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The development of smart grid business models: A theoretical perspective and research agendas

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The developments of smart grid business models: A theoretical discussion and research agendas

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Abstract

Smart grids (SGs) are widely regarded as a key to both demand-side (e.g. energy saving and energy efficiency, managing peak load) and supply-side (e.g. renewable energy) management of energy systems. Mainstreaming SGs for achieving sustainability however, present profound challenges to policy-makers, industries and practitioners all over the world. Business models have been widely regarded as critical to scaling up SGs from pilot scale to large scale deployment through value creation, economies of scale and risks sharing. A large number of SG business models have emerged in recent years in a broad range of SG-related technologies, products and services. The extent to which and how business models work has however remained under-researched. This working paper firstly outlines major theoretical concepts associated with SG business models. We will illustrate our theoretical discussion with some empirical case examples. We will then discuss future research agendas that emerge from the dynamism of the SG landscape.

1. INTRODUCTION

In response to climate change, energy security, and volatile prices, SG technology has been increasingly recognised as an enabling technology for realising sustainable energy transitions. A large number of SG initiatives have emerged over the past decade in both developed and developing economies. Alongside endeavors in basic R&D, pilot projects (e.g. GRID4EU in Europe, SG testbed in Korea), policy developments and roadmapping, one of the latest developments of SGs is the emergence of a large number of business models.

In the US, a great variety of SG-related business models have emerged in community-scale solar projects (Coughlin *et al.*, 2010), electric vehicles (Bohnsack, Pinkse, & Kolk, 2014), and other energy technologies. In Europe, SG business models tend to focus on consumer engagement (JRC, 2014). Beyond the West, this trend of business model innovation is also noticeable. In Japan, following the completion of the four high-profile demonstration projects

in Kyoto, Yokohama, Kitakyushu, and Toyota City in 2014, the next phase of seven new smart grid pilots that has scheduled to be launched also in 2014 is distinguished by a new focus on piloting business models (Mah *et al.*, 2013). For example, Hitachi City, which hosts one of these seven pilots, is piloting how to create and validate markets for electric vehicles (METI, 2013). In China, the State Grid Corporation of China, the dominating driver of SG developments in the country, has also researched and piloted these models (personal communication, April 2015).[1]

While many SG-related enterprises and ventures have attempted to develop a variety of business models, not all of them were successful (Suhonen & Okkonen, 2013). Many energy technologies (e.g. PV, distributed storage systems), products (e.g. smart meters, green electricity), and services (e.g. home energy monitoring services, energy service companies) associated with SG developments have fallen short in terms of diffusion (Pätäri & Sinkkonen, 2014). Large-scale deployment of SG faces many barriers. These include economic, political and social ones. To overcome these barriers, business models of various types and at different scales related to SG have emerged. These emerging models seek to identify who the customers are, what customer values can be created, how a business can make money from it, and what revenue models can work well to deliver value to customers at reasonable costs while ensuring profitability (Mah *et al.*, 2014; Mah *et al.*, 2013; Zott, Amit, & Massa, 2011). Little is, however, known about how these business models evolve, under what conditions these emerging models work (i.e. help overcome barriers to SG deployments), and what are their limitations.

To partially address these knowledge gaps, this paper aims to provide a more comprehensive theoretical understanding of how and the extent to which business model innovation can facilitate the mainstreaming of SGs. This paper is structured as follows. Section 2 provides a theoretical perspective of SG business model innovation. Our discussion will highlight a set of relevant concepts that are instructive to help us understand, examine, evaluate and explain the evolution and developments of business models associated with SG technologies. We review the definitions, significance, major components, key approaches and mechanisms associated with SG business models. Based on our theoretical understanding, Section 3 will discuss some research agendas for future research.

[1] A face-to-face interview was conducted with a researcher of a research institute under the State Grid company in July 2014.

2. LINKING BUSINESS MODELS TO SMART GRID DEPLOYMENT: A THEORETICAL PERSPECTIVE

The literature in the fields of SGs, energy governance, energy transitions, and business models has offered various ways of conceptualizing the approaches, functions and mechanisms of business models. This section provides a review of the literature, and our discussion will highlight a number of themes in the literature that are particularly instructive in shedding light on how and why business models related to SG technologies emerge and develop. An overview of the discussed themes is provided in Table 1 below.

