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King Abdullah Petroleum Studies and Research Center

The Future of Cooling in Saudi Arabia:
Technology, Market and Policy Options

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

This publication is also available in Arabic.

Legal Notice

Key Points

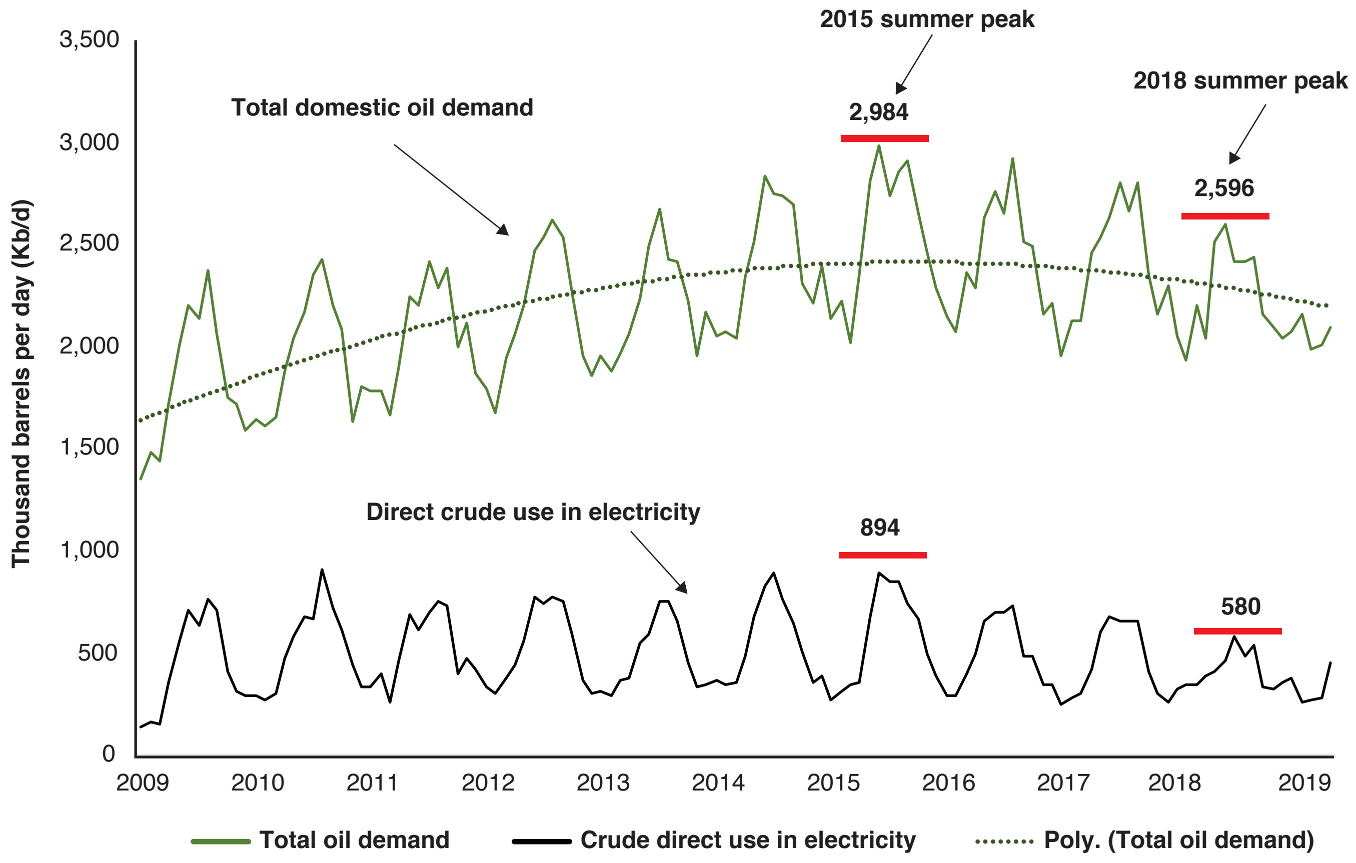
This workshop, held on May 1, 2019, brought together over 40 academics and industry experts to discuss the importance of cooling for energy consumption trends in Saudi Arabia and the potential for the Kingdom to transform its global cooling sustainability efforts during its G20 presidency in 2020.

Saudi Arabia is located in a global warming hotspot. Over the last 40 years, the temperature in Riyadh and many other cities has increased by more than 3 degrees Celsius (°C).

While the country remains the third-largest consumer of electricity for air conditioning (AC) in the world after the United States and China, it is no longer burning as much oil to keep cool thanks to domestic energy reform and stronger AC energy efficiency standards.

AC accounts for more than 50% of total annual electricity consumption in buildings and for around 70% at peak cooling demand. This is the highest use of AC in the world, with 101 terawatthours (TWh) used by households and 70 TWh by businesses in 2018.

Figure 1. Domestic consumption of oil products in Saudi Arabia (2009-2019).



Source: KAPSARC, based on data from the Joint Organisations Data Initiative (JODI).

Key Points

District cooling and phasing out obsolete technology, such as window units, can achieve major reductions in electricity consumption and carbon dioxide emissions. For example, fully implementing the Kingdom's high-efficiency AC incentive program for households could yield 35 TWh in annual electricity savings at a cost of 6 billion U.S. dollars to the government.

Innovative business models, such as selling cooling as a pay-per-use service, could substantially increase market efficiency and competition in both commercial and residential cooling sectors.

The 'living lab' concept, a user-centered research approach to understanding user behavior and generating new innovations, could help fill knowledge and data gaps for the energy market in Saudi Arabia and help facilitate a sustainable cooling transition at policy, market, and consumer levels.

A new G20 cooling initiative could help transform cooling markets by building on the 2019 G7 Pledge for Fast Action on Energy Efficiency Cooling and the 2016 Kigali Amendment to the Montreal Protocol to phase down hydrofluorocarbons (HFCs) in cooling technologies.

