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Business models for distributed energy resources: A review and empirical analysis

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ABSTRACT

This paper presents a novel, empirical analysis of the most common business models for the deployment of demand response and energy management systems, electricity and thermal storage, and solar PV distributed energy resources. We classify the revenue streams, customer segments, electricity services provided, and resources for 144 business models. We use this assessment to identify a set of business model "archetypes" in each resource category. Our analysis leads us to five observations that have important implications for policymakers and regulators. First, our analysis highlights that business models are deeply embedded in myriad policy and regulatory frameworks. Second, current DER business models are driven more by regulatory and policy factors than by technological factors. Third, the relatively small set of well-defined DER business model archetypes suggests that the determinants of success within a given archetype may include executional capabilities, culture, and other activities that are not captured in our framework. Fourth, continued cost declines, technological innovation, and changing policy and regulatory landscapes mean the business models of tomorrow will likely look very different than the business models of today. Finally, DER business models compete within archetypes for market share in providing a limited set of electricity services.

1. Introduction

The electric utility business model is in a state of profound transition (MIT, 2016). A 2013 survey found that 94% of the senior power and utility executives surveyed "predict complete transformation or important changes to the power utility business model" by 2030 (PwC, 2013). These changes are being driven primarily by the influx of distributed energy resources (DERs), including solar photovoltaics and other distributed generation, thermal and electrical energy storage, and more flexible and price-responsive management of electricity demand. Many predict that these changes will be highly disruptive, and that, without adaptation, incumbent utilities[1] risk falling into a "death spiral" that threatens their economic viability (Kind, 2013; PwC, 2015).

Electricity infrastructure is considered uniquely critical due to its role as an enabler of other economic functions and sectors (Office of the Press Secretary, 2013), and the financial stability of electric utilities is key to the effective management, maintenance, and expansion of the trillions of dollars of global critical electricity assets (Kind, 2013). A well-crafted business model has important impacts on the financial performance of a firm (IBM Global Business Services, 2006; Zott and Amit, 2007). Understanding the business models that are emerging in the power sector is therefore important for ensuring the continued economic viability of critical electricity infrastructure.

Furthermore, distributed solar PV, energy storage, and demand response offer significant potential for decarbonizing the power sector and are becoming increasingly economically important. Indeed, the solar industry now employs more people in the United States than does the oil and gas industry (Anna Hirtenstein, 2016). Continuing to unlock the economic and climate potential, however, requires the development of economically sustainable business models.

Business models in the electric power sector are embedded in the regulatory and policy frameworks that characterize the sector. State- or national government-appointed regulatory commissions regulate the revenues of electricity distribution companies. The revenues – and thus the viability – of distributed energy businesses in distribution networks are therefore exposed in part to these regulatory frameworks. Similarly, in wholesale electricity markets, market rules are established by a central authority (e.g. in the U.S., market rules are established by

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[1] In the U.S. context, the "utility" typically refers to the distribution system owner/ operator, whether in a traditional or restructured environment. In European or other contexts, the term "utility" is often interpreted more broadly and refers to generators, network companies, and other power sector firms involved in the supply of electricity. We adopt a broad definition of the utility, and use the term to describe any company engaging in the provision of electricity services.

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Independent System Operators [ISOs] or Regional Transmission Operators [RTOs], and these entities are monitored and regulated by a Federal Energy Regulatory Commission [FERC]). New DER business models selling services in wholesale electricity markets must conform to the market rules and regulations established by these authorities.

In addition to regulatory scrutiny, the electric power sector is the subject of significant national and state (in the U.S.) policy support. This support takes the form of subsidies or favorable rules for a variety of technologies. In recent years, significant policy support has targeted the development and deployment of low- or zero-carbon electricity generation technologies such as solar PV, as well as associated technologies such as energy storage. Understanding these policy and regulatory interdependencies is critical to ensuring the sustainable development of these businesses.

This review is intended to shed light on the structure of electricity services business models such that policy makers and regulators can work towards building industries that will be societally beneficial in the long term. Towards that goal, we perform a novel empirical review and analysis of the business models for three of the most widely deployed DERs: solar photovoltaics, electricity and thermal storage, and demand response. We define the key “value capture” and “value creation” components of 144 distributed energy business models.[2] We use an ontological approach,[3] building on the approaches used by Osterwalder and Pigneur (2010) and Richter (2013a) (2012), to define distributed energy business models. We use a structured framework to analyze and classify distributed energy business models.

For each business in our dataset, we define the electricity services provided, revenue streams captured, customers targeted, and key DER resources used. We use this data to define a small set of business model “archetypes” that describe common classes of many business models. For each archetype, we provide concrete examples of active business models.

