Technological Disruptions and Service-Based Business Models in the Power Sector

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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.

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Key Points

Electricity markets around the world are facing significant challenges from the demand and supply side of the industry. From the supply side, distributed energy resources, usually owned by third parties, are forcing utilities to re-evaluate their business models; while developments in information and communication technologies, such as smart metering and blockchains, are enabling new opportunities for both existing and new players on the demand side.

This confluence of factors is driving a transition from the notion of electricity as a traded commodity to an ingredient of an ecosystem that offers a wide range of flexible services – related to electricity consumption or production – that consumers want and are willing to pay. Three broad themes underline this shift in the electricity value proposition:

> Future business models in the power markets will probably not be centered solely on electricity. Consumers may not be interested in products that only save electricity, but rather on products that deliver new services that have the collateral benefit of saving electricity.

> Some of these services would be at the intersection between energy, finance and internet access. This would require new forms of regulation, developed in tandem with market offerings rather than constrained by functional silos.

> In many cases, the utility will behave as the incubator of new businesses by acting as the operator of last resort. Regulators could allow this to grow, by turning a 'strategic regulatory blind eye', until rents captured by newcomers constrain further societal benefits.

Summary for Policymakers

The power sector, in many countries, is undergoing major changes largely driven by technological developments that are affecting both electricity supply and demand. Entrepreneurs are seeking to turn the traditional top down supply model, which flows from generation through transmission and distribution to retail, on its head by embracing the emergence of distributed energy resources (DERs), allowing households to produce, consume, store and trade power.

A fundamental shift is taking place from the notion of electricity as a traded commodity to becoming a component in a range of value-added and flexible services that are currently dormant in consumer demand. Distributed ledger technologies, such as blockchain, have opened the distribution and retail sectors to diverse innovators and startup companies, which are developing services and applications that bring together producers, consumers and third-party service providers. Some of these new businesses are at the intersection of energy, finance and internet. If this approach takes off, it would probably require new forms of regulation that reflect the integrated business proposition rather than falling between functional silos that are the responsibilities of banking, communications and utility regulators.

Innovation in distributed energy technologies allows end users to produce their own power locally and also sell any surplus. Although DERs are usually not owned by utilities, most new businesses ultimately rely on the safety net provided by the utility as the electricity provider of last resort. Utilities must therefore manage their business models at the retail end to keep up with the changes brought about by distributed generation and demand.

However, societal benefits could be jeopardized if new business models endanger the financial viability of the utility, or if the new business models become a dominant platform that prevent the incubation of fresh ventures. The regulatory framework must therefore adapt to the new environment; regulations will need to be formulated in parallel with markets, by allowing innovators and newcomers to fill the gaps as well as develop services enabled by technological progress.

Technology also introduces new risks that may not have been imagined when regulatory systems were designed. Establishing industry wide standards that deal with these new risks will be crucial in helping build trust and confidence in the new electricity systems as they grow.

Background to the Workshop

KAPSARC convened workshops over two days on the utilities of the future in May 2017, in London. These sessions addressed technological disruptions and service-based business models in the power sector. They build on two previous sessions: New Business and Regulatory Models for the Utilities of the Future (March 2016) and Future of the Electricity System in GCC Countries (December 2016).

Participants discussed the future of the electricity sector by taking a closer look at the role that technological disruptions are playing in reshaping the industry, particularly at the distribution and retail end of the value chain. Specifically, these workshops explored the impact of technologies such as distributed ledgers (e.g., blockchain) on electricity markets that remove some of the economies of scale in reducing transaction costs. Lowering the transactional barriers places pressure on the current business models of traditional utilities in the face of emerging business models spearheaded by new players and startup companies.

The workshops included contributions from both traditional utilities as well as startup companies offering all sorts of new services to existing electricity customers. Key questions discussed include: How is technology, particularly information and communications technology (ICT) and blockchain technologies, helping in the shift toward a decentralized generation and demand model of electricity provision? What type of products and services are driving the emergence of a wide range of third-party companies in the electricity retail sector? What market design is needed to support the evolution toward the new electricity-based services consumers are willing to buy? What regulatory models are needed to enable the necessary innovation in electricity market redesign?