The emergence of COVID-19 in 2020 has also highlighted the need for AC systems to provide clean as well as cool air. Whether through increased use of fresh versus recirculated air or various filtration techniques, this is likely to increase energy use from cooling systems.

Summary

The world needs cooling. Air conditioning (AC) and refrigeration protects our health and productivity at home and work, and supports a host of critical services such as internet data centers, food delivery, and medicine. Around 1.6 billion AC units are in use globally, consuming over 2,000 terawatthours (TWh) of electricity every year, or about 2.5 times the total electricity use in Africa.

Such widespread usage of AC brings significant challenges. Rising demand for space cooling is putting enormous strains on electricity systems in many countries and is driving up emissions. Beyond increasing overall power consumption, greater reliance on AC also means higher spikes in demand during heat waves, which can exceed a system's generation and distribution capacities.

Furthermore, AC and refrigeration combined cause 7% of global carbon dioxide (CO2) emissions and use hydrofluorocarbons (HFCs), a greenhouse gas thousands of times more potent than CO2. HFCs have become the primary alternative to ozone-depleting chlorofluorocarbons, which are being phased out under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. If HFC use continues to rise, it could become responsible for nearly half of all global greenhouse gas emissions by 2050. Phasing out HFC usage, as called for by the Kigali Amendment to the Montreal Protocol, to which Saudi Arabia is a signatory, would not only help reduce greenhouse gas levels but would also open the possibility for energy efficiency gains with higher efficiency refrigerants.

According to Enerdata's Enerdemand Database, Saudi Arabia is the third-largest consumer of electricity for cooling after the United States and China, and accounts for 10% of the total electricity cooling demand from G20 countries (despite representing just 1% of the G20 population and 2% of its economy). Cooling sector reform must be approached in a holistic way that looks beyond mandatory energy efficiency performance requirements. To substantially increase cooling efficiency, Saudi Arabia faces challenges on three fronts. First, enhancing cooling technology to reduce electricity consumption and waste; second, making the power generation system more efficient and environmentally friendly; and third, achieving zero-emissions, temperature-controlled transport.

Some of the highest impact and most achievable gains can be made by policies that phase out obsolete cooling technologies. More efficient AC and refrigeration units offer benefits from a lifetime cost perspective but require higher upfront investment. Phasing out incandescent lighting in favor of more efficient alternatives is one example where phase outs were employed successfully to speed the transition to more efficient appliances. Policies that foster new business models that shift the market toward cooling as service, supported by novel financing, will be key to moving forward. Other solutions include strategies that integrate renewable energy and energy-efficient AC, technologies that capture wasted cold and heat, and upgrades to data connectivity and energy management systems that increase the efficiency of energy consumption and storage.

Background to the Workshop

Fueled by rapid urban development, rising incomes, and a growing population, energy consumption in buildings in Saudi Arabia has been rising at an average rate of around 6% per annum since 2010. Cooling accounts for around 70% of buildings electricity consumption and has been the main driver of this trend. At the same time, policymakers have committed to phasing out oil-based liquids from the electricity generation mix; in 2018 these still provide around 40% of electricity fuel inputs, and natural gas makes up the rest.

To meet these challenges, the Kingdom is implementing a domestic energy price reform program that aims to increase efficiency, reduce waste, and stimulate private sector investment in renewables and other sustainable technologies. Since 2016, two waves of reforms have led to electricity prices more than tripling for the majority of households. However, the authorities have also implemented a significant means-tested household payment support package, launched in January 2018, to mitigate the impact of higher electricity prices on lower-income families.

Given the importance of air conditioning (AC) to both the Kingdom's future development and possible energy consumption pathways, this workshop focused on technological options and behavioral economics related to cooling and thermal comfort.

The workshop comprised four sessions:

- The importance of cooling and electricity transitions in Saudi Arabia
- Future trends in air conditioning technologies
- Toward a 'living lab' for the behavioral analysis of energy consumption in Saudi Arabia
- Cooling as an energy service and business models moving behind the meter

