

Integrated Approaches to Decentralized Electricity Transitions

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.

Legal Notice

© Copyright 2019 King Abdullah Petroleum Studies and Research Center (KAPSARC). No portion of this document may be reproduced or utilized without the proper attribution to KAPSARC.

Key Points

Electricity sector reform is a key part of the Kingdom of Saudi Arabia's economic transformation agenda, as set out in the Saudi Vision 2030 goals, and of achieving its renewable energy targets. The electricity distribution sector in the Kingdom is expected to evolve, with implications for the ongoing affordability, reliability and sustainability of electricity services in the country. Lessons for the Saudi distribution sector can be drawn from international experience, including opportunities and challenges, to better inform policymakers and regulators in the Kingdom about possible evolutionary pathways for the industry. This workshop produced the following key insights:

Transformational technologies are fundamentally changing the electricity distribution sector. This transition is testing the limits of existing market, business and regulatory models, and pushing governments and industry to innovate in these areas.

A key challenge is the rapid adoption of distributed energy resources (DERs) in many parts of the world, which have disrupted the traditional utility business model. They have also prompted a variety of regulatory responses aimed at addressing the relentless trend in revenue losses and network operators' consequent inability to recover their network costs.

New pricing models and tariffs are being proposed and tested in order to be able to reflect true network costs, with the aim of sending the correct signals to network users and informing network investment decisions.

New business models are beginning to emerge around differentiated products and services that offer enhanced reliability, convenience and flexibility, to better address consumer needs and preferences. Early customer trials of innovative services are already providing valuable insights into the viability of the 'energy-as-a-service' concept.

Testbeds for trialing new business models and electricity sector offerings can offer a reliable and safe way to help stakeholders in the Kingdom better understand the implications of current trends in the electricity industry. The findings can then help inform the development of a new regulatory framework to support the sector's transformation.

Summary

Electricity sector reform in Saudi Arabia is ongoing and is expected to include policies that will encourage digitalization of the network and the deployment of distributed renewable generation. There is considerable interest among Saudi policy practitioners, regulators and utilities in gaining a full understanding of the key legal, regulatory, commercial and market issues that arise from such a transformational change. The first phase of this evolutionary process, which is underway, is the unbundling of the Kingdom's generation, transmission and distribution sectors. It is expected that the next phase will address the distribution and retail sectors, which will be key areas of focus for policymakers and regulators over the next few years. This workshop was convened to explore the challenges and opportunities affecting electricity distribution networks in the context of increasingly dynamic power systems and rapid technological changes.

International experience shows that business model innovations in distribution, retail and services are reshaping how electricity is purchased and consumed. This transformation is driven by the digitalization of networks, the rapid take-up of distributed energy resources (DERs), and the increasing involvement of end users and customers in the management of their energy use. Innovation is a central theme in this transformation, not only in technologies – smart grids, smart meters, batteries,

and DERs – but also in business models which facilitate the creation of new products and services and bring new types of players into the electricity sector. These new developments are all relevant to the future evolution of the Saudi Electricity Company, to the Electricity & Co-Generation Regulatory Authority and to future Saudi utilities, as the country embarks on an ambitious electricity sector reform.

Utilities and electricity regulators could explore new market structures and business models to take advantage of new technologies and adapt to the changing needs and preferences of the Saudi consumer. Traditional distribution utilities might wish to change from a model based on security of supply to a model of offering flexible services, in order to meet the different needs and preferences of customers both large and small. Services such as enhanced flexibility will also be important for distribution utilities, to help manage network operations flexibly and efficiently. As many developed countries have witnessed, renewable and distributed technologies have substantially increased the volatility of supply, stressing network operations and leading to curtailment of renewable generation. The role of regulation will be central to the sector's future. Regulation should facilitate the development of a market structure that ensures fair competition, cost-reflective prices and innovation in products and services.

Background to the Workshop

KAPSARC convened the workshop Decentralized Electricity Transitions in October 2018, in Brussels. The workshop comprised four sessions that discussed the impact of technological disruptions and service-based business models on the power distribution sector. The sessions addressed the evolution of distribution businesses in the power sector, new developments in network pricing, and the emergence of service-oriented business models based on the value of electricity attributes such as flexibility and reliability. This workshop built on three previous workshops: New Business and Regulatory Models for the Utilities of the Future (March 2016), Future of the Electricity System in GCC Countries (December 2016) and Technological Disruptions and Service-Based Business Models in the Power Sector (May 2017).