Table 1: An overview of the themes in the literature related to SG business model innovation

Themes of business model literature	**Key references**
Definitions of business models	(Chesbrough & Rosenbloom, 2002; Pätäri & Sinkkonen, 2014; Richter, 2013b)
Significance and driving forces of business models in energy sectors	(Würtenberger *et al.*, 2012) (Barker *et al.*, 2014; Nillesen, Pollitt, & Witteler, 2014; Radcliffe *et al.*, 2014; Richter, 2012)
Major components and functions of business models	(Branscomb *et al.*, 2000; Richter, 2012)
Approaches to business models	(Coughlin *et al.*, 2010; Huijben & Verbong, 2013; Kley, Lerch, & Dallinger, 2011; Würtenberger *et al.*, 2012)
Mechanisms of business model innovation (barriers, facilitating factors, causal relationships, etc)	(de Medeiros, Ribeiro, & Cortimiglia, 2014; Nair & Paulose, 2014; Zott *et al.*, 2011)
Evaluation of the effectiveness of business models	(Zott *et al.*, 2011)
Role of governments, utilities, businesses, and consumers in business model innovation	(Desyllas & Sako, 2013; Mahapatra *et al.*, 2013; Würtenberger *et al.*, 2012)

2.1 Definitions

The literature has offered many different definitions of business models and there is no universally adopted definition of the concept (Chesbrough & Rosenbloom, 2002; Pätäri & Sinkkonen, 2014). Some of the general and SG-specific definitions of business models are provided in Table 2.

Table 2: Definitions of business models

General definitions of BMs	**Sources**
Business models are the methods of doing business by which firms can sustain itself through generating revenue.	(Chesbrough & Rosenbloom, 2002)
"Teece explains that the essence of a business model lies in defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit."	(Richter, 2013b): 457
"BM is a statement of how a firm will make money and sustain its profit stream over time."	(Stewart & Zhao, 2000): 290
"A business model is a description of how your company intends to create value in the marketplace. It includes that unique combination of products, services, image, and distribution that your company carries forward. It also includes the underlying organisation of people, and the operational infrastructure that they use to accomplish their work."	KMLab, a consulting firm, cited in Chesbrough and Rosenbloom (2002): 532
Business models "consist of four interlocking elements, that, taken together, create and deliver value". These are customer value proposition, profit formula, key resources, and key processes.	Johnson, Christensen, & Kagermann, 2008, cited in Zott *et al.* (2011): 52
Definitions of SG-specific business models	
The PSC proposes a new model where utilities will plan and operate the distribution grid, integrate distributed energy resources, and provide a market where consumers can optimize their energy generation, management and delivery options. Utilities will assume a role as distributed system platform providers (DSPP) acting as the interface between customers and the bulk power system. Central to the utilities' new role and future business model is the establishment of a new market where consumers have greater access to energy resources. PSC noted that "The DSPP will create markets, tariffs and operational systems to enable behind-the-meter resource providers to monetize products and services that will provide value to the utility system, and thus to all customers. This will provide customers and resource providers with an improved electricity pricing structure and vibrant market to create new value opportunities."	New York Public Service Commission (Cameron, 2014)
Both Accenture and Lehr define business model in a similar approach as utilities' strategy, depending on their standpoint of SG development, to manage their smart investment portfolio as well as investment in maintaining and shaping external relationships with other stakeholders. There are three different types of business models driven by utilities' position on SG development – namely incremental traditionalist, SG challenger, and SG embracer. Each business model is differentiated by the four consortiums, reflecting the level of engagement in low to high risk smart investments. In all of the business models, utilities remain the key to investment unlocking changes in infrastructures, technologies, market schemes necessary to wide-spread SG deployment.	(Accenture, 2013; Lehr, 2013)
Lee describes the four business models KT, the largest Korean telecom company, has adopted to develop SG – Smart Energy Savings Business, Smart Power Trading/Selling Business, Smart ICT Convergence Business, and Smart City Business. In general, KT facilitates in SG development by providing access to energy information for better energy management, developing a platform and trading mechanism for energy transactions among different market players, acknowledging consumers with ICT-based services and technologies, and last but not least the integrated mix of all these strategies as a comprehensive package.	(Jisun *et al.*, 2010)

