

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 distributed energy resources. Specifically, this research focuses on demand response and energy management systems, electricity and thermal storage, and solar PV business models. We classify the revenue streams, customer segments, electricity services provided, and distributed energy resources leveraged for 144 business models. We use this empirical assessment to identify a limited set of business model archetypes in each distributed energy resource category. Within each archetype, concrete examples of individual business models are presented, along with notable exceptions or extensions of these business models. Our review leads us to five key takeaways regarding the structure of distributed energy resource business models. First, business models can be classified into a discrete number of archetypes based on common characteristics. This clustering indicates that there are factors that contribute to the success or failure of a business model that cannot be captured in reviews of business model structures (for example, company culture, or factors linked to execution). Second, as anticipated, regulatory and policy environment is a significant, if not the most significant driver of business model structure. Third, business models are not static with time – technological, policy, and regulatory developments all drive changes in a company’s business model. Finally, business models compete for the provision of a limited set of commodity electricity services. This observation leads two final conclusions. Structures (such as markets) should be encouraged to allow competition among service providers and efficient solutions to emerge; additionally given that these business models are fundamentally competing for the provision of commodity services, differentiation beyond price will be difficult to realize.

Keywords: *Business Models; Distributed Energy Resources (DERs); Solar; Photovoltaics; Demand Response; Energy Storage; Business Model Ontology; Energy Services.*

1 INTRODUCTION

“It would be foolish to dismiss the potential for major changes in the utility business model.”

- Theodore Craver Jr., CEO, Edison International [1]

Craver, the CEO of the U.S.’s second largest utility and chairman of the Edison Electric Institute, the trade organization representing U.S. utilities,¹ is not alone in his belief that the utility business model is on the threshold of dramatic change. 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 [2]. 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 the changes driven by DERs will be highly disruptive to the electricity sector, and that, without adaptation, incumbent utilities² risk falling into a “death spiral” that threatens their financial viability [3,4]. While some industry analysts see changes to utility business models occurring in years to come, some of the world’s largest incumbent utilities are taking action today; for example E.ON, Germany’s largest utility, and NRG Energy, one of the U.S.’s largest power producers, each announced major structural changes to their business models, selling off billions of dollars in assets, and developing new undertakings in distributed resources and renewable energy [5,6].

Electricity infrastructure is considered uniquely critical due to its role as an enabler of other economic functions and sectors [7]. The bankability of electric utilities is key to the effective management, maintenance, and expansion of the trillions of dollars of global critical electricity assets [4]. Further, a well-crafted business model will, logically, have important impacts on the financial performance of a firm [8,9]. Understanding the business models that are emerging in the power sector is therefore important, not only to incumbent utilities and new market entrants, but to the public at large.

Given high profile business model shifts at organizations like E.ON and the importance of the viability of electricity services business models, many industry analysts have begun to speculate about what business models will be leveraged to deliver electricity services in the future. In order to shed light on this discussion, this paper performs a novel empirical review and analysis of the business models for three of the most widely

¹ Edison International is a holding company that owns both Southern California Edison and Edison Energy. Southern California Edison is the second largest utility in the United States by revenue [97]. The Edison Electric Institute members represent roughly 70% of the electric power industry [98].

² 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.

deployed distributed energy resources: solar photovoltaics, electricity and thermal storage, and demand response. We define the key value capture and creation components of 144 distributed energy business models. We take an ontological approach, as proposed by Osterwalder and Pigneur [10], to define distributed energy business models. As noted by Zott et al. [11], ontological definitions provide a “conceptualization and formalization of the elements, relationships, vocabulary, and semantics of a business model and which is structured into several levels of decomposition with increasing depth and complexity.” The business model ontology deployed herein creates a structured framework with which to analyze and classify distributed energy business models [12,13].

For each business in our dataset, we define the electricity services provided, the revenue streams captured by the provision of these services, the customers targeted, and the key DER resources used. The Osterwalder and Pigneur framework also includes the business models’ value proposition, key activities, cost structure, and key partners. We reviewed these components of the business models in our dataset, but do not include it in our results since in many cases the data is sparse, unavailable, or unreliable. We use data about electricity services, revenue streams, customer segment, and key DER resource to define a small set of business model “archetypes” that describe common classes of many business models. While differences exist amongst the business models in each archetype, each archetype shares a common set of features. For each archetype, concrete examples of active business models are provided.