Participants also considered lessons from international experiences and their implications for future reforms. These new developments create an opportunity for the Saudi Electricity Company, potential Saudi utilities, and the Electricity & Co-Generation Regulatory Authority, to better understand current trends and develop new regulatory frameworks that will facilitate the emergence of new business models and allow a smooth transition to a new power sector aligned with Vision 2030 priorities.

The workshop included contributions from international research institutes, innovative electricity companies, leading universities and experts in electricity regulation.

The Evolving Role of Distribution Utilities: Value Adding or Platform for Services?

Following the initial international wave of power industry liberalization in the 1990s, the sector has undergone fundamental changes in many parts of the world over the past decade, driven by the increasing penetration of distributed energy resources (DERs) and the digitalization of the electricity system. These changes are fundamentally disrupting the traditional vertically integrated and centralized utility business model, based on the economic concepts of natural monopoly and economies of scale. In the new paradigm, electricity is increasingly produced, traded and consumed in a decentralized way and by a multitude of players, eroding conventional revenue streams upon which utilities have traditionally relied to cover their costs and to fund future investments. These changes have led many utilities to the brink of bankruptcy.

Many countries have been grappling with the central question of ‘How can the utility be re-invented so it remains viable and relevant in the new regime?’. Over the past decade or so, two broad approaches have gradually emerged in an attempt to create market structures that will allow utilities to continue to play a key part in the electricity value chain. The first is exemplified in North America by the New York Commission and its plan, Reforming the Energy Vision (REV). Here the utility becomes a distributed system platform, the main responsibility of which is to ensure system reliability and provide functions that allow equal access to consumers, third-party market players and aggregators, and enable them to develop products and services addressing customer needs and preferences. In this approach, the utility centers on the purely ‘natural monopoly’ part of the

value chain, allowing it to focus on its key strength of providing efficient and reliable distribution network services to electricity service providers. The second approach, followed by the European Union (EU), aims to transform utilities into value-adding entities, working alongside and competing with third-party service providers. This approach requires utilities to radically transform the way they do business and to develop new products and services to address customer needs.

Both of these approaches involve addressing policy and regulatory challenges. The platform-for-service approach addressed later in this paper requires a complete rethink of the regulatory framework around the compensation for, and pricing of, network services. The value-adding approach raises important questions about market power and anti-competitive behavior, as incumbent utilities have an advantage over new market entrants. Participants in the workshop observed that there are parallels between the power sector currently and the challenges faced by the telecommunications industry’s liberalization and unbundling of its value chain in the 1990s. There are no absolute solutions to the regulatory challenges facing the power sector, but policymakers and regulators might wish to consider the impact of the two approaches outlined above, and the emergence of technological and business model innovations. Lessons can be learned from the telecommunications industry, in order to avoid the mistakes of not clearly separating monopoly and competitive functions, and the drift toward market concentration over time through mergers and acquisitions.

Network Pricing in the New Regime: What Are the Options?

The evolution of distributed electricity networks is at the core of the energy transition and, as stated earlier, is driven by two major trends: increasing DERs penetration, and the digitalization of the electricity system. As a result, the role and responsibilities of distribution utilities are changing, forcing a rethink of their traditional business model. A key part of this process is the development of a new economic regulatory framework that will allow distribution utilities to adequately recover their fixed costs and fund their future investments. Consequently, tariff design and the development of network charging methodologies that reflect true costs are crucial to this process. Network tariff design should aim at:

- Adequate cost recovery: Network charges should reflect the network operator's true costs.

- Sending appropriate signals to the system operator to facilitate efficient network operation and investment, and to the network users to optimize dispatch and consumption, and minimize network costs in the short- and long-term.

- Being acceptable and equitable: Network users should be treated in a non-discriminatory way to avoid unfair charging and cross-subsidies between customers.

- Meeting policy objectives and being simple enough for efficient implementation.

To be efficient, mechanisms for good tariff design should in some way reflect both time and place variations in network costs, driven by peak time loads and location-dependent network congestion. Marginal cost pricing, in general, addresses all of these principles and allows appropriate pricing

signals to be sent to network users. However, marginal cost pricing is difficult to implement in practice due to uneven and sporadic network investments. In particular, the question of whether to use short-term or long-term marginal costs is not straightforward.

To overcome the difficulties of marginal cost pricing, a number of methodologies have been proposed, with relative advantages and disadvantages. Novel pricing methodologies discussed in the workshop included cost allocation mechanisms based on:

- Price elasticities (Ramsey-Boiteux), the most economically efficient approach, but complex to implement.

