

Commentary

The Role of Building Energy Efficiency in Shaping the Energy Transition in Saudi Arabia: Key Challenges and Initiatives

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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

This commentary 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 transition. It provides a straightforward analysis of the prominent role that residential energy efficiency may play in shaping the energy transition and the pathway to sustainability. The primary focus is the energy efficiency initiatives in Saudi Arabia, as an example of a country that is very concerned by the transformation of the energy landscape. Saudi Arabia has also been very proactive in its efforts to boost its energy transition. From a policy perspective, the commentary 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 buildings sector.

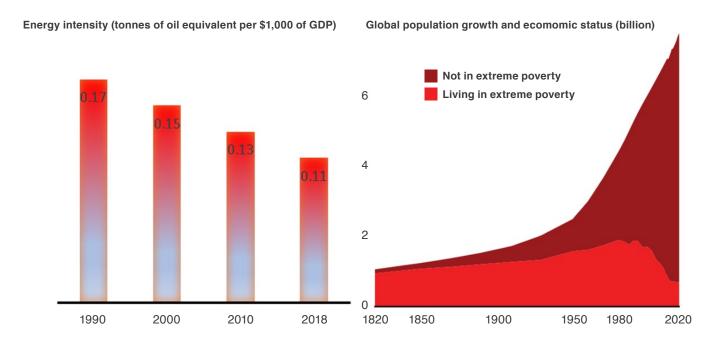
Introduction

Currently, approximately 100 million barrels of oil are consumed globally per day. The world population grew from 3.8 to 7.7 billion between 1972 and 2019. During this period, annual energy demand per capita also rose from 57 to 75.7 gigajoules (GJ) (BP 2020). This consumption pattern highlights the accelerating pursuit of mass energy 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 its carbon source.

Energy demand is increasing regardless of its 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's) recently released International Energy Outlook 2019 (EIA 2019) Reference Case expects global energy consumption to increase by nearly 50% from 2018 to 2050. It expects the bulk of this increase to originate from non-OECD countries, and to be driven by regions where strong economic growth is stimulating demand, particularly Asia. During this period, it expects the energy consumed in the buildings sector, encompassing residential and commercial buildings, to increase by 65%, from 91 quadrillion to about 139 quadrillion British thermal units (Btu). It expects 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 current global energy mix, with a share of 80%. 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% in the next two decades.

Aware of the role that energy efficiency could play in accelerating the energy transition and meeting global climate and sustainability goals, several countries have adopted energy efficiency plans as an effective strategy to reduce the energy demand in different sectors (e.g., buildings, 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 (IEA 2014).

Figure 1. Energy intensity and global population growth.



Sources: Authors using IEA data and Our World in Data.

Nowadays, energy efficiency investments seem to lag behind public policy objectives set by several countries. In the economic literature, this phenomenon is commonly referred to as the "energy efficiency gap" or "energy efficiency paradox." These terms describe 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; 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 commentary provides a comprehensive overview 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 commentary provides an integrated policy framework to accelerate and monitor the energy decarbonization process of the buildings sector. By so doing, this commentary will help facilitate 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 commentary proceeds as follows. The following section briefly introduces energy efficiency and discusses the unmet potential for energy savings in buildings. The next section reviews and comments on energy efficiency initiatives in Saudi Arabia. The last section concludes and offers some policy recommendations.

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Energy efficiency in buildings: Huge untapped potential

The building and construction sectors combined are accountable for more than one-third of the world's final energy consumption and for nearly 40% of total direct and indirect carbon dioxide (CO₂) emissions (IEA 2021). Further, buildings use 25% of the world's water and 40% of the world's resources. This demand continues to grow, due principally to improved energy access in developing countries, increased ownership and use of energy-using devices, and the fast growth in building sizes worldwide (Belaïd and Rault 2021).

According to a recent study by the International Energy Agency (IEA), direct and indirect emissions from electricity and commercial heat used in buildings reached 10 gigatonnes of CO₂ (GtCO₂) in 2019, the highest level ever recorded (IEA 2020). This represents about 28% of total global energy-related CO₂ emissions. If emissions from the building and construction sectors are included, this share reaches 38% of global energy-related greenhouse gas (GHG) emissions.

