucial topic that has emerged in the policy and economic literature in recent years: the potential role of energy efficiency in the current energy transformation process. It provides a straightforward analysis to explore the prominent role that building energy efficiency may play in shaping the energy transition and sustainability path. The focus of the investigation is the energy efficiency initiatives in Saudi Arabia, as an example of an economy very concerned by and very proactive in terms of efforts to boosting its energy transition. From a policy perspective, the paper emphasizes the importance of accelerating the decarbonization process in the building sector and suggests ways to consider a holistic view of energy efficiency policies in the building sector.

Keywords: *Energy efficiency; Energy Transition; Sustainability; Saudi Arabia.*

1. Introduction

Currently, approximately 100 million barrels of oil are consumed in the world per day. The world population grew from 3.8 to 7.7 billion in barely 50 years, between 1972 and 2019, respectively. During the same period, annual energy demand per capita also went up from 57 to 75.7 gigajoules (GJ)(BP, 2020). This energy consumption pattern highlights the accelerating pursuit of mass usage and, consequently, energy demand across many developing economies. The contemporary global energy system has fueled this pathway and propagated it on a large scale. Nonetheless, the current global power system, while diverse in type, is still nearly uniform in terms of carbon source.

Demand is increasing regardless of the energy source. Since the world's population is projected to expand by approximately two billion people over the next two decades, and as standards of living improve, electricity generation is expected to increase by 50% by 2040. The U.S. Energy Information Administration's (EIA) recently released International Energy Outlook 2019 (IEO2019) Reference Case expects global energy consumption to increase by nearly 50% in the period from 2018 to 2050. The bulk of this increase originates from non-OECD countries, and it is being driven by regions where strong economic growth is stimulating demand, particularly in Asia. During this period, the overall energy consumed in the buildings sector, encompassing residential and commercial buildings, will increase by 65%, from 91 quadrillion to about 139 quadrillion Btu. This growth will be driven by a combination of rising incomes, urbanization, and increased access to electricity. We note that fossil fuels continue to largely dominate the contemporary world energy mix with a share of 80% (UN, 2021). In such context, by the following decades, even with a sustained high penetration rate of new technologies, the percentage of these alternative energies in primary energy generation will likely be less than 15-20% (Figure 1).

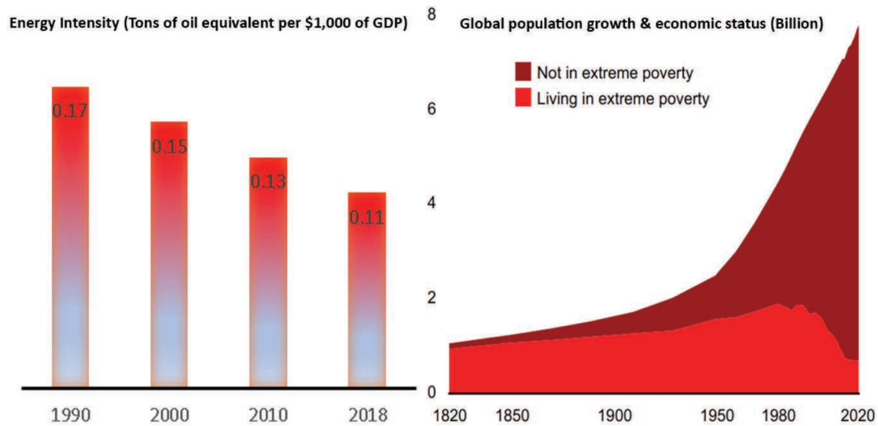

Figure 1: Energy intensity and global population growth (Sources: International Energy Agency & Our World in data).

Aware of the role that energy efficiency could play in accelerating the energy transition and meeting global climate and sustainability goals, several countries around the world have adopted energy efficiency plans as an effective strategy to reducing the energy demand in different sectors (e.g., building, transportation, industry, etc.). Despite the considerable effort made by various countries, the potential to drive further energy savings is still immense. According to the International Energy Efficiency Market Report of 2014, roughly 70% of world energy consumption is not subject to mandatory efficiency standards targets.

Nowadays, energy efficiency investments seem to lag behind public policy objectives set in several countries. In the economic literature, this phenomenon is commonly referred to as "Energy efficiency gap" or "Energy efficiency paradox"- a persistent and significant difference between socially optimal levels of energy efficiency investment - broadly defined as a substantial gap between levels of energy efficiency investment and actual investments made by individuals (Jaffe and Stavins, 1994; Gerarden et al., 2015; Belaïd et., 2019; Bakaloglou and Belaïd, 2022). The underlying assumption of this analytical framework is that energy efficiency investments are not as attractive as theoretically expected due to the existence of barriers that prevent their large-scale diffusion. These barriers include market and behavioral failures (Gillingham and Palmer, 2014).