- Game theory, the most equitable approach, but complex and not very economically efficient.

- Reference network models, which offer a true reflection of network costs, but are not very economically efficient and do not consider customer responsiveness to price signals.

- Ad-hoc pricing models, which are simple to implement but do not specifically consider the pricing principles above.

- Insurance based models (proposed by KAPSARC), which focus on the value of reliability of supply and fully consider customer responsiveness to price signals, but require detailed information on individual 'prosumer' characteristics and risk profiles, as well as data over complete tariff cycles.

Practical experiences with new network pricing mechanisms vary substantially between countries and regions. In Europe, for example, there is an

Network Pricing in the New regime: What Are the Options?

increasing trend towards a non-linear tariff structure, where the fixed charge component, the network connection charge, takes up a bigger, though varied, proportion of the overall charge. The Netherlands is the only country in Europe to have chosen an entirely fixed charge tariff. Spain and Italy have implemented a structure with a dominant fixed charge component, which Austria is also considering, while the United Kingdom (U.K.), France and Germany have tariff structures that are still dominated by energy or

usage-based components. Countries everywhere are still trying to establish what the correct share of the fixed charge component should be. Energy regulators need to stay abreast of current research into charging methodologies and approaches and also to follow the various early experiences globally. They also need to understand the increasing role of digitalization and big data applications to develop effective pricing methodologies that meet basic economic principles and are easy to implement.

Rethinking Energy as a Consumer Service

Compared with other network economies such as telecommunications, the electricity industry has traditionally been the least innovative and the most risk-averse. Over several decades, the industry has been built – understandably – around the need for stability and reliable supply, with no real incentive to innovate and take risks. The recent changes in the electricity landscape are forcing the industry to embrace innovation in all parts of the value chain and, importantly, in business models and services. The role of policy and regulation is crucial to fostering innovation in the sector.

The need for innovation was triggered by the growing trend toward self-generation of power through technologies such as solar rooftop photovoltaics (PV), the digitalization of electricity systems and changing consumer aspirations. These factors are causing the traditional energy system to expand into new territories. Customers worldwide are starting to realize that electricity has monetary and non-monetary values, which vary by place and time.

Electricity as a commodity is becoming an invisible component of consumers' lifestyle. Consumers do not fully understand the value of a kilowatthour of electricity, but they do place a value on what electricity allows them to have or to use, such as thermal comfort, reliability or personal mobility (electric vehicles, for example). As customers have heterogeneous needs and preferences, they will value energy attributes differently. Such attributes include security of supply, autonomy, local generation and environmental benefits. This creates an opportunity for new business models to

emerge that explicitly incorporate these attributes into customizable service offerings, and develop tangible ways to monetize their intrinsic values.

An innovation mindset in the energy sector could emerge from viewing electricity as a commodity that underpins a market for private goods (i.e., energy services based on electricity attributes), rather than as a good provided by utilities through a universal service obligation. The active participation of customers and a deeper understanding of how people interact with and respond to energy services could be important instigators of this transition.

In the U.K., for example, the Living Lab operated by Catapult has 100 real-world homes that subscribe to innovative services provided by utilities and third parties, supported by smart meter technology and data analytics. The aim is to test a range of customizable energy services in real life, such as heat packages. Through analyzing usage and customer response, service providers can propose novel services, fine-tune service offerings, estimate price points and design tariffs.

Experiments like this provide pathways for energy sector innovators to test and demonstrate new ideas for energy services and business models, and to develop associated business cases for investors. The role and engagement of policymakers and regulators are integral to this process; innovative energy services could be aligned with policy objectives, such as decarbonization goals, while behavioral insights could be valuable in helping to adapt and shape regulatory frameworks.

Decentralization and Customer Empowerment: Lessons From the EU

The EU's Clean Energy Package focuses on regulations and directives covering electricity market design, regulation and efficiency. However, it suffers from a lack of focus on retail pricing. The current focus is on customer empowerment, looking at ways to engage customers more fully – for example, clearer and more detailed energy bills that provide information and feedback to customers on their consumption and its impact on the environment. Another area of focus is creating a level playing field for all market players and service providers through certified comparison tools, providing information on providers and prices, and making it easier for customers to switch between providers. The new directive also focuses on creating favorable investment conditions for digital demand-side management services and applications that enable customer empowerment.