This increase was driven by multiple factors, including growing energy demand for heating and cooling, increased air conditioner (AC) ownership, and recent extreme climatic events (IEA 2021a). The recent BP Energy Outlook (BP 2020) states that 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 6,008 terrawatthours (TWh) of electricity, with consistent growth over the last three decades (IEA 2021b). This growth is driven by different factors, but mainly the increase in the global population and, hence, demand for housing, rising living standards, and, arguably, global warming. From 2010 to 2019, for instance, residential energy consumption increased by more than 5%, adding more upward pressure on emissions, which grew by about 4% during this period. This residential energy consumption growth does not account for the building and construction sectors (UNEP 2020). This remarkable growth in energy consumption was 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 IEA estimates that the number of air conditioning units will increase from 1.93 to 5.58 billion units between 2020 and 2050 (Statista 2020).

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Nevertheless, buildings also have a tremendous potential to deliver cost-effective GHG emission reductions in both developed and developing countries. In addition, buildings' energy consumption can be lowered by 30%-80% using commercially available, mature technologies. It is generally agreed that enhancing energy efficiency in buildings will contribute to achieving the United Nations Sustainable Development Goals (Figure 2) and generate economic, environmental, and social benefits, among other advantages.

Arguably the most obvious potential benefits of energy efficiency investments are environmental, i.e., reducing carbon emissions, improving environmental quality, and mitigating the effects of climate change. But energy efficiency can also improve welfare, reduce inequality, and stimulate economic diversification.

The economic benefits of energy efficiency investment are less obvious but prevalent. They include energy cost savings, job creation, and increasing property values. With more emphasis on energy efficiency measures, between 280 billion euros and 410 billion euros in energy costs could be saved in the EU, equivalent to nearly twice the annual electricity consumption of the United States (European Commission 2015). Energy efficiency investment could create an average of 1.1 million net additional jobs by 2050.

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 healthier home environments, people will pay less for medical expenses, miss fewer days of work, and be more productive when they are at work. This would increase well-being while encouraging economic growth.

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Figure 2. Contribution of buildings' decarbonization to the U.N. Sustainable Development Goals.



Source: Authors, adapted from the World Green Building Council.

Pressing agendas, including climate change mitigation, boosting the energy transition, and strengthening energy security, have put the residential sectors in many countries under the spotlight due to their substantial potential for energy savings (Lévy and Belaïd 2019). This potential 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 buildings sector appear to be lagging behind the public policy goals set by several countries (Bakaloglou and Belaïd 2022).

The impact of energy efficiency is much broader than saving energy and money, as it embodies productivity-enhancing technologies and innovation

Building decarbonization initiatives globally are on a clear upward trajectory. However, they must accelerate in both scale and pace to meet the climate and sustainability goals of the Paris Agreement. These efforts are reflected, for example, in the World Green Building Council's Net Zero Carbon Buildings Commitment. It represents a global action network comprising around 70 green building councils committed to transforming the building and construction sectors to achieve the goal of net-zero buildings operations by 2050. A second example of a global decarbonization initiative is the science-based target initiative for business, a joint partnership between CDP, the UN Global Compact, the World Resources Institute and the World Wide Fund for Nature. 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 European Union (EU) has emphasized its aim of 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 2021a). Both initiatives confirm the important role of the buildings sector in achieving the EU's energy efficiency target, as it accounts for about 40% of the EU's final energy consumption. The EU's Energy Union Strategy (COM/2015/080), published on 25 February 2015, is designed to build a unified energy system that provides EU consumers - both businesses and households - with reliable, sustainable, competitive and affordable energy (EU Commission 2021). According to the European Commission, the first priority in establishing the Energy Union is 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) reinforcing the modernization of the entire existing dwelling stock by implementing smart technologies with a close link to clean mobility.