This paper proceeds as follows. First, we provide a brief review of the current literature on utility business models. Second, we introduce the method by which our data was collected. Third, we provide an overview of the business models in our sample. Fourth, we define business model archetypes for the three largest DER categories: demand response (DR) and energy management systems (EMS), electrical and thermal storage, and solar PV. Within this section we describe some of the interesting nuances that exist within each archetype. Finally, the paper concludes with a discussion of the results and directions for future research.

The analysis presented in this paper leads to several key insights. First, despite the great number of business models currently operating around the world, these business models can be classified into a discrete number of archetypes. This clustering, combined with the diversity in performance of businesses within each cluster, indicates that there are factors that contribute to the success or failure of a business model that cannot be captured in ontological reviews. Second, the regulatory and policy environment is a larger driver of business model structure than technological differences or other factors. Third, business models are not static with time – technological, policy, and regulatory changes all drive changes in the business model adopted by a given company. Finally, business models compete for the provision of the same electricity services, indicating that structures (such as markets) should be encouraged to allow competition that will enable the most efficient solutions to emerge.

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 broadly³ [14–16]. 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 [17–21]. 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 [17,18]. 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 [22]. Indeed, business models flourish due to market imperfections that hinder the discovery of value, while engineering analyses assume that if value exists, a supplier will always deliver it and consumers will always pay for it [22].

Only a small subset of business model studies have analyzed utility business models using an ontological approach such as the one used in this paper, but none have done so using 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 [23] and Okkonen and Suhonen [24]). Richter [13] and Richter [12] 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. Our paper builds upon the existing literature by taking a data-driven approach to circumscribe and glean insights from the current distributed energy business model landscape.

3 DATA COLLECTION METHOD

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 rely heavily on information and communication technologies (ICTs) to enable communication to and

³ 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.”

control of the DER resource of interest. However, 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 order to ensure that the sample was representative of the “universe” of DER business models that exist today, 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 [25]. 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 form the solar PV set), “grid energy storage,”⁴ 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 of the sampled companies did not fit our coding criteria, and thus were not included in our final sample.

Tables 1 and 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 and 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%.

Table 1: Founding year of companies in sample

Year Founded	Demand Response & Energy Management Systems			Electrical & Thermal Storage			Solar PV		
	Sample Number	Sample Percent	i3 Percent	Sample Number	Sample Percent	i3 Percent	Sample Number	Sample Percent	i3 Percent
1990 or Earlier	4	9%	7%	3	6%	6%	6	12%	9%
1991-1995	1	2%	3%	1	2%	2%	2	4%	5%
1996-2000	6	13%	12%	3	6%	6%	4	8%	8%
2001-2005	9	20%	20%	5	10%	11%	9	18%	19%
2006-2010	20	43%	46%	22	47%	47%	23	46%	47%
2011-2015	6	13%	13%	14	29%	28%	6	12%	12%
Total	46	100%	100%	48	100%	100%	50	100%	100%

⁴ Note that despite the name, this category also includes “behind-the-meter” energy storage companies, as discussed in Section 6.

Table 2: Headquarter region of companies in sample

Region	Demand Response & Energy Management Systems			Electrical & Thermal Storage			Solar PV		
	Sample Number	Sample Percent	I3 Percent	Sample Number	Sample Percent	I3 Percent	Sample Number	Sample Percent	I3 Percent
Africa	0	0%	0%	0	0%	1%	1	2%	1%
Asia Pacific	0	0%	4%	4	8%	8%	4	8%	9%
Central & South America	0	0%	0%	0	0%	0%	0	0%	0%
Europe & Israel	10	22%	22%	12	25%	24%	19	38%	38%
Middle East	0	0%	0%	0	0%	0%	0	0%	1%
North America	36	78%	74%	32	67%	67%	26	52%	52%
Total	46	100%	100%	48	100%	100%	50	100%	100%

4 OVERVIEW OF BUSINESS MODELS

Figures 1-3 summarize the business models in our sample in terms of the services they provide (Figure 1), the customer segments they target (Figure 2), and the revenue streams that they leverage (Figure 3). Each DER technology category (i.e. demand response & energy management systems, electrical & thermal storage, and solar PV) is represented by a different color, and the size of each individual circle represents the number of business models in a given service, customer segment, or revenue stream category. For the sake of efficiency, these summary charts only show categories that contain four or more business models. Detailed analyses of each DER category are provided in Sections 5-7. However, the summary data provided in this section gives us some initial insights into the DER business model landscape.