While clean energy policies have generally been successful in promoting non-fossil fuel generation and reducing the carbon footprint of the industry, retail electricity prices have increased steadily in the majority of EU countries. This is because the retail price structure in most countries is not aligned with costs. In addition, taxes and levies dealing with clean energy policies are not related to energy supply. This phenomenon has hampered progress in the electrification program – especially in transportation – and created major distortions in resource allocation, investments and customer behavior. As discussed earlier, developing new charging methodologies and retail tariffs to deal with these issues is one of the most urgent requirements for industry and regulators.

Another key focus for the EU is the use of digital technologies to enable new flexibility services to be developed, both for customers and distribution utilities. As renewable and distributed energy resources and technologies become commonplace, flexibility services become critical. Smart meters are already enabling consumers to take a more active role in managing their power consumption, while digitalization is at the center of developing added value energy services, as discussed in the previous section. For utilities, and in particular distribution system operators (DSOs), however, digital technologies are critical in developing flexibility services to help them manage their networks and operations more efficiently in the emerging distributed generation paradigm. Digitally-enabled flexibility services will allow DSOs to manage network congestion in real time and reduce the negative impact of curtailment arising from the unpredictable nature of renewable power generation. Other potential benefits of flexibility services for DSOs include managing supply and demand more flexibly to flatten the load curve, and to increase the reliability of supply through dynamic system optimization. Flexibility requires the cooperation of utilities, transmission system operators, DSOs and end users. An urgent requirement for EU regulators is the development of a suitable framework that helps all stakeholders to access, pay for and use flexibility services to optimize the electricity system in an economically efficient manner, and which avoids undue distortion to markets and competition.



Renewable Energy Policy: Lessons From the Japanese Experience

The Japanese experience presents useful lessons for countries in the early stages of DERs adoption, driven by renewable energy policies and incentives such as feed-in tariffs (FITs), that need to prepare for the phasing out of these subsidy programs. Japan's renewable energy policy is driven by three main factors: decarbonization of the electricity sector by 2050, reducing dependence on nuclear power, and increasing the resilience of the electricity system against natural risks such as earthquakes. As part of its objective to achieve 100% renewable generation, known as the RE100 plan, Japan introduced net metering and FIT programs for rooftop solar PV in 2009 and 2012 respectively, followed by auctions for utility-scale PV and biomass in 2018. The first net metering contracts will expire in 2019, while the first FIT contracts will expire in

2032. The anticipated impact of contract expirations is causing FIT surcharges to increase yearly. The government is responding by moving the focus of its renewable strategy to large-scale PV and biomass over the next decade. A major challenge for DERs in Japan is that renewable energy intermittency brings considerable stress to the network during blackouts resulting from natural disasters such as earthquakes. Japan has to tackle the economic challenges of DERs, such as designing appropriate retail tariffs, and their impact on network resilience and stability. Japan believes batteries and hydrogen-based technologies have an important role to play in solving the country's renewable energy challenges. Countries about to embark on a DER strategy need to be aware of the kinds of challenges and potential risks that may emerge in the medium to long term.

Electricity Sector Transition in the MENA Region

While almost all countries in the Middle East and North Africa (MENA) region have a history of state-owned, vertically integrated electricity sector monopolies, most have embarked on a journey of power sector reform that targets liberalization, deregulation and ambitious renewable objectives. MENA countries are currently at different stages of power sector reform. Electricity system unbundling typically starts by separating generation and transmission, then distribution and retail. Some countries have established market structures implementing the first stage of the reform: unbundling generation and wholesale supply and establishing a single buyer model where the electricity company still controls the remaining parts of the value chain. In Saudi Arabia, the Saudi Electricity Company (SEC) has plans to unbundle its generation business from its transmission and distribution business. In an effort to comply with renewable energy objectives and decarbonization goals, such as the ones set out in Saudi Vision 2030, many MENA countries have

embarked on investment programs, mainly through international tenders and auctions and building large-scale renewable, mainly solar, power plants.

Reforming distribution and retail in the MENA region will be the next step in the process, but this faces substantial challenges. The need to phase out regulated energy prices to create a viable competitive retail market, in particular highly subsidized electricity tariffs, represent one of the main obstacles. Another related obstacle is the revenue deficits that many of the MENA region utilities sustain, severely limiting their ability to finance ambitious transformational projects. Introducing competition and involving both the private sector and customers in electricity distribution and retail are keys to achieving successful reforms. Regulation that facilitates the development of a market structure ensuring fair competition, cost-reflective prices and innovation in products and services will be central to this transformation.