This working paper adopts Osterwalder (2010)'s definition, and defines business models as "the rationale of how an organisation creates, delivers, and captures value" (p. 14). By creating opportunities to link technological, potential, and economic values, business models are critical to enable firms to move away from government support (e.g. through subsidies, grants) in start-up phases to sustain itself (Chesbrough & Rosenbloom, 2002). Revenue can be generated in various ways: it can be by ways of achieving economies of scale, cost effectiveness, risks sharing, value creation, and profitability (IEA, 2011; Satchwell, Cappers, & Goldman, 2011; Suhonen & Okkonen, 2013). Business models are therefore a key to realising operational benefits of SG, and can play a critical role in scaling up SG deployment (Chesbrough & Rosenbloom, 2002; IEA-RETD, 2013; Mah *et al.*, 2013).

It is important to note that the terms, such as business models, financing models, and financial models are used interchangeably in some of the literature. There are however subtle distinctions among these three closely related concepts. *Financing* models differ from business models in that financing models relate to venture capital industries and legal and banking systems (Chesbrough & Burgelman, 2001). The role of state-owned banks in the Chinese financial system, for example, would have important implications for the SG financing models in China. Energy cooperatives and closed-end funds are some good examples of financing models for energy innovation in Germany (Yildiz, 2014). *Financial* models, on the other hand, refer to methods that derive the return expectations from projected costs and revenues (Richter, 2012). This working paper focuses on business models rather than financing or financial models.

2.2 Significance of business models to SG deployment

In what ways are business models significant to SG deployment? While the deployment of SGs has been limited by a large number of technological, economic, social and political factors, the literature has suggested that although business models cannot address all of them, they can at least help overcome some of them.

A growing body of the literature on SG studies has instructively identified four types of risks that are particularly relevant to SG deployment. These are technological risks, market and financial risks, policy and regulatory risks and social risks (Table 3) (Radcliffe *et al.*, 2014). A selection of case examples, as shown in Table 4, suggests that some of these risks can be overcome by SG business models.

Table 3: Business risks of SG deployment

Risk category	Dimensions/aspects
Technological risks	(a) One may not know whether and how one can solve technical problems (Odagiri & Goto, 1996)
Market and financial risks	(a) Externalities (b) Price distortion (e.g. cross-subsidies, incumbent technology may be subsidised) (IEA, 2010) (c) Information • Demand for a new product may not be known in advance (Odagiri & Goto, 1996) • Market risks exist if the first-mover makes its early investments without full information about demand for the new project. Uncertainty about demand makes early investment risks. If demand does not turn out to be as high as expected, a first-mover may be saddled with capacity that cannot be used (McGahan, 1993) • Information failures, lack of knowledge and competence by installers (Branscomb *et al.*, 2000; Owen, 1999) (d) Transaction costs (Branscomb *et al.*, 2000; Owen, 1999) (e) Finance • High upfront costs (buyer's perception of risk, e.g. 'pay-back gap'), difficult access to capital, (Branscomb *et al.*, 2000; Owen, 1999; Würtenberger *et al.*, 2012) • Perceived risks on the part of financial institutions (IEA, 2010) (f) Inefficient market organisation in relation to new technologies (IEA, 2010, p. 633) • Split incentives – between owner/ designer/ user, etc (Branscomb *et al.*, 2000; Owen, 1999) • Firms may have great difficulty managing innovations that fall outside of their previous experience where their earlier beliefs and practices do not apply (Chesbrough & Rosenbloom, 2002)
Policy/regulatory risks	(a) Tariffs (such as declining block prices) that discourage DSM investment (b) Incentive structures that encourage energy providers to sell energy rather than invest in DSM (c) Institutional bias towards supply-side energy investment - Low priority of energy issues (Branscomb *et al.*, 2000) - The supremacy of the generalist over the subject specialist in civil services (Owen, 1999) - A government may try to prevent a new venture which, in their eyes, would cause a disorder (Odagiri & Goto, 1996) - Restrictive procurement policies, cumbersome permitting processes (Branscomb *et al.*, 2000)
Social risks	(a) The society may be skeptical, or even hostile, to the new enterprise (Odagiri & Goto, 1996)8; [e.g. in response to the introduction of dynamic pricing], (Sauter & Watson, 2007). (b) "hassle" factors (Owen, 1999)