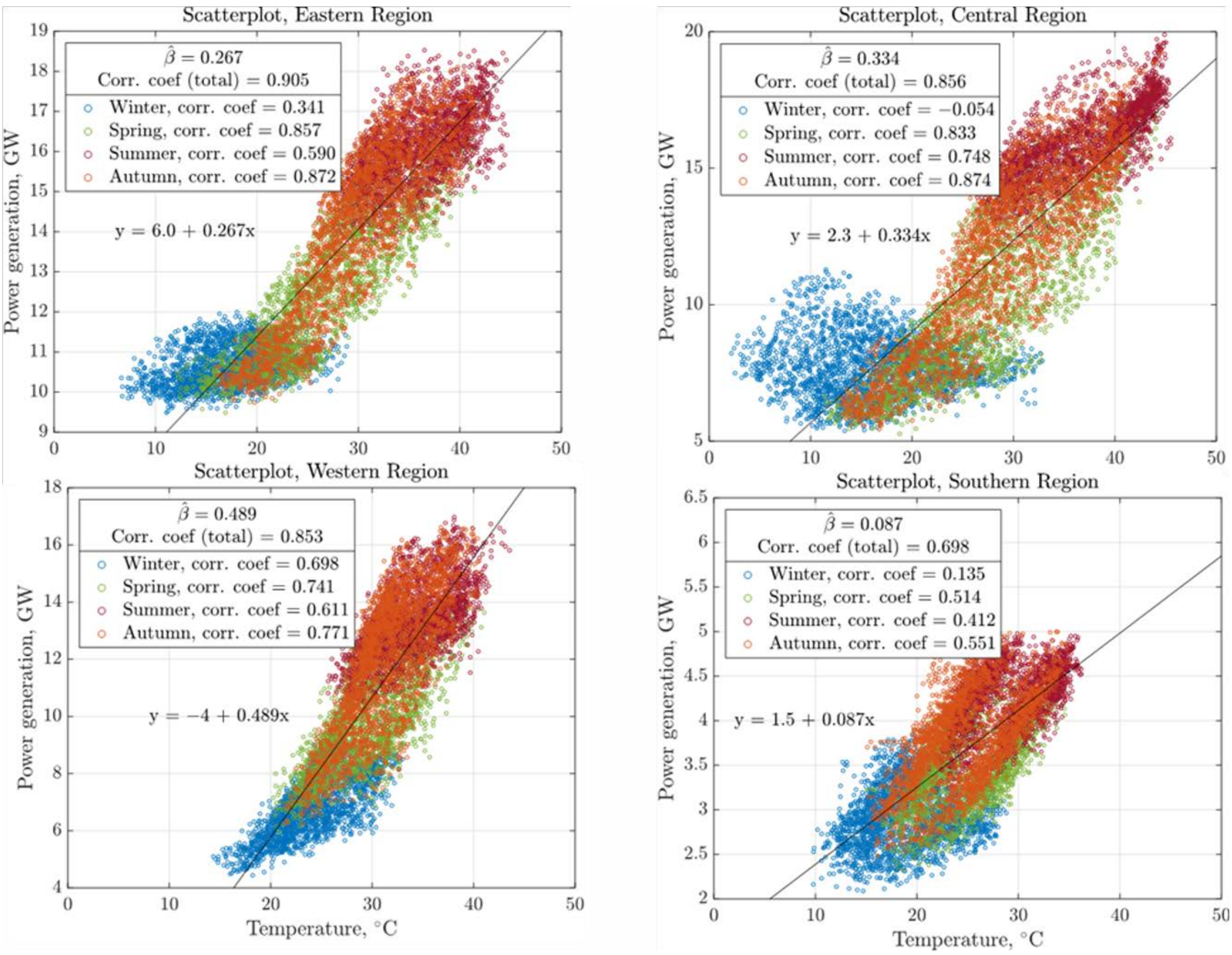
This workshop also helped to inform potential collaborative projects between KAPSARC and other institutions, with the aim of establishing a 'living lab' focusing on energy consumption and thermal comfort in Saudi Arabia, and the transition to more consumer-oriented models of energy markets for households.

The Importance of Cooling and Electricity Transitions in Saudi Arabia

From 2010 to 2015, AC electricity demand in Saudi Arabia increased by around 6% annually, contributing to surging electricity consumption. In 2011, Chatham House published a controversial report titled “Burning Oil to Keep Cool” that warned the Kingdom could become a net oil importer by 2040 and face “intractable” fiscal deficits by 2022 if it did not reduce its energy consumption.

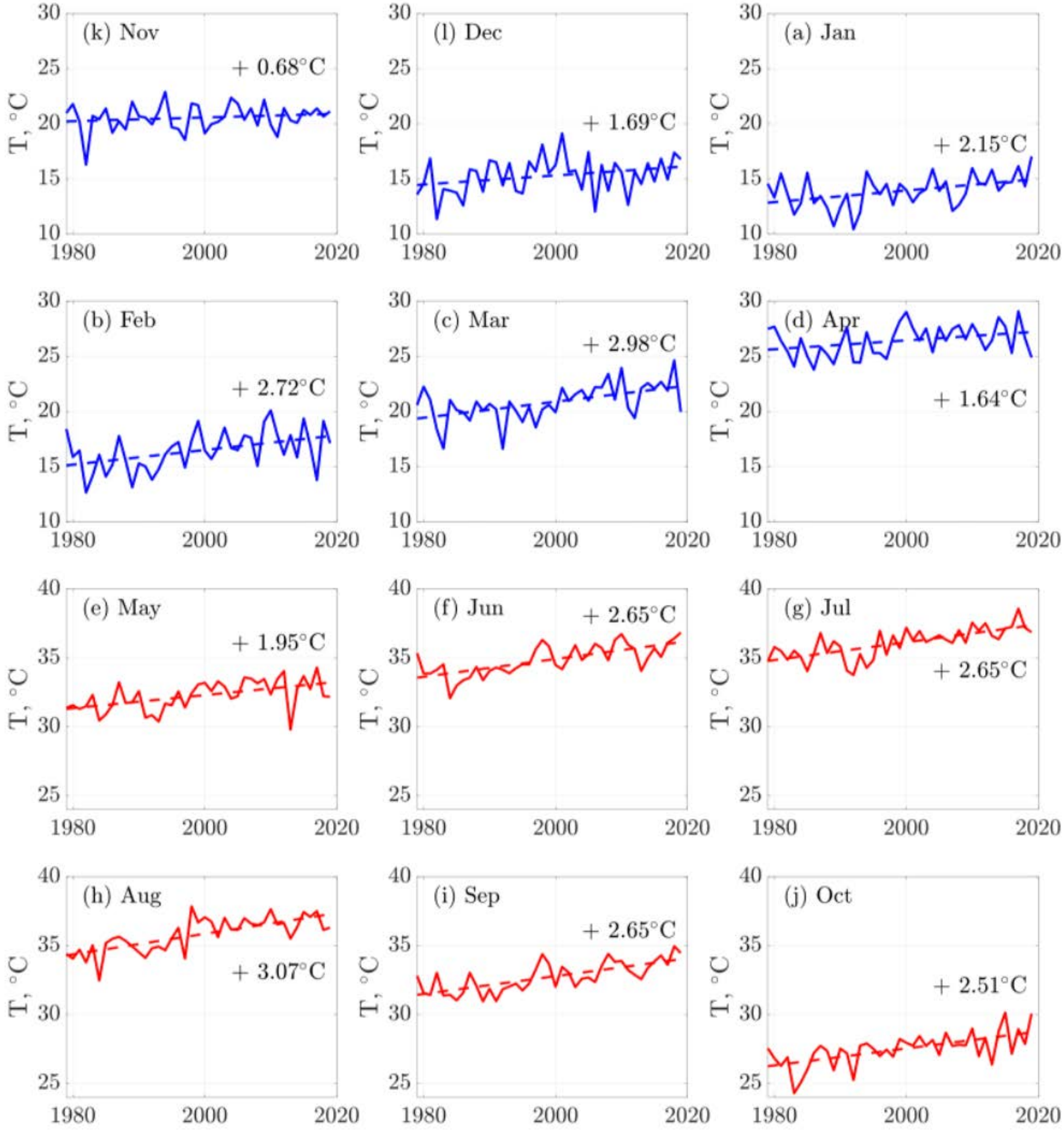
For example, in 2015 around 1.2 gigawatts (GW) of electricity were added for each 1 degree Celsius (°C) increase in temperature from winter to summer (Figure 2) (Howarth et al. 2020). As can be seen from Figure 1, around 1 million barrels per day of domestic oil consumption was added in 2015 to handle this increase in summer demand.