Implications for Saudi Arabia's Electricity Sector Transition

As the incumbent utility in Saudi Arabia, the SEC will play a critical role in the transition towards a new national electricity distribution model. The topics covered in this workshop have strong implications for the utility and for the future of energy systems in the country. In particular, there are potential areas of particular relevance to key stakeholders in Saudi Arabia.

The current business model could benefit from evolving. In line with trends in developed countries, the SEC could develop innovative value-adding services while ensuring reliability of supply. As in ongoing efforts in Europe and elsewhere, the SEC might wish to benefit from an in-depth understanding of the value its customers place on electricity, and to identify their preferences and the attributes most important to them. This knowledge could help establish new and workable business models and develop business cases for innovative services that meet customer needs and market demand.

Collaboration with customers and 'prosumers' will help meet market challenges. By working closely with customers, especially those that become both producers and consumers (prosumers), the SEC will be ready for the changes that DERs will impose on the distribution network. This includes dealing with two-way power flows and maintaining acceptable

levels of network reliability and operational efficiency. Collaboration with customers through living lab experiments and testbeds could help the SEC foster an innovation mind-set and engage with different stakeholders, including customers. That would help the SEC develop business models that could help it to design products and services to capture and monetize customer needs and preferences and offset any revenue lost from an increase in DER adoption.

An adequate and flexible regulatory framework will help utilities manage change most effectively. The electricity generation sector might want to consider additional factors when liberalizing distribution and retail, such as the tension between achieving competition and ensuring security of supply in distribution networks. Economic regulation of natural monopoly distribution businesses could help protect security of supply and investment in the network, ensuring its stability. However, a new regulatory framework could help foster an innovative mind-set for the creation of new business models and services, and promote fair competition between incumbents and new entrants. If this were to happen, the present regulatory framework would need to evolve. Regulators might wish to find innovative ways to tackle issues related to information asymmetries, public goods, monopoly power and environmental externalities.

About the Workshop

KAPSARC held the workshop, Integrated Approaches to Decentralized Electricity Transitions on October 4, 2018, in Brussels, as part of its workshop series, Utilities of the Future. The workshop was held under a modified version of the Chatham House Rule, under which participants consented to be listed below. However, none of the content in this briefing is attributable to any individual attendee.

List of participants

Iqbal Adjali – Senior Research Fellow, KAPSARC

Asper Bing – CEO, M-PAYG

Jorge Blazquez – Head of Electricity Market Analysis, BP

Andrea Bollino – Professor, University of Perugia

John Bower – Energy Specialist

Elizabeth Carey – Senior Research Associate, KAPSARC

Sebastien Dolige – Manager Markets and Customers, Euroelectric

Amro Farid – Associate Professor, Dartmouth College

Rolando Fuentes – Research Fellow, KAPSARC

Scott Hempling, Attorney – Scott Hempling Attorney at Law LCC

Yu Nagatomi – Senior Researcher, Institute of Energy Economics Japan (IEEJ)

Philip New – CEO, Catapult Energy Systems

Nawaz Peerbocus – Program Director, KAPSARC

Fabien Roques – Senior Vice President, Compass Lexecon

Anupama Sen – Senior Research Fellow, Oxford Institute for Energy Studies (OIES)

Abhijit Sengupta – Senior Lecturer in Business Economics, University of Essex

Enrique Sira – CEO, Upside Value Group

Matthew Wittenstein – Senior Energy Analyst, International Energy Agency (IEA)

Frank Wouters – Director, EU-GCC Clean Energy Network

About the Team



Iqbal Adjali

Iqbal was a senior KAPSARC research fellow specializing in energy systems modeling, with a focus on electricity sector transitions. He holds a Ph.D. from Oxford University and an MBA from Cranfield University.



Rolando Fuentes

Rolando Fuentes is a research fellow working on new business and regulation models for the Utilities of the Future project. He holds a Ph.D. from the London School of Economics.

About the Project

KAPSARC's Electricity Sector Transition initiative examines the challenges and opportunities of technological innovations in the electricity sector and their impact on policy choices and business models. Like many other countries, Saudi Arabia is undertaking a major electricity sector liberalization which will shape its socioeconomic development and crucially affect the government's wider economic diversification strategy. The Electricity Sector Transition initiative seeks to draw from international experience and discussions to provide practical guidance to policy practitioners and other key stakeholders as they grapple with related policy and implementation challenges.



مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

www.kapsarc.org