This paper proceeds as follows. First, we provide a brief review of the current literature on utility business models. Second, we present an overview of our data and methodology. Third, we provide an overview of the business models in our sample. Fourth, we define business model archetypes for demand response (DR) and energy management systems (EMS), electrical and thermal storage, and solar PV businesses. We then describe some of the nuances that exist within each archetype, including a description of the types of policies and regulations that these businesses depend upon and interact with. Finally, the paper concludes with a discussion of the results and policy implications.

2. Literature review

Little academic literature describing current or potential future utility business models exists. However, a number of trends emerge from reviewing the existing academic, trade, and industry analyst literature. First, paradoxically, studies of business models often do not define either the utility business model or a business model more broadly[4] (Lehr, 2013; Newcomb et al., 2013; Rocky Mountain Institute, 2013). Second, many studies define and explore a single business model or a small set of business models associated with a single technology without exploring how these models may be competitively positioned against other business models (Behrangrad, 2015; Bell et al., 2014; Huijben and Verbong, 2013; Vasconcelos et al., 2012; Weiller et al., 2015). Finally, a number of studies perform analyses of a technology providing a limited set of electricity services, without exploring the full range of services that the technology is providing or may provide (Huijben and Verbong, 2013; Weiller et al., 2015). Traditional engineering or economics-driven business model analyses tend to assume that business models are superfluous, because suppliers can simply capture economic rents through the sales of services at competitive, market-based rates (Teece, 2010).

Only a small subset of business model studies have analyzed utility business models using a structural approach similar to the one used in this paper. This is the first to do so with quantitative empirical methods. Several of these studies focus on a subset of business models that utilize a particular technology (e.g. see Schoettl and Lehmann-Ortega (2011) and Okkonen and Suhonen (2010)). Richter (2012), (2013b) use case studies and surveys in combination with an ontological approach to develop an understanding of utility business models that utilize a variety of renewable energy technologies. Hamwi and Lizarralde (2017) perform a literature review and identify business model archetypes, but do not leverage the existing literature on business model structures. Our paper builds upon this existing literature by using a data-driven approach to glean insights into the current distributed energy business model landscape for policy makers.

3. Data and methodology

Our analysis includes a sample of 144 regionally diverse companies whose core business operations are associated with one or more of three DER technology categories – demand response (DR) and energy management systems (EMS), electrical and thermal storage, and solar PV. Many of the companies in our sample heavily rely on information and communication technologies (ICTs) to enable communication and control of the DER resource of interest. Given their ubiquitous nature, we do not include ICT as a standalone category in this analysis.

Data for the companies used in this analysis were collected from publicly available news, academic, and industry publications between February 2014 and October 2015. In addition, in an attempt to ensure that the sample was representative of the “universe” of DER business models, we sampled from the Cleantech Group's i3 database, a commercial database that contains information on more than 24,000 “clean tech,” DER, and sustainability-focused businesses (“i3 Connect, n.d.). We created three sets of companies from the i3 database – one for each of the DER technology categories. The i3 database categorizes businesses by their core focus; we used this feature to create sets of all business models that were categorized as ”ground-mounted PV,” “rooftop PV” (which together comprised our solar PV set), “grid energy storage,”[5] and “demand response.” We then drew stratified random samples from each of these three sets, such that the distributions of companies in our final sample were similar to those of the i3 database in terms of company headquarter region and founding year. We sampled 50 companies in each of our three DER technology categories. A small number (6) of the companies did not fit our coding criteria, and thus were not included in our final sample.

Tables 1, 2 show the number of companies in our sample in each founding year bracket and in each region. These percentages are compared with the percentages that are found in the larger i3 database. As Tables 1, 2 show, the distribution of companies in our sample deviated from the relevant distribution of companies in the i3 sample by no more than 5%. We note that the bulk of the companies in our sample are headquartered in the U.S. and Europe. This is likely due to bias in the i3 database; thus, our sample is more representative of the U.S. and European markets than of African or Asian markets.

[2] Value capture is the means by which a business monetizes its product or service. Value creation is the means by which a business generates welfare for its customer(s).

[3] An ontology is defined as an explicit specification of a conceptualization (Gruber, 1993). It can be understood as a formal description of the concepts and relationships in a specific domain, in our case business model research.

[4] Many of the early authors of business model literature failed to provide a definition of a business model as well. Of the studies surveyed by Zott et al., 2011, 37% did not promulgate a definition of a business model, “taking its meaning more or less for granted.”.

[5] Note that despite the name, this category also includes “behind-the-meter” energy storage companies, as discussed in Section 6.