In 2012, Saudi Arabia launched the Saudi Energy Efficiency Program (SEEP), a national awareness campaign to increase community awareness of the importance of energy rationalization and energy efficiency. The design of this campaign was based on scientific studies undertaken in association with local and international awareness-raising experiences, and studies of previous awareness-raising campaigns conducted around the world. Implementing a large-scale energy efficiency program on the Saudi buildings stock was estimated to reduce energy consumption by 100 TWh/ year and shrink peak demand by 25 gigawatts (GW). In addition, enforcing a more rigorous energy efficiency code in Saudi residential buildings could save up to 1.7 TWh/year and dampen peak demand by 468 megawatts (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).

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% of local energy consumption. In 2010, Saudi Arabia established the Saudi Energy Efficiency Center (SEEC). It has a sizable mandate to enhance energy efficiency in Saudi production and consumption to prevent depleting national resources and enhance economic and social welfare. Since its establishment, SEEC started SEEP, described above. SEEC has been able to make a giant energy efficiency leap in residential buildings during the last decade through three main initiatives: energy labeling and energy ratings, public awareness campaigns, and updating minimum energy performance standards (MEPS).

In conjunction with the Saudi Standards, Metrology, and Quality Organization (SASO), SEEC has been regularly developing and updating the energy ratings system of different residential appliances. As in some other countries, this energy ratings system evaluates and ranks the energy efficiency of residential electric appliances, and estimates their annual electricity consumption under normal usage. This ratings system has been updated frequently as technology and, hence, efficiency improves. In 2010, the Saudi government made this labeling system mandatory for all electrical appliances. As a result, all imported and locally manufactured electrical appliances need to be rated and labeled before being allowed to enter the Saudi market. In addition, the SEEC's Testing, Inspection, and Certification (TIC) team monitors various products in the market, in collaboration with the concerned stakeholders (the Ministry of Commerce, the Ministry of Industry and Mineral Resources. Saudi Customs, and the Saudi Standards Organization [SASO]). This is to ensure all electrical products comply with the mandated standards and regulations covering refrigerators, ACs, water heaters, washing machines, lighting products, thermal insulation materials, electric motors, cars, and tires.

Since its establishment, the SEEC believes that one of the main factors in reducing energy consumption is changing consumer behavior. In the last few years, it has been investing heavily in public awareness campaigns via different channels, including local television, social media, and billboards, among others. These public campaigns mainly target the behavioral aspects of demand and detail how consumers reduced their electricity consumption by changing their habits and choices when investing in new electrical equipment. For instance, prior to the summer months, when demand for cooling starts to increase, the SEEC encourages people to set their cooling setpoint temperature at 24 degrees Celsius, which significantly reduces their electricity bills. Encouraging consumers to buy efficient residential equipment is another common year-long public awareness campaign.

One of the most critical elements in enhancing energy efficiency, especially with fast improvements in technology, is the regular revision of the MEPS. In other words, electrical equipment in the market, including

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refrigerators and freezers, washing machines and dryers, water heaters, air conditioners, and lighting products either imported or locally manufactured, should continually meet the MEPS. This practice ensures energy efficiency in the residential sector improves and cheap products that stimulate wasteful use of resources are eliminated. The evolution of the MEPS thus reflects the development of the technology, and hence energy efficiency, in electrical appliances. One appliance that has been witnessing recurrent MEPS updates is the AC unit. At the beginning of 2012, the minimum EER of small AC units in Saudi Arabia was 7.5. This included split and window units, which are the most common AC units in the country. In 2013, the minimum EERs of window and split AC units were increased from 7.5 to 8.5 and 9.5, respectively. Three years later, in 2015, the minimum EER for split ACs was increased to 11.5 and between 8.5-9.8 for window AC units. The last MEPS revision took place in 2018, with a minimum EER of 11.8 for split ACs and 9-9.8 for window ACs. Recently, SEEC developed the Seasonal Energy Efficiency Ratio (SEER) standard, which will be enforced in 2022. To ensure an even more efficient cooling process in buildings, in 2019 Saudi Arabia created the requirement for a stringent thermal envelope insulation for new buildings, including residential, commercial, and government, in order to be connected to the electricity grid. Although other residential appliances do not consume as much electricity as ACs do, their MEPS have been regularly updated. For example, the MEPSs of refrigerators, freezers, washing machines, dryers, and lighting, were revised and enforced in 2015 and 2016 to ensure they were efficient. One of the most critical initiatives introduced by the SEEC is the High-Efficient AC (HEAC) program. It aims to motivate end users to purchase high-efficiency split ACs (>13.0 EER) by means of a SAR 900 (240 US\$) incentive applied as an instant discount upon purchase.