Figure 2. Power generation and temperature in Saudi Arabia (regions as defined by the Saudi Electricity Company).



Source: Howarth et al. (2020).

Figure 3. Monthly mean temperatures in Riyadh, 1979-2019, and linear regression trends.



Source: Howarth et al. (2020).

Cooling directly impacts the Kingdom's strategy to reduce the reliance of oil in its electricity generation mix and transition to less carbon-intensive gas and more renewable energy. More recently, the desire to reduce carbon dioxide (CO2) emissions from cooling was discussed in reference to Saudi Arabia's circular carbon economy strategy that forms part of its 2020 G20 presidency.

Three main factors drive residential AC use and its impact on electricity consumption: the area and number of rooms being cooled in each dwelling, the thermostat or temperature setting, and how long the AC is turned on for. Thus, cooling demand is a function of temperature, AC unit efficiency, and other factors such as the size and type of dwelling and user behavior, including subjective perceptions of comfort. Families in Saudi Arabia tend to live in relatively large villas with many AC units. Studies suggest that around 73% of people in the Kingdom use their air conditioners between 10 and 24 hours a day throughout the year, with most people leaving them on non-stop from May through to September to mitigate the hot summer conditions (Figure 3).

Future Trends in Air Conditioning Technologies

Consumer and policy decisions surrounding cooling technologies depend on the nature of a given market and its specific set of social, technological, and economic variables. These include supply-side issues related to energy supply and producer behavior, demand-side factors related to user behavior, and energy efficiency, all of which have a varying impact according to end-user characteristics and existing technology options. National and local AC systems also vary in terms of temperature and humidity conditions, housing and urban landscape considerations as well as differentiated technology standards and preferences.

Supply-side measures that involve the conventional power generation model, in which large utility firms provide end-users with electricity, benefit from having fewer stakeholders, more standardized solutions, higher investment, and lower transaction costs. On the demand side, stakeholders are heterogeneous, small and dispersed, with no 'one-size-fits-all' solution and high transaction costs for implementing measures. Space cooling involves residential, commercial, and public buildings, both on and off the grid, as well as the industrial process cooling, transportation, and refrigeration requirements of stationary and mobile 'cold chains' for food and medicine.

Future consumers, behavioral trends and government policies will affect cooling in several ways. Common AC unit types include room ACs, which can be window or split systems, central systems, and different types of chiller technology, including vapor absorption and compression, evaporative cooling, heat pumps, solar cooling, and liquid air, among others. District cooling offers vast potential to cool at scale, but it is difficult to coordinate outside highly planned and dense urban contexts. The thermal efficiency of building insulation, windows, and roofing also plays a major role in cooling decisions and may be determined by aesthetics or upfront costs rather than long-term energy consumption and efficiency.

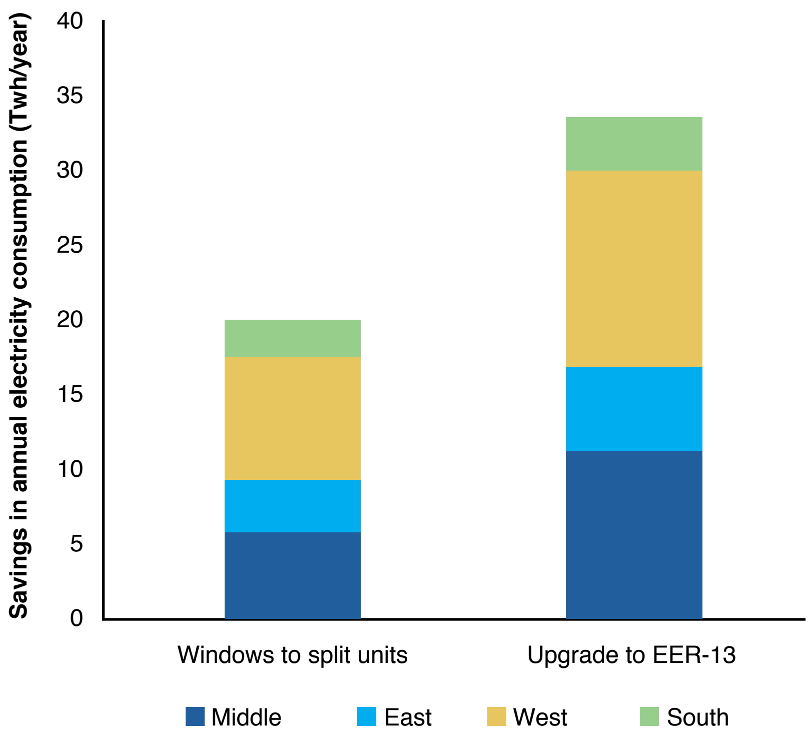
Going forward, more advanced controls, including 'smart' thermostats and building energy management systems, will become increasingly important to the sector. The choice of refrigerant in vapor compression systems will also continue to be a key area of technological and regulatory reform. The 1987 Montreal Protocol led to the replacement of ozone-damaging chlorofluorocarbons with HFCs, with the latter targeted for a phase-down through the Kigali Amendment.