Table 4: Case examples of SG business models

Business Model Example	Place (start date)	Focus Areas for BMs	Description	Which barriers/ risks are addressed by the business model?	Sources of information
Austin Technology Incubator (ATI), The University of Texas	Austin, Texas	Clean energy solutions	• ***Partnerships*** between startups and established players in the market helped validate new technical solutions and create opportunities for rapid scaling of businesses. • ATI provided ***"early-stage environment"*** coupled with National Grid's ***industry knowledge and expertise*** • ***ATI – helps startups to raise investor capital*** • ***The presence of forward-thinking established players*** (National Grid in this case) • Start with ***"informal" partnership – then formalised***	*Transaction costs*- lowered *Finance:* access to investment capital	(The University of Texas at Austin, 2013)
Juwi	Germany	RE	***Collaboration***: pooled resources together to make things work: Juwi brings in expertise in project development and operations management and the utilities bring in their financial strength and use the electricity	Transaction costs lowered; efficiency improved	(Richter, 2012)
Grameen Shakti	Bangladesh	EE	***Risk-shifting***: the business model shifts the operation and maintenance risks to customers	Market and financial risks	(Schillebeeckx, Parikh, Bansal, & George, 2012)
Energy Cooperatives	Germany		Financial barriers lowered – through low amount of investment required Active role played by members of the cooperative	Financial risks	(Yildiz, 2014)
One-stop-shop business models	Denmark, Norway, Sweden		*Transaction costs* lowered *Buyers' risks* - managed	Market and financial risks	(Mahapatra *et al.*, 2013)
Progress Energy Florida	US	Utility energy efficiency programs	Offer economic incentives, together with technical assistance ***Partnership./ accreditation****:* it works with Florida Solar Energy Centre to certify a group of manufacturers and installers who are eligible to install the systems	Technological risks Financial risks	(Fox-Penner, 2010)
Save-a-Watt program	Duke Energy	*Utility* EE program	***Create new values****:* Make the installation of a basic package of EE measures an automatic part of electric services; plus "profit incentives", plus "speed up the planning and approval cycle	Policy/regulatory risks	(Fox-Penner, 2010)

2.3. Major components and functions of SG business models

How, then, do business models function to achieve normative desirable outcomes? The literature offers various ways of conceptualizing the major components of business models. Richter (2012)'s work instructively specifies that there are four pillars of business models in general. These are value proposition, customer interface, infrastructure, and revenue model. Osterwalder (2010)'s "9 Building Block" offers a more operational way of conceptualizing the main components as follows:

i. *Customer segments*: mass market, niche market, segmented, diversified, multi-sided markets;
ii. *Value propositions:* through newness, performance, customization, "getting the job done", design, brand/status, price, cost reduction, risk reduction, accessibility, convenience/usability;
iii. *Channels*: through which channels our customer segments want to be reached? Direct channels: Sales force, web sales; Indirect channels: own stores, partner stores, and wholesaler. Channels have five distinct phases: awareness, evaluation, purchase, delivery and after sales;
iv. *Customer relationships:* personal assistance, dedicated personal assistance, self-service, automated services, communities, co-creation;
v. *Revenue streams:* ways to generate revenue streams: asset sale, usage fee, subscription fees, lending/renting/leasing, licensing, brokerage fees, and advertising;
vi. *Key resources:* physical, intellectual, human, and financial;
vii. *Key activities*: production, problem solving, and platform/network;
viii. *Key partnerships*: four types of partnership: strategic alliances between non-competitors, cooperation, strategic partnerships between competitors, joint ventures to develop new businesses, and buyer-supplier relationships to assure reliable supplies; THREE MOTIVATIONS for creating partnerships: optimization and economy of scale, reduction of risks and uncertainty, acquisition of particular resources and activities; and
ix. *Cost structure.*

It is important to note that *value creation* is one of the most important functions of business models. According to Richter (2012), the value proposition refers to "the bundle of products and services that create value for the customer and allows the company to earn revenues" (p. 2484). The literature suggests that these values can be of different nature. Work by Boons *et al.* (2013) and Nair and Paulose (2014) suggests that business models can create not only economic value, but also environmental and social values (Boons *et al.*, 2013).