Starting from this conjecture, this analysis will provide a comprehensive view of energy efficiency trends with a significant focus on Saudi Arabia. Specifically, it will explore the role of residential energy efficiency in shaping the energy transition and sustainability goals. Further, based on the analysis, the paper provides an integrated policy framework to accelerate and monitor the energy decarbonization process of the building sector. By so doing, this paper will help to gain a better understanding of the role of energy efficiency in addressing critical energy and environmental issues facing developing countries, particularly Saudi Arabia.

The remainder of this paper proceeds as follows. Sections 2 briefly introduces energy efficiency and discusses the unmet potential for energy savings in buildings. Section 3 reviews and comments on energy efficiency initiatives in Saudi Arabia. Finally, Section 4 concludes and offers some policy recommendations.

2. Energy efficiency in buildings: Huge untapped potential

Combined, the building and construction sectors are accountable for more than a third of the world's final energy consumption and for nearly 40% of total direct and indirect CO_2 emissions (IAE, 2021). Further, buildings use 25% of the world's water, 40% of the world's natural resources. This demand continues to grow, due principally to improved access to energy in developing countries, increased ownership and use of energy-using devices, and fast growth in building size worldwide.

According to the International Energy Agency's recent study, in 2019, direct and indirect emissions from electricity and commercial heat used in buildings reached 10 $GtCO_2$, which is the highest level ever recorded. This represents about 28% of total global energy-related CO_2 emissions. If emissions from the building and construction sector are included, this share reaches 38% of global energy-related greenhouse gas emissions.

This increase was driven by multiple factors, including growing energy demand for heating and cooling, increased air conditioner ownership, and recent extreme climatic events (IAE, 2021a). The recent BP Energy Outlook (BP, 2020) states the growth in energy use in buildings is entirely emanating from the developing world, as improvements in wealth and living standards enable people to live and work in greater comfort.

In 2018, the global residential sector solely consumed about 6008 TWh of electricity, with consistent growth over the last three decades (IAE, 2021b). This growth is driven by different factors, mainly the increase in global population, and hence the demand for housing, the rise in living standards, and, arguably, global warming (Lévy and Belaïd, 2019; Belaïd and Joumni, 2020). From 2010 to 2019, for instance, residential energy consumption increased by more than 5%, adding more pressure on emissions that witnessed a growth of about 4% during the same period, not accounting for the buildings construction industry (UNEP,2020). This remarkable growth is driven mainly by appliances in which energy efficiency plays a critical role in determining their demand, including air conditioning systems, residential appliances, and lighting. The International Energy Agency (IEA) estimates the number of air conditioning units to increase from 1930 to 5577 million units between 2020 and 2050 (Statista, 2020).

Therefore, buildings have a tremendous potential to deliver cost-effective GHG emissions reductions in both developed and developing countries. In addition, buildings' energy consumption can be significantly lowered by 30-80% with commercially available, mature technologies. There is a remarkable agreement that enhancing building energy efficiency in buildings will contribute to the Sustainable Development Goals achievement (Figure 2) and generate multiple advantages, including economic, environmental, and social benefits.

Arguably the most obvious potential benefits of energy efficiency investments are the environmental ones. More energy-efficient buildings would reduce the use of fossil fuels, leading to lower greenhouse gas (GHG) emissions, which is essential to achieving the goal of a decarbonized building stock by 2050.

The economic benefits are less obvious but prevalent. These include energy cost savings, creating jobs, and increasing propriety values. With more emphasis on energy efficiency measures, between €280 and €410 billion in energy costs could be saved, equivalent to nearly twice the annual electricity consumption of the United States (European Commission, 2015). The jobs generated could reach an average of 1.1 million net additional jobs by 2050 (European Commission, 2015).

Energy efficiency investment has the potential to "knock two birds down with one stone" by fostering healthier environments and improving well-being. Energy-efficient homes tend to be warmer and less moldy than energy inefficient homes. They also have better air quality. With less sickening settings, people will pay less on medical expenses, miss fewer days of work, and be more productive when they are at work. This increases well-being while encouraging economic growth.

Pressing agendas, including climate change mitigation, boosting the energy transition, and

Figure 2: Contribution of buildings decarbonization to the Sustainable Development Goals achievement (Source: Adapted from World Green Building Council).

strengthening energy security, have put the residential sector in many countries around the world in the spotlight due to its substantial energy-saving potential, which could be realized through investments in energy efficiency (Masson et al. 2015; Belaïd et al., 2019; Belaïd et al., 2020). Nevertheless, energy efficiency investments in the building sector appear to be lagging behind the public policy goals set in several countries (Belaid and Rault, 2021; Belaïd et al., 2021; Bakaloglou and Belaïd, 2022).