While unit AC energy efficiency is covered by mandatory energy efficiency performance regulations in different jurisdictions, there is an urgent need to go further and introduce gradual bans of obsolete AC technologies. For example, according to the Japan Refrigeration and AC Industry Association, just 10 countries account for 86% of worldwide sales of window AC units, while the vast majority of global markets have already effectively banned or heavily restricted their use. These units may be relatively cheap and easy to install, but they are much less efficient than split systems.

Saudi Arabia is the second biggest market for window units in the world after the United States, with 772,000 units purchased in 2018. If the operated stocks and new purchases of window units were replaced with split systems that met the minimum Saudi Arabian Standards Organization (SASO) requirements, around 20 terrawatthours (TWh) of electricity could be saved per year. The Kingdom also currently operates a consumer incentive scheme, the High Efficiency AC (HEAC) initiative, which provides a 900 Saudi riyal (US$240) rebate for each high-efficiency split system unit (energy efficiency rating [EER]=13.8 or higher) purchased, up to a maximum of six units per household. If the HEAC initiative were fully implemented, the residential sector could save almost 35 TWh of electricity consumption each year. This saving represents 24% of the Kingdom's total residential electricity consumption in 2018 (144 TWh) or around 35% of its total residential AC electricity consumption (101 TWh). Under the above scenarios, SASO and HEAC would also reduce annual CO2 emissions by 14 million tonnes and 24 million tonnes, respectively.

While large benefits can be had by simply replacing older and obsolete units with up-to-date ones, several emerging technologies will further advance energy efficiency and transform future markets. These include sorption cooling, using an inert silica gel-water pair that can utilize process waste heat, and solar heat replacing electrically generated heat in cooling systems. The shift from traditional vapor compression (in which refrigerant vapor is compressed) to absorption (in which refrigerant is absorbed and heated) will also make systems more efficient and environmentally friendly. In addition, integrating renewable energy-powered cooling technologies can provide sustainable solutions at scale, especially when coupled with cool storage and district cooling systems. The Saudi Electricity Company and the King Abdullah City for Science and Technology are both conducting trials on such technologies, offering an exciting glimpse of the future.

Figure 4. Electricity savings from a phase-out of window units and full implementation of Saudi Arabia's High Efficiency AC consumer incentive scheme.



Source: Krarti and Howarth (forthcoming).

The King Abdullah University for Science and Technology (KAUST) launched a cooling initiative on April 1, 2019. It is expected to run to March 31, 2022, to address the phenomenon of stagnating kilowatt per refrigeration tonne (kW/Rtonne) of AC. The program addresses the inherent weaknesses of existing mechanical vapor compression (MVCs) in the treatment of outdoor air. It also identifies nine research packages (processes and new adsorbents for moisture removal) focused on disruptive cooling processes that could improve the energy efficiency of AC units. The initiative aims to reduce AC consumption of electricity (by 50%-60%) and water (by 25%-30%), and, in turn, significantly lower the Kingdom's domestic oil consumption.

A ‘Living Lab’ for the Behavioral Analysis of Energy Consumption in Saudi Arabia

In the future, traditional consumer and market research methods may become increasingly less effective. Popular methodologies often fail to forecast consumer adaptation to new technologies or predict the policy and regulatory implications of new market structures. This leads to unsuccessful commercial efforts with poor returns, despite substantial investment in product and service innovation.

An ‘energy living lab’ is a user-centered research approach, which can be utilized to:

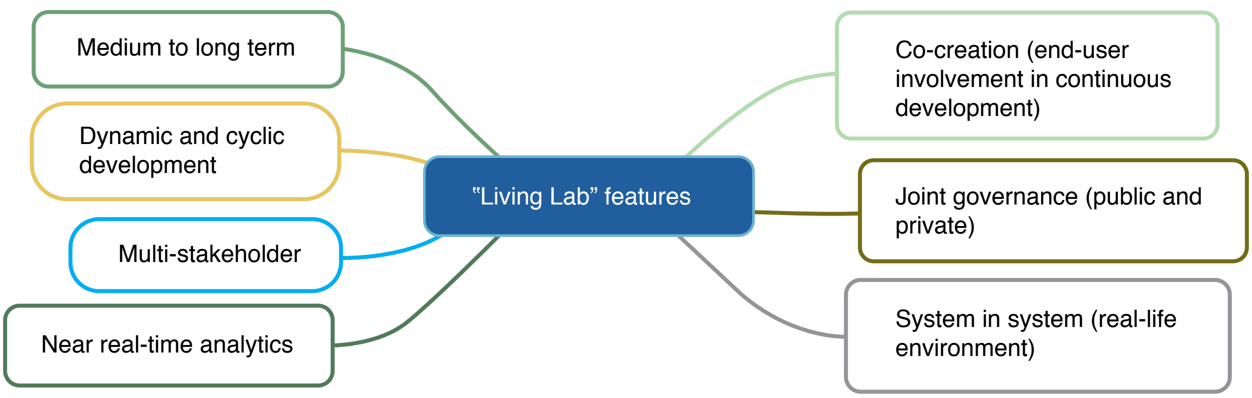
- extract distinctive consumption and environmental patterns;
- understand consumer behavior; and
- provide a framework to develop and/or test innovative energy products, services, and business models in transparent real-life scenarios.

The following key characteristics distinguish ‘living labs’ from pilot studies and other field tests (Lucassen et al. 2014):

Regardless of other features, the active involvement of end-users remains the most important characteristic that distinguishes living labs from other user-centric methods. Living labs focus on users, seeing them as key actors that continuously collaborate to achieve goals using certain technologies, rather than focusing on the technology itself.

The living lab methodology offers particular advantages for researching user behavior in residential buildings, which is subject to complex and subjective factors such as comfort, convenience and social restrictions that vary from one person and household to another. Unlike other indoor spaces, where cooling levels are generally optimized to achieve a specified level of comfort or function at minimum cost, energy consumption in residential buildings tends to vary according to the preferences of individual users.