2.4 Major approaches to business models

The literature has offered different ways to distinguish approaches to business models (see Table 5).

Table 5: Approaches to business models

Classification: Approaches to business models	**Sources**
Three approaches: (1) product-service-system business models, (2) business models based on new revenue models, and (3) business models based on new financing schemes	(Würtenberger *et al.*, 2012)
Two approaches: (1) the traditional, centralised and asset focus model, and (2) the decentralised, customer focus model	(White *et al.*, 2013)
(1) Product-oriented, and (2) Service-oriented	(Kley *et al.*, 2011)
Customer-owned, community shares, and third party	(Huijben & Verbong, 2013)
Community solar-specific models: (1) utility-sponsored model, (2) special purpose entity models, (3)non-profit model, (4) group billing, (5) virtual net metering, and (6) joint ownership	(Coughlin *et al.*, 2010)

The above-mentioned approaches are more generic and applicable to a range of businesses and industries. It is noteworthy that there is an emerging theme of business model literature that discusses approaches which focus on various specific aspects of SGs. IEA-RETD (2013), for example, specifies that there are three main types of business models for renewable energy: energy product service systems (e.g. Energy Supply Contracting (ESC) and Energy Performance Contracting (EPC)), business models from new revenues (e.g. feed-in tariffs or feed-in premiums for renewable energy), and business models from new financing schemes (e.g. Energy Saving Obligations Business Model, renewable energy equipment leasing, Property Assessed Clean Energy (PACE) financing, and on-bill financing). Work by Lehr (2013) and Zpryme (2014) for example highlight a wide spectrum of utility models: (a) maximum utility role: utility as "energy services utility" – utilities owns and operates all systems; (b) middle way: utilities as "smart integrator" – utilities partners with competitive providers to deliver energy services; and (c) minimal utility involvement: utilities maintain the grid and let competitive providers supply the rest.

2.5 Mechanisms of business model innovation

The literature has offered different conceptualisations of the mechanisms of business models that enable us to better understand how business model innovation influence outcomes, i.e. SG deployment. A theme of the literature highlights the facilitating factors of, and barriers to, business model innovation (Table 6). Another theme of the literature adopts a systemic view of understanding the mechanisms that operate in business models. These systemic approaches specify the main components, the linkages between the components (e.g. interdependence and causal relationships), and the dynamics between them.

(a) Facilitating factors and barriers

Major facilitating factors include the market, law and regulation, learning, innovation capabilities, pre-existing trust (e.g. a good long-term customer relationships), and availability of resources of various types (e.g. financial, knowledge). Major barriers include inertia, a lack of an established market, and a lack of government interest.

(b) Systemic perspectives of business model mechanisms

Another theme of the business model literature offers systemic perspectives of the mechanisms that operate in business models. de Medeiros *et al.* (2014) suggest that an integral system of a business model consists of four critical components, (1) market, law and regulation; (2) collaboration; (3) innovation-oriented learning, and (4) R&D investment. Work by Nair and Paulose (2014), for example, sheds light on the political, regulatory, and market conditions for the emergence of green business models, and thus shed important light on the contextual circumstances where green business models emerge. Work by Zott *et al.* (2011) instructively conceptualises the mechanisms through which business models influence outcomes. For example, Zott et al. (2011) suggest that value chain deconstruction and reconstruction, pricing systems, competitive advantages, and networks are some of the critical processes in business models that may be conducive to desirable outcomes and consequences of business models, such as innovation network dynamics and relationship infrastructure. Work by Nair and Paulose (2014) and Zott *et al.* (2011), on the other hand, shed important light on the evaluative dimension of business models. While the pace of innovation is a determinant of critical success of green business models (Nair & Paulose, 2014), we may also evaluate the extent to which the major risks (technological risks, market risks, policy and regulatory risks, and social risks) are managed (Zott *et al.*, 2011).