Building decarbonization initiatives are on a clear upward trajectory around the world. However, they must accelerate in both scale and pace to meet climate and sustainability goals of the Paris Agreement. These efforts are reflected, for example, in the (1) World Green Building Council's Net Zero Carbon Buildings Commitment. It represents a global action network comprised of around 70 Green Building Councils around the globe committed to transforming the building and construction sector to achieve the net-zero buildings operations by 2050; and (2) Science-based target initiative for business, which is a joint partnership between CDP, the UN Global Compact, the World Resources Institute (WRI) and the World Wide Fund for Nature (WWF). It federates approximately 1,000 companies committed to cutting carbon emissions beyond their own activities by including further indirect carbon emissions in their carbon mitigation plans.

Further, the EU has emphasized becoming a world leader in energy efficiency and pushing pro-environmental agendas. Particularly influential initiatives include the Energy Performance of Buildings Directive (EPBD) and Energy Efficiency Directive (EED) (European Commission, 2021). Both initiatives confirm the important role of the building sector in achieving the Union's energy efficiency target, as it accounts for about 40% of final energy consumption. According to the European Commission, the first priority in establishing the Energy Union rely on the full reinforcement and implementation of existing energy legislation. The key complementary goals of the EPBD are: (i) the stimulation of existing building renovation by 2050; and (ii) reinforce the modernization of the whole existing dwelling stock by implementing smart technologies with a close link to clean mobility.

As for Saudi Arabia, implementing a large-scale energy efficiency program on Saudi building stock was estimated to reduce energy consumption by 100 TWh/year and shrink peak demand by 25 GW. In addition, enforcing a more rigorous energy efficiency code in Saudi residential buildings can save up to 1.7 TWh/year and dampen peak demand by 468 MW/year (Krarti et al., 2017). Moreover, insulating all non-insulated housing units in Saudi Arabia could have saved up to 22 TWh in 2019, and upgrading all air conditioning units to an Energy Efficiency Rating (EER) of 12 could have saved up to 30 TWh in the same year (Krarti et al., 2021).

3. Energy efficiency initiatives in Saudi Arabia

Energy efficiency has been gaining the attention of Saudi policymakers in different sectors, including buildings, transportation, and industry. These three sectors account for 90 percent of local energy consumption. In 2010, Saudi Arabia established the Saudi Energy Efficiency Center (SEEC) with a sizable mandate to enhance energy efficiency in production and consumption to prevent depleting national resources and enhance economic and social welfare. Since its establishment, SEEC started the Saudi Energy Efficiency Program (SEEP) that aims at rationalizing energy consumption and improve efficiency. In residential buildings, SEEC was able to make a giant energy efficiency leap during the last decade through three main initiatives. These are labeling and energy ratings, public awareness campaigns, and updating MEPS.

In conjunction with the Saudi Standards, Metrology, and Quality Organization (SASO), SEEC has been regularly developing and updating the energy rating system of different residential appliances. As in some other countries, this energy rating system evaluates and ranks residential electric appliances in terms of energy efficiency as well as providing estimating the annual electricity consumption under normal usage. These rating systems have been updated frequently as technology, and hence efficiency, improves. In 2010, Saudi government enforced these labeling systems as mandatory for all electrical appliances. As a result, all imported and locally manufactured electrical appliances are not allowed to enter the Saudi market before being rated and labeled.

Since its establishment, SEEC believes that one of the main factors to reduce energy consumption is through changing consumers' behavior. In the last few years, SEEC has been investing heavily in public awareness via different channels, including local TV, social media, and billboards, to name some. within the framework of the Saudi Energy Efficiency Program (SEEP), a national awareness campaign was launched in 2014 to increase community awareness regarding the importance of energy rationalization and energy efficiency. This campaign was designed based on both scientific studies undertaken in association with local and international awareness-raising experiences, as well as studies of previous awareness-raising campaigns conducted around the world. These public campaigns target mainly the behavioral aspects of demand and how consumers reduced their electricity consumption only by changing their habits and choices when they are about to invest in new electrical equipment. For instance, prior to summer months, when demand for cooling starts to increase, SEEC encourages people to increase cooling setpoint temperature above 20 °C so they can see significant reductions in their electricity bills. Encouraging consumers to buy efficient residential equipment is another common public awareness that people see all year long.