Figure 5. Living lab characteristics.



Source: KAPSARC, based on (Lucassen et al. 2014).

The workshop showcased successful living lab projects conducted in other countries that focused on building efficiency and indoor environments. The Barbara Hardy Institute and the Low Energy Housing Development in Australia project demonstrated how near net-zero energy homes could be achieved with efficient thermal comfort by utilizing the living lab. Their research has provided building professionals and regulators with important evidence-based insights.

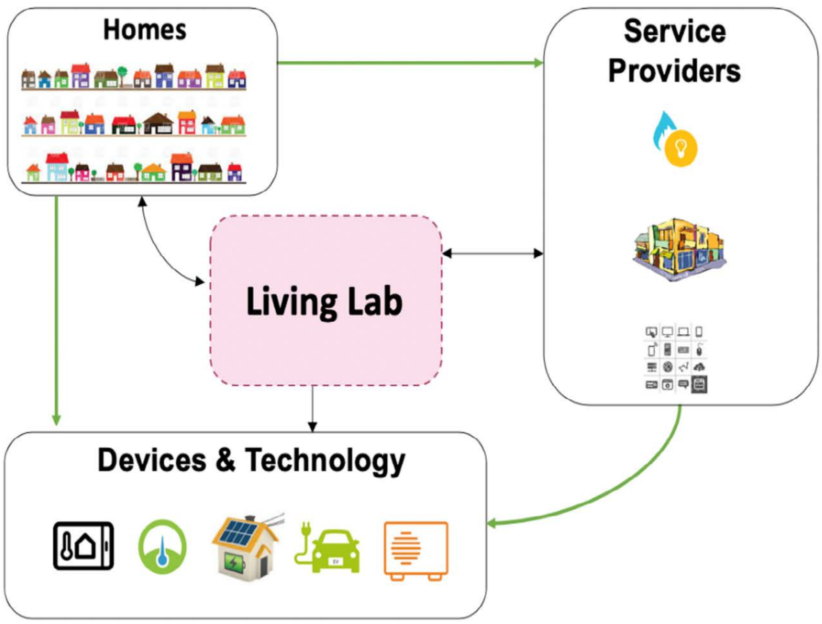
Broadly, the Energy Systems Catapult (ESC), showcased a state-of-the-art living lab with a whole system-view approach. The ESC’s living lab was used as a hub to bridge the gap between different stakeholders in the sector while placing the consumers at the center.

The workshop also explored the potential of applying the living lab approach to residential energy consumption and thermal comfort in Saudi Arabia, where electricity demand nearly doubles due to AC demand.

Saudi Arabian households have the world’s highest share of AC consumption from electricity demand at around 70% of total residential electricity consumption. According to the 2016 GAS demography report, more than 60% of those in Saudi households are under 20 years old. Understanding the behavior of younger AC users will be particularly valuable in guiding long-term policy over the coming decades.

Building energy efficiency options and technologies, such as more efficient AC units, can only provide part of the solution. Understanding consumption behavior and energy use in different environments would provide policymakers with the tools to design better policies and mitigate social risks.

Figure 6. The living lab approach to residential energy and thermal management.



Source: Energy Systems Catapult 2019.

Workshop participants concluded that establishing a living lab in each climatic zone in Saudi Arabia would expand the country’s knowledge base and the data available for its energy sector. It would also provide the basis for innovative studies on energy use in buildings. As the Kingdom transitions toward higher domestic energy prices and seeks to reduce the quantities of oil consumed in domestic power generation, a deeper understanding of end-user behavior can help guide policymaking, and private-sector research and development initiatives. This should, in turn, foster the development and adoption of more efficient cooling technologies.

Cooling as an Energy Service, as Business Models Move Behind the Meter

Cooling must, in large part, be viewed through the lens of the wider electricity sector. In Saudi Arabia, space cooling can represent more than 70% of peak residential electricity demand on extremely hot days, according to some estimates shared in the workshop. To date, electricity consumption has been a major contributor to the country's carbon emissions. However, new clean technologies can support the decarbonization of the electricity sector, without requiring customers to change their behavior. Workshop participants noted that refrigeration and air conditioning cause 10% of global CO2 emissions, three times more than aviation and shipping combined (Teverson et al. 2015).

At the same time, the electricity sector itself is navigating major disruptions, driven by the emergence of distributed energy systems that combine distributed generation technologies, such as solar photovoltaic generation, energy storage, and digitalization. Together, these three technologies can allow customers to, at least in part, bypass the grid and traditional utility companies. This raises the questions of exactly what the product or service is that the power sector ultimately produces for end-users, how it should be priced, and what will emerge as the dominant business models going forward.