Table 6: Facilitating factors of, and barriers to, business model innovation

Facilitating factors	**Illustration**	**Sources**
A set of four factors: (1) market, law and regulation knowledge; (2) interfunctional collaboration; (3) innovation-oriented learning; and (4) R&D investments.	These four factors are directly related to the success of environmentally sustainable product innovation.	(de Medeiros *et al.*, 2014)
Learning, capability building, shifting stakeholder values from single to multiple objectives	The complex nature of sustainable business models calls for an integrative approach of supply chain members and other stakeholders. Collaborative relationships improve the chances of finding creative solutions. Governments need to develop effective mechanisms to convince stakeholders to shift from single to multiple objectives.	(Matos & Silvestre, 2013)
Utilities' business model **innovation capabilities**: *organizational structure and external partnership* (Richter, 2013a, 2013b)	Organizational structure (e.g. establishing a separate venture, or at least separate and independent business units) ▪ External partnerships (to foster the accumulation of know-how and innovation capabilities to face radical changes in the firm's environment), and collaboration can comprise external stakeholders, like universities, suppliers, research centers, competitors, customers, or NGO, and can range from research projects to equity joint ventures	(Richter, 2012, 2013a, 2013b)
Pre-existing positive relationships between utilities and customers	A good long-term customer relationship e.g. customer service activities that use a corporation's major retail asset and its employee's expertise on energy matters	(Richter, 2013b)
Availability of resources	Resources/knowledge: - Financial or information support from government - Knowledge about cultural variables that influence buyer behaviour - Knowledge about factors that drive sustainable buying - Knowledge about consumption patterns of reference persons - Competitor monitoring	(de Medeiros *et al.*, 2014)
Barriers		
Inertia	• Inertia at industrial level: the issues of path dependency and inertia. • Inertia at the corporate level, firms, especially large incumbent firms, may be biased against business models and technology shift that do not fit their core business. • Inertia at enterprise level: firms may have great difficulty managing innovations that fall outside of their previous experience, where their earlier beliefs and practices do not apply • Inertia at consumer level: customer loyalty may become a hurdle – large incumbent firms may have existing customers loyal to established products.[2]	(Branscomb *et al.*, 2000; Chesbrough & Rosenbloom, 2002; Tongur & Engwall, 2014)
A lack of an established market	(i) lack of products and services, (ii) lack of customer demand, (iii) lack of competences, and (iv) lack of profitability.	(Richter, 2013b)
Partnership is rare	Although partnership is key to business model innovation, partnerships were only business oriented, and collaborations among competitors were rare….A lack of government interest…	(Nair & Paulose, 2014)
A lack of government interest	A lack of government interest in investing in alternative energy options could be a concern because it would leave the R&D costs to the private sector.	(Nair & Paulose, 2014)

[2] McAfee, R. P., Mialon, H. M., & Williams, M. A. (2004). What Is a Barrier to Entry? *The American Economic Review, 94*(2), 461-465. doi: http://dx.doi.org/10.1257/0002828041302235

3. FUTURE RESEARCH AGENDAS

Having reviewed the emergence of business models as a sub-discipline in SG studies and discussed its main conceptual perspectives, this section outlines the emerging research agenda for SG business model innovations. Based on our reflections on the current state of research, we will identify important research questions that need to be answered.

The literature has suggested that the stakeholder landscape associated with SG business models is highly dynamic. The traditional, vertically integrated utility models have been in decline alongside the rise of decentralised energy sources. Distributed power systems, new firms (e.g. energy services companies), and consumers may play more important roles and become much more proactive in interacting with incumbent utilities. Governments and regulators also undergo major changes in their functions as new energy products and services require new regulatory arrangements. Given the dynamism and significance of the SG landscape, there are at least four important areas which appear to offer the potential for new and significant research engagement as follows:

3.1 Understanding the dynamism of SG landscape and the associated challenges and impacts

In the context of these new sets of government-utility-consumer relationships, there are at least three important questions that we have to ask:

- To what extent and in what ways can the traditional business landscape dominated by vertically integrated utilities change as SG business models evolve?
- What are the features of the stakeholder interactions that may facilitate or impede the development of SGs?
- What are the possible governing strategies that can be adopted to forge greater alignment across utilities, regulators, government agencies, manufacturers, and energy consumers?