The Business Models' Evolution

Potential high penetration of DERs could have far reaching implications for the electricity system. The way electricity is consumed, produced and traded could in the future be decentralized as opposed to centralized, which is the case currently. As a result, consumers may rely less on the utility and the grid as they or their neighbors produce a growing share of their electricity consumption.

Advances in energy technologies, such as solar photovoltaic (PV) panels and batteries as well as progress in ICT allow individuals to have more control over their own load and consumption. Such technologies permit new entrants, to some extent, to overcome constraints previously imposed by the need for 'economies of scale.' This opens the sector to smaller players who can offer more granular options to consumers, many of whom are not aware that they could be offered products other than conventional utility services.

If these predictions turn out to be accurate, the question that arises is whether the system needs to be reorganized to operate in a decentralized fashion or can the existing system survive with marginal amendments. The most likely answer seems to be that both centralized and decentralized systems will coexist, and that this would be similar to having an operating system (utility/grid) with different applications (new business models) that interact among themselves, and with the operating system.

The natural selection of business models

A key insight is that future business models in the power sector probably won't be centered on the delivery of electricity. Once access is guaranteed and becomes the norm, the marginal provision of electricity offers little value. Electrons are not very valuable because they have to be consumed when they are produced, so to speak, and often times this does not coincide with when they are needed.

Customers will not 'buy' energy efficiency – It will be the collateral benefit of a product or service that they value independently

Since the actual provision of power is taken for granted, a business value proposition cannot be based on that alone. Other industries have experienced a similar process of differentiation of their core product; for example, the telecoms industry experienced this when metered calls were the bedrock of their business model but technological advances, such as Skype, WhatsApp and FaceTime, made it irrelevant to price calls by the minute. A business model whose value proposition is the provision of power at a low cost may not be enough for consumers when they have other options. Therefore, the notion of it being a simple traded commodity could change to electricity as a component within an offering of a wide range of value-added and flexible services (enabled by electricity) that consumers want and for which they are willing to pay. Consumers want options, but not the obligation, to have increased control over their suppliers and usage of energy resources, especially when these are twinned with other beneficial aspects of their consumption. For instance, people would probably not buy products to save electricity per se, but they would buy products that deliver new services that have the collateral benefit of saving electricity.

This shift in the electricity value proposition raises three key challenges:

Some of the new services lie at the intersection between energy, finance and internet access. This would require new forms of regulation, developed in conjunction with the integrated business offerings rather than choosing the most appropriate functional silo and then expecting a utility regulator to be able to handle financial and communications regulatory tasks.

Businesses that fail to focus on simplifying the consumer experience may overwhelm themselves with new time consuming tasks. Simplicity seems to be an essential precondition for success.

Increasing options for consumers may appear to be at odds with keeping coordination costs in check. New technologies, such as blockchain, are in a race to lock-in their solutions and become the standards for future trade. Developing information technology (IT) infrastructure to handle these new technologies can help reduce transaction costs by enabling solutions that are scalable but without significant establishment costs that would require defraying through economies of scale.

In this context, energy firms that would thrive are those that can develop software solutions, data analytics platforms and applications that provide consumers with more choice over their suppliers or that increase their control over usage without substantially increasing transactional overheads, either in time or costs.

Centralized vs. decentralized system

The current energy distribution and transmission system is highly centralized and optimized for moving power generated at the core to end-users on the periphery. Increasingly, however, new energy resources coming online are decentralized and have unpredictable intermittency. These structural trends imply that future energy systems will need to be responsive, resilient and adaptive. Centralized control of such decentralized, reactive systems is currently neither technologically nor economically viable. It seems likely that both centralized and decentralized systems will coexist, and that this would be similar to having an operating system (utility/grid) with different applications (new business models) that interact among themselves, and with the operating system.