One of the most critical elements in enhancing energy efficiency, especially with the fast improvements in technology, is the regular revision of the Minimum Energy Performance Standards (MEPS). In other words, all electrical equipment in the market, either imported or locally manufactured, should meet these MEPS. This practice ensures improving energy efficiency in the residential sector and eliminating cheap products that stimulate wasteful use of resources. It is worth mentioning that updating the MEPS is not isolated from how technology, and hence energy efficiency, has been evolving in electrical appliances industry. One of the appliances that has been witnessing recurrent MEPS updates is the air conditioners (AC). At the beginning of 2012, the minimum EER of small AC units was set to 7.5, including split and window units, which are the most common AC units in Saudi Arabia. In 2013, the minimum EER of the same size and type was further increased from 7.5 to 9.5. Three years later, in 2015, the minimum EER of these AC units was also boosted to 11.5, then to 11.8 in 2018. To ensure even a more efficient cooling process in buildings, Saudi Arabia enforced a stringent thermal envelop insulation in 2019 in which all new buildings, including residential, commercial, and government, are to meet this requirement in order to be connected to the electricity grid. Although other residential appliances do not consume as ACs do, their MEPS also have been updated on a regular basis. For example, the MEPSs of refrigerators, freezers, dishwashers, washing machines, dryers, and lighting, were revised and enforced in 2015 to ensure being within the efficient range.

These three main factors are expected to continuously dampen the energy demand growth that the electricity market has been witnessing in the last few decades. A recent study conducted by Aldubyan and Gasim (2021), uses an econometric technique to estimate the impact of different factors, such as price reforms and energy efficiency on electricity demand, has shown strong evidence of the impact of energy efficiency on reducing demand in the last few years, especially after 2014, when the upward trend of the total electricity demand reversed.

4. Discussion & Policy recommendations

This article aims to emphasize the important role that building energy efficiency can play in framing sustainability goals and the so-called welfare economic model. It also discusses the massive unexploited energy-savings potential of the building sector in the context of the energy efficiency paradox. The analysis supports the argument that building sector is associated with a substantial unrealized energy-saving potential. Further, scaling up energy efficiency in the building sector (new and existing buildings) will generate multiple benefits for the environment, economy and society. Compared to other major emitting sectors, buildings offer considerable greenhouse gas emission reduction potential. In parallel, decarbonizing the sector brings many economic benefits, including reducing energy bills, increasing competitiveness of industries and services, and easing pressures on national budgets. Finally, beyond the environmental and economic advantages, the efficient building sector has shown substantial social impacts, including well-being and health improvement. The analysis also documents the Saudi energy efficiency journey and its considerable efforts to improve energy efficiency, mainly in the building sector.

This article is not actually geared to evaluate a particular energy efficiency policy. Nonetheless, it raises questions about the importance of accelerating the decarbonization process in the building sector and suggests ways to consider a holistic view of energy efficiency policies in the building sector.

In line with this statement, an effective energy efficiency program in the building sector should be integrated and holistic to consider the complexity of the process and different barriers that policy implementation faces. Accordingly, as displayed in Figure 3, a successful program should include not only a single measure but a set of interconnected instruments to ensure a substantial transformation, including: (1) regulatory framework; (2) fiscal and financial schemes; (3) information and awareness campaign; and (4) institutional reforms.

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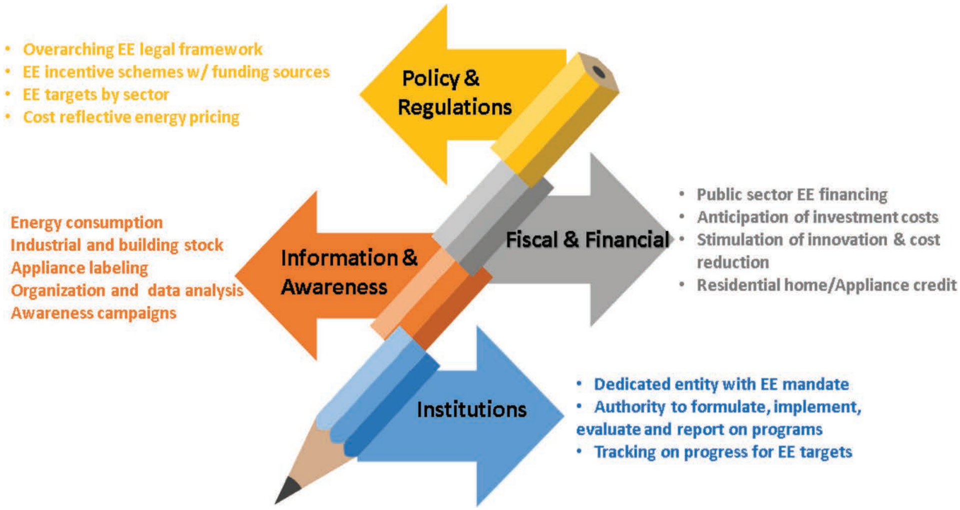

Figure 3: Framework for holistic and successful energy efficiency program in the building sector.

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