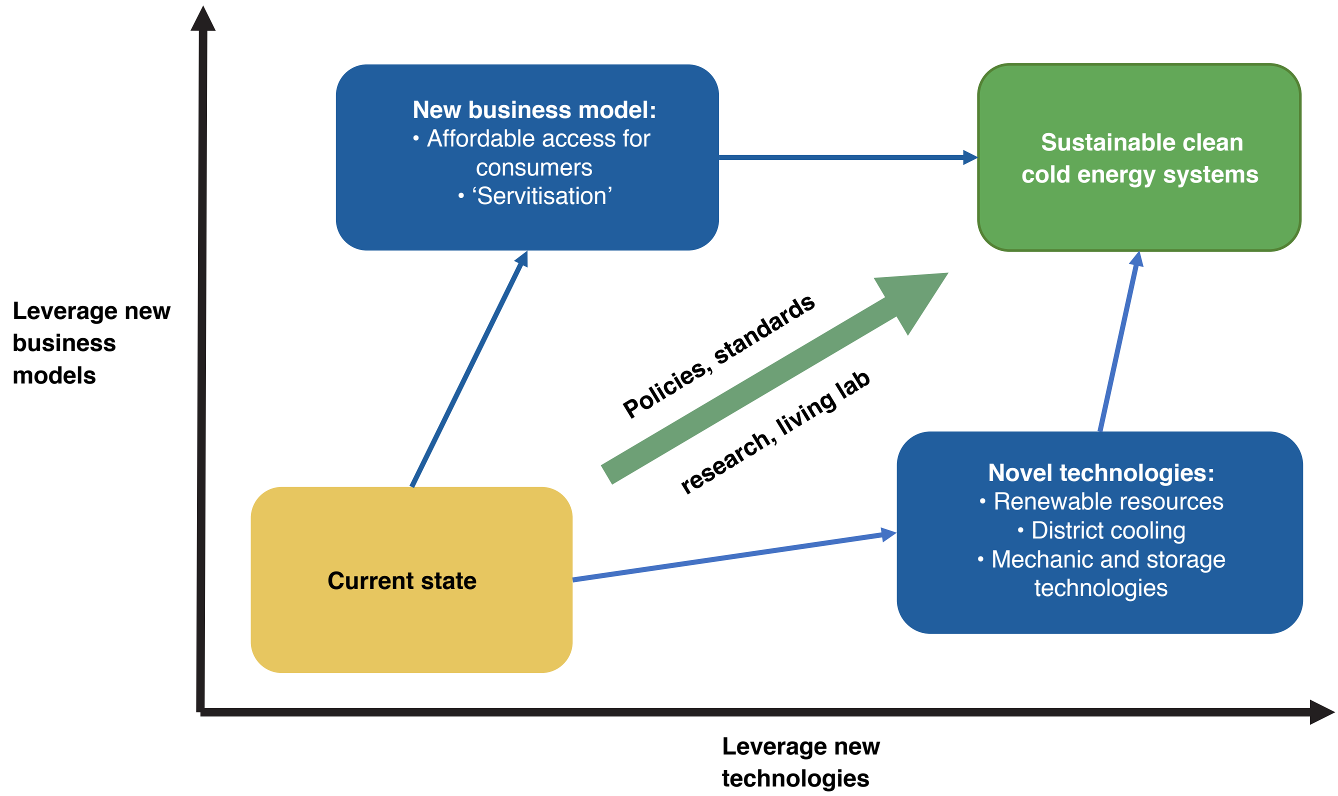
Decoupling the demand for electricity and cooling is a central challenge for policymakers, especially as the electricity sector as a whole transitions to low- and zero-emissions generation. While technological improvements that bring greater efficiency can, in theory, solve the problem, market solutions can also greatly advance policy and environmental goals, even if technologies remain static. Workshop participants discussed whether cooling can be provided as a service by third parties and how this could address the difficulties facing the cooling sector. This provision would require policies that consider how technology intersects with economics, especially end-user behavior. Technology can help to more efficiently make, store, move, and utilize cold and cooling loads. Innovative economic frameworks can guide policies and, in turn, producer and consumer behavior, to reduce electricity consumption and achieve other desired policy outcomes.

The literature and industry research discuss how market participants could trade electricity (and cooling) as a service. For example, the Rocky Mountain Institute has explored the possibility of providing 'lumens' as a service; KAPSARC has developed the idea of a reliability insurance business model for an electricity sector dominated by distributed energy resources, and ESC has taken steps to create a market for 'heating-as-a service' in the United Kingdom. The German technology firm Siemens has been working on how digitalization can help to design products that enable better solutions for cooling. Figure 7, below, shows a schematic of alternative ways to view the cooling sector.

New business models could take a service-based approach to providing end-users with the benefit or experience they seek. For example, a specialized firm can sell cooling on a pay-per-use or subscription basis as an alternative to the traditional model of consumers procuring AC units from retailers and buying the electricity necessary to run it from a utility separately. Under a cooling-as-a-service model, consumers can more freely choose how much they utilize cooling and how much they spend. This also encourages producers to use more energy-efficient, and therefore cost-saving, equipment.

One potential obstacle discussed by workshop participants is that households tend to view AC

Figure 7. Transition path to a sustainable and clean cold energy system.



Source: KAPSARC, based on Teversen et al. (2015).

units as durable assets. For instance, a family that purchased AC units 10 years ago may still consider it a relatively new purchase and unnecessary to replace, when in reality technology may have greatly advanced and new models could offer substantial energy efficiency gains. Under the traditional model, which requires consumers to invest in AC units and other items, frequently replacing functioning equipment with the latest technology is impractical and expensive. However, a firm specializing in cooling-as-a-service can continuously phase in newer, more efficient technology.

The economic rationale for the service-based approach is that households have a specific demand for cooling, regardless of how the market provides it. Simply put, there must be a price for a given demand, and therefore a potential market must exist. If a cooling service were offered that, for instance, guarantees a specific area is cooled to a given temperature for a specific set of hours per day, households would, at least hypothetically, respond rationally and determine an optimal cost-benefit for the amount of cooling they purchase.

To implement this framework into a business model, smaller-scale experimentation would be useful before testing in the open market. ESC Catapult discussed in the workshop the use that they have given to their living lab, how they have been able to identify different groups of consumers, what bundle of services these consumers value, and the price the consumers would be willing to pay for them.

About the Workshop

KAPSARC convened this workshop, The Future of Cooling in Saudi Arabia: Technology, Market and Policy Options, on May 1, 2019, to highlight the importance of cooling to Saudi Arabia and the region in light of the impacts of a warming climate and economic growth. It also explored technological and behavioral economics options that could help to achieve sustainable, efficient cooling and thermal comfort.