In the new environment, policies are needed to cope with the growing share of DERs, while at the same time allowing innovators and newcomers to fill the gaps and develop consumer services enabled by these technological developments. In order to maximize value creation a decentralized software infrastructure layer will need to be built; it would be based around distributed ledger technologies using open technology that is tightly integrated with the existing energy sector operating system. Such a shared, open software for the energy sector would have a number of benefits:

Allow entrepreneurs to innovate by extending the functionality of the core energy sector operating system by developing new consumer-oriented software platforms and applications. This would be similar to how software entrepreneurs built innovative applications that relied on the open-source Linux operating system.

Support the development of a vibrant ecosystem of end-users, application developers and infrastructure providers.

Provide a set of open standards that would improve the ability of regulators to develop new regulations that are better suited to a reactive or decentralized energy system.

Arbitraging the Regulatory Ecosystem

For many new business ideas, the utility will effectively act as an incubator (either voluntarily or involuntarily). Many of them will ultimately rely on the utilities' infrastructure to provide their services and expect them to act as the operator of last resort. It seems the utility will frequently consent to this, at the margin, because third-party services will allow utilities to defer or even do away with investments in new infrastructure, which otherwise they would have to undertake. It appears that regulators will, in the early stages, also allow new entrants to incubate their business model using the utility's infrastructure. For example, many regional or national regulators subsidize or explicitly encourage incumbent utilities to sub-contract investment in additional infrastructure to new entrants. Subsidies might take the form of tax breaks or perhaps relaxation of certain regulatory requirements.

Facilitating this transition may sometimes require a 'strategic regulatory blind eye'

Adopting this 'strategic regulatory blind eye' can only continue until rents from newcomers constrain further societal benefits. To use a biological evolution analogy, often times there is a symbiotic relationship between incumbent utilities and new entrants. The symbiotic relationship could be mutualistic (i.e., beneficial to both new entrants and incumbents) or commensalistic (beneficial to either new entrants or incumbents); regulators would decide against turning a 'regulatory blind eye' if the relationship becomes parasitic and new entrants start to endanger the host. Further societal benefits could not materialize if new business models endanger the financial viability of their host, the utility, or if the new business models become dominant platforms that can't incubate new ventures themselves.

There are a number of externalities that justifiy regulatory intervention:

> **Public goods.** The infrastructure that hosts certain new business models is a public good (shared good) and needs to be refinanced over time; but by trading locally, customers don't contribute to sunk costs. Historically, regulators have been prepared to step in to ensure the financial viability of future infrastructure investments.

> **Information asymmetry.** Regulators find themselves having to keep abreast of innovations, perhaps by putting themselves in the position of the newcomers. In this way, they can hope to reduce the instances of business models based entirely on regulatory arbitrage rather than value added.

> **Property rights.** Regulators can create new markets by reassigning property rights and obligations. Consequently, customers will reveal their true valuation of these electricity services, while transparency over ownership can spark further innovation.

> **Rival vs non-rival consumption.** Consumption of electricity cannot be shared but some services, based on the generation of data, may be used by many consumers at the same time.

New risks

Another externality that deserves a closer look is the emergence of new sources of risks. The growing dependence on semi-autonomous software components at all points in the energy sector value chain creates new risks such as cyber security. An increase in the number of attack vectors (i.e., paths that a malicious hacker could exploit) might provide greater access to critical energy infrastructure. In general, however, such cyber security risks are well understood. Whilst defending an increasingly automated, decentralized electricity system from cyber-attacks is non-trivial, it is a well-defined problem that can be solved through rigorous application of existing industry standard solutions.

Not all cyber security risks fall into this well-understood category. Some of these semi-autonomous software components including 'smart contracts,' trading agents and 'Internet of Things' enabled appliances, as well as a growing dependence on them, raise additional risks that are not well understood. For example, how can industry stakeholders, and in particular regulators, verify and validate the behavior of these semi-autonomous software components required to implement a truly reactive energy system? How can regulators verify that the auctions being used to price electricity are not open to exploitation by machine learning algorithms?