3.2 Utility-led business models for SGs

Another theme is related to a utility perspective of business models. Utilities have been widely regarded as a necessary and critical actor in facilitating SG deployments. They are, however, often found to be the major roadblock to SG deployments as they can be “the last pace in business where innovation can rationally be expected to occur” (Lehr, 2013, p. 42). On the one hand, utilities are under mounting pressure (such as electricity price increases, the tightening up of environmental rules and standards) to change their ways of doing business.

Because of their business nature and a number of their pre-existing strengths, they can also serve as a powerful driving force in SG deployment. For example, utilities in a vertically integrated market system own and operate grid systems – the critical infrastructure of SG deployment. They also have the advantages of possessing expertise on energy matters and technologies, pre-existing relationships with customers, and good access to customers' electricity consumption data (Pätäri & Sinkkonen, 2014). On the other hand, utilities are found to have very few incentives to take risks and have strong incentives to prevent market entry by competitors (Lehr, 2013). Notwithstanding these mixed motivations of utilities with regard to SG deployment, it is important to answer the following questions:

- What are the ***major approaches for the utility-led business models*** that have merged in responses to SG developments, and ***with what objectives***? What are the features of these approaches?
- What are the ***achievements*** of these utility-led business models in facilitating SG deployments? What are their ***limitations***? And ***how*** (under what conditions) do they work/ or fail to work?
- When and why do the interests of incumbents and new market players conflict, and with what impacts does this have on SG deployments? And how can such conflicts be mitigated?
- To what extent can new market players (e.g. energy services companies and other intermediaries) make a difference as these new business models emerge, and how?

3.3 Consumer engagement

The essence of business models is related to value creation, in that electricity consumers are willing to buy new energy products (e.g. smarter electric appliances) and energy services (e.g. allowing electricity suppliers to automatically shut down some of their prescribed appliances at peak times in order to get rebates) that are associated with SGs. The important questions that we need to answer are the following:

- What are the facilitating factors and barriers that affect consumers' awareness, participation, and persistence in engaging in SG technologies (EPRI, 2014)?
- What are the possible strategies that can be adopted to overcome the identified barriers?

3.4 The changing role of the governments

In the emergence of utility-led business models, the emerging/changing role of governments as electricity market regulators warrants further research. Because regulators can determine market structure and conduct, and thereby determine the technical, economic as well as environmental performance of regulated utilities, it is important for us to have a better

understanding of the following areas:

- What are ***the roles of government*** in facilitating utility-led business model innovation (to facilitate utility's transition to new business models (Miller, Risser, & Kline, 2014)), and ***with what objectives*** (e.g. to ensure sufficient regulatory flexibility for innovation, risk-taking, competition, and other kinds of market responsiveness) (Riesz *et al.*, 2014)?
- What strategies can help the government to align the interests of utilities and other stakeholders in business model innovation? E.g. related to the challenges of integrating RE into the grid, what can the government do to align the interests between DSO and TSO? (Matos & Silvestre, 2013)? What strategies can be adopted to overcome the opposition against net metering since many utilities see net metering as lost revenue opportunities (SmartGridNews, 2014)?
- How can the government regulate cost recovery mechanisms while ensuring customer benefits are well protected? (Hieta, Kao, & Roberts, 2012)?
- How can regulatory challenges be overcome when introducing dynamic pricing?

4. CONCLUSIONS

As the discussion in this working paper has shown, the importance of business models in SG deployment has strong theoretically underpinning. Business model innovations in the SG-related industries present new opportunities for businesses, electricity consumers, and governments to create innovative ways to realign interests in the pursuit of the sustainable energy transition. Under this context, SGs have an important role to play.

While the literature and prior local studies have been instructive in shedding light on some aspects of SG business model developments, the extent to which and under what circumstances normative desirable outcomes of business models can be realised are questions that require more detailed investigation. A stakeholder approach for examining the new and evolving roles of businesses, consumers, and governments in this area may advance our understanding of the complex dynamism of SG business model innovation.

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