List of participants

H.E. Saleh H. Al-Awaji - Ministry of Energy, Industry and Mineral Resources (MEIM)

Professor Kim Choon Ng - Director, King Abdullah University of Science and Technology (KAUST)

Dr. Ana Margarida Costa - Head of Sustainability, King Abdullah University of Science and Technology (KAUST)

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Professor Wasim Saman - University of South Australia

Mr. Benoit Lebot - Head of Secretariat, International Partnership for Energy Efficiency Cooperation

Dr. Ashok Sarkar - Senior Energy Specialist and Task Team Lead for Energy Efficiency, World Bank

Dr. Saeed Al Shahrani - Director of Research and Studies Department, Saudi Standards, Metrology and Quality Organization (SASO)

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Princess Noura Al-Saud - Founding Partner, Aeon Strategy

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Dr. Saeed Al Noman - Research and Development Engineer, Saudi Electricity Company (SEC)

Dr. Mazhar Bari - Head of MindSphere Application Centre, Siemens

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Ms. Natalia Odnoletkova - Researcher, King Abdullah University of Science and Technology (KAUST)

Professor Alan Meier - Senior Scientist, Lawrence Berkeley National Laboratory

Dr. Wesam Al Sabban - Vice Dean, Umm Al Qura University (UQU)

Mr. Michel Farah - Director, Daikin Middle East & Africa

Mr. Sachin Nehete - Senior Product Manager, Rheem Manufacturing MEA FZE

Mr. Mohammed Khawaldah - Director of Product Units, Zamil Air Conditioners

Mr. Fahad Al Shahrani - Design Manager, The Red Sea Development Company

Dr. Mohammad Alghoul - Research Engineer, KFUPM

Mr. Charles Phillips - OIES and Institute of Oriental Studies, Oxford University

Mr. Quentin Blommaert - Beuth University of Applied Science

Mr. Adam Sieminski - President, KAPSARC

Mr. Thamir Al Shehri - Research Associate, KAPSARC (workshop coordinator)

Dr. Nicholas Howarth - Research Fellow, KAPSARC

Dr. Rolando Fuentes - Research Fellow, KAPSARC

Mr. Nawaz Peerbocus - Program Director, KAPSARC

Dr. Andrea Bollino - Visiting Researcher, KAPSARC

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Notes

About the Team

Thamir Al Shehri

Thamir Al Shehri is a research associate in the Energy Transitions and Electric Power program, currently focused on creating data-driven tools to identify and evaluate different energy market scenarios, as well as using 'big data' technologies to better understand the impact of consumer behavior and the built environment on energy consumption. Thamir is interested in using technologies to facilitate better public energy policy and energy economics systems. He previously worked as a lecturer in Australia. He also has entrepreneurial and industrial experience of working on award-winning projects such as the Burj Khalifah Building Management System.

Dr. Nicholas Howarth

Dr. Nicholas Howarth is a research fellow at KAPSARC and an applied economist specializing in energy, technological change and climate change. He obtained his D.Phil. in economic geography and an M.Sc. in environmental change and management from the University of Oxford. He also has a Bachelor of Economics with honors from the University of Adelaide, South Australia.

Natalia Odnoletkova

Natalia Odnoletkova is a researcher at the Ali Al-Naimi Petroleum Engineering Research Center, focusing on sustainable energy and development. Her current research focuses on temperature change, electricity consumption and air conditioning in Saudi Arabia. This builds on her work on sustainable cities as part of Duke University's Smart Home Energy Program. She has a master's degree in sustainable energy engineering and a bachelor's degree in petroleum engineering from the Gubkin Russian State University of Oil and Gas, Moscow.

Dr. Rolando Fuentes

Dr. Rolando Fuentes is a visiting fellow at KAPSARC, where he researches business and regulatory models in the Innovation in Electricity Transitions program. He has extensive experience in the energy and environmental sectors as an academic and policymaker. Rolando holds a B.A. (Hons.) from Tec de Monterrey, an M.Sc. from University College London and a Ph.D. from the London School of Economics. He was awarded a United Kingdom government Chevening Scholarship in 2001.

Nawaz Peerbocus

Nawaz Peerbocus is the program director for Energy Transitions and Electric Power. Before joining KAPSARC, he was chief economist at the Saudi Electricity Company (SEC), where he led the strategic transformation project and advised on strategic planning issues. Prior to the SEC, Nawaz was director of market strategy at Enbala and a senior economist at the Ontario Independent Electricity System Operator.

Tadeusz Patzek

Tadeusz Patzek is the director of the Ali I. Al-Naimi Petroleum Engineering Research Center and professor of petroleum and chemical engineering at the King Abdullah University of Science and Technology (KAUST) Saudi Arabia. Until December 2014, he was the Lois K. and Richard D. Folger Leadership Professor and chairman of the Petroleum and Geosystems Engineering Department at The University of Texas at Austin. He also held the Cockrell Family Regents Chair #11. Between 1990 and 2008, he was a professor of geoengineering at the University of California, Berkeley. He has co-authored some 300 papers and reports, and has written five books, one of which is currently submitted for publication.

About the Project

KAPSARC held this workshop, The Future of Cooling in Saudi Arabia: Technology, Market and Policy Options, as part of its Innovations in Electricity Markets project. Rapid technological innovations in low-carbon, demand-response and storage technologies can lead to a more efficient and secure electricity system. However, achieving the full potential of these innovations requires new approaches to policy, regulation and business models. If regulatory reforms, market design, and systems do not keep pace with technological deployment, the outcome could be a less secure electricity market and a longer low-carbon transition period. To successfully manage the sector’s transformation, policymakers must balance the need for innovation and competition while enabling capital deployment for low-carbon sources of electricity. A market design appropriate for the energy transition must provide efficient price signals and enable a flexible and adequate competitive supply. New technologies will allow consumers to participate more directly in the market in response to wholesale price signals, which will help create a more flexible and less costly electricity system. This could improve the balancing of electricity generation with energy services and storage, increasing the system’s ability to integrate variable renewable energy output and improve the security of the electricity supply. Regulating distribution networks should, in principle, enable distributed energy resources to participate in local and wholesale markets. There are presently no clear solutions to these challenges.

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