The computer science research community, particularly in the fields of functional programming, formal verification and distributed systems, has developed techniques to address a number of these problems. These include ways of defining financial contracts as algorithms so that the correctness of the contracts can be formally proved. These solutions, however, have not yet been widely adopted.

Technology is enabling innovation in electricity markets, not driving it

A key takeaway is that the trend toward an increasingly decentralized energy system seems to be driven less by technological innovation than by a shift in end-user preferences toward having more choice over their suppliers and more control over their consumption. Technological innovation, particularly innovation in blockchain-based technologies facilitates the fulfillment of these preferences. New technologies – distributed ledgers as well as innovations in auction design and implementation – are enabling the development of decentralized allocation of energy resources, which potentially may include peer-to-peer (P2P) relationships.

As the energy sector unbundles, incumbent firms and new entrants are being led toward more service-oriented business models, ICT will play an increasingly important role in this change. This shift will introduce new risks but the value of the services will make these risks worth taking.

The role of open technology in electricity markets

In order to thrive, energy firms believe they will need to leverage recent innovations in software engineering and data science that are currently disrupting other service-oriented industries such as finance and health care. The widespread adoption of open source code, open standards and open protocols (open technology) is a major factor driving technological innovation that is disrupting service-oriented industries.

When considering the impact open technology might have on the energy sector, it is useful to differentiate the 'operating system' from 'applications.' The operating system consists of infrastructure necessary to generate, transmit and distribute energy from producers to consumers, as well as infrastructure, such as smart meters, necessary to monitor the integrated system. Energy sector ‘applications,’ meanwhile, will consist of an ecosystem of auxiliary services designed to function using the operating system.

As software solutions grow to provide mission critical services at all points in the energy sector value chain, Open technology will be a key driver of disruptive technological innovation and will enable forward-looking incumbents and new startups to create value for end-users.

About the Workshop

KAPSARC convened two workshops on the Utilities of the Future series on May 3 and 4, 2017 in London, under the common theme of Technological Disruptions and Service-Based Business Models in the Power Sector. The workshops were held under a modified version of the Chatham House Rule under which participants consented to be listed below, having joined on one or both days. However, none of the content in this briefing can be attributed to any individual attendee.

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About the Workshop

David Shipworth – Professor, University College London

Andrew Scobie – Executive Chairman, Faraday Grid Limited

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Notes

About the Team

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Iqbal is a senior research fellow and leader of the Utilities of the Future project in KAPSARC. His research interests lie at the intersection of energy economics, mathematical modeling and simulation and the behavioral sciences. He holds a Ph.D. from Oxford University, an M.Sc. from King's College London and an MBA from Cranfield University.

Rolando Fuentes

Rolando is a fellow researching business and regulatory models for the Utilities of the Future team. He is an economist from the Tecnológico de Monterrey (graduated with honors) and holds a Ph.D. and an M.Sc. in Environmental Economics from the London School of Economics (LSE) and University College London (UCL), respectively.

David Pugh

David is a senior research associate whose work focuses on electricity auction design and smart meter data analytics for the Utilities of the Future team. David holds a Ph.D. and M.Sc. in Economics from the University of Edinburgh and a B.Sc. in Mathematics from the College of William and Mary. David is also an associate fellow at the Institute for New Economic Thinking at the University of Oxford.

Jorge Blazquez

Jorge is a research fellow specializing in energy and economics, with research interests in energy and macroeconomics, energy policies and transitions. He holds a Ph.D. in Economics from Universidad Complutense de Madrid.

Noura Mansouri

Noura is a senior research associate working in the Energy Systems Modeling team. Her research interests include energy technology innovation and renewables integration in the electricity grid. Noura holds a Ph.D. in Sustainable Energy Transition and an MBA specialized in sustainable energy technology management from Queen Mary University of London.

About the Project

The Electricity Sector Transition KAPSARC 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 socio-economic development and crucially affect the government’s wider economic diversification strategy. The Electricity Sector Transition initiative seeks to draw from international experience and discussion to inform and provide practical guidance for policy practitioners and other key stakeholders, as they grapple with the related policy and implementation challenges.

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