These commitments are expected to continuously dampen the energy demand growth that the electricity market has seen in the last few decades. A recent study that 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 total electricity demand reversed (Aldubyan and Gasim 2021).

Discussion and policy recommendations

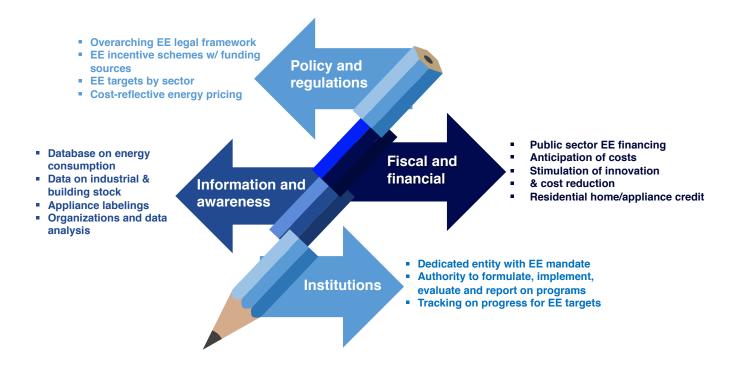
This commentary emphasizes the important role that energy efficiency in buildings can play in framing sustainability goals and the so-called 'welfare economic model.' It also discusses the massive unexploited energy savings potential of the buildings sector in the context of the energy efficiency paradox. The analysis supports the idea that the buildings sector has a substantial unrealized energy savings potential. Further, scaling up energy efficiency in the buildings sector (for new and existing buildings) will generate multiple benefits for the environment, economy and society. Compared with other major emitting sectors, buildings offer considerable GHG emissions reduction potential. In parallel, decarbonizing the sector brings many economic benefits, including reducing energy bills, increasing the competitiveness of industries and services, and easing pressures on national budgets. Finally, beyond the environmental and economic advantages, it has been shown that an efficient buildings sector

has substantial social impacts, including improved well-being and health. The analysis also documents the Saudi energy efficiency journey and its considerable efforts to improve energy efficiency, mainly in the buildings sector.

This commentary does not evaluate a particular energy efficiency policy. Nonetheless, it raises questions about the importance of accelerating the decarbonization process in the buildings sector and suggests ways to consider a holistic view of energy efficiency policies in the sector. An effective energy efficiency program in the buildings sector should be integrated and holistic to consider the complexity of the process and the 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 integrated instruments to ensure a substantial transformation in energy efficiency. These instruments include (1) regulatory frameworks; (2) fiscal and financial schemes; (3) information and awareness campaigns; and (4) institutional reforms.

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Figure 3. Framework for a holistic and successful energy efficiency program in the buildings sector.



Source: Authors.



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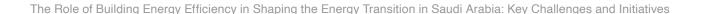
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About the Project

This study is part of the Modeling Residential Energy Demand and Energy Efficiency in Saudi Arabia project, which aims to accurately model the country's entire residential building stock. The project's key goals are (i) to better understand the current status of the Kingdom's housing sector in terms of its energy consumption, and (ii) to assess the potential of different energy efficiency programs and demand-response management to reduce electricity demand from both households and the government. More broadly, the project aims to help KAPSARC conduct technical, economic, and environmental assessments of residential demand-side management options, and, in turn, to support policymakers seeking to design impactful energy strategies for Saudi Arabia's housing sector.

About KAPSARC

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