Figure 1 summarizes the electricity services provided by the business models in our sample. The vast majority of business models in our dataset are either providing a mix of firm capacity and operating reserve⁵ products, or providing energy. While operating reserve services are rather lucrative, the markets for these services are very small (typically making up less than 4% of total energy costs) [26–28]. The intense competition for the provision of operating reserve services could prove challenging for demand response and energy storage technologies. On the other hand, payments for firm capacity can be quite significant depending on desired

⁵ Note that operating reserves take different definitions depending on the system. This paper uses the terms primary, secondary, and tertiary operating reserves, which are corollaries to the European system of Frequency Containment Reserve (FCR), Frequency Restoration Reserves (FRR), and Replacement Reserves (RR) respectively. See I. Pérez-Arriaga, “Managing large scale penetration of intermittent renewables”, MIT Energy Initiative Symposium, 2011 for a review of various reserve taxonomies. Note however, that this review does not include the new European Network Codes, released in 2013 (i.e. FCR, FRR, and RR).

reserve margins (for example, on the order of hundreds of dollars per megawatt-day and with a market size of tens of gigawatts in certain systems) [29,30]. As one might expect, the only business models in our dataset providing energy in a distributed fashion are those that utilize solar PV. Where a business model is described as providing “operating reserves,” the business can provide the range of primary, secondary, or tertiary reserves; other business models may provide only a single type of reserves (notably, secondary reserves).

Figure 1: Electricity Services Summary

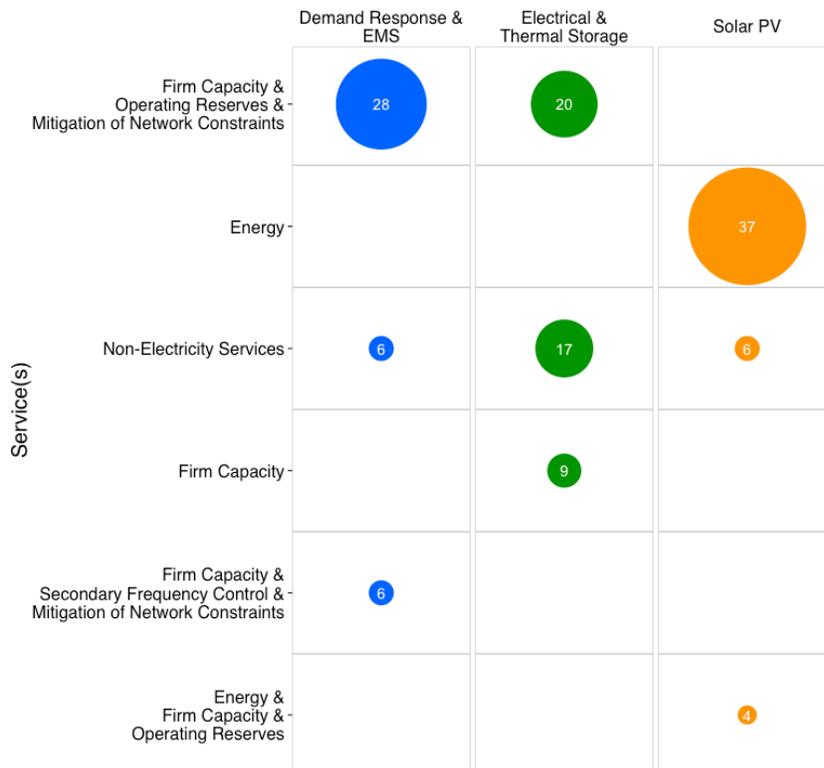


Figure 2 summarizes the customers targeted by the business models in our sample. Business models that act as intermediaries between (and therefore service providers to) two agents are represented with a double-sided arrow (<->) connecting the two customer segments. Commercial, institutional, or municipal customers are represented by the abbreviation “C/I/M.” The customer segment “DER Provider” indicates that the company is selling its products to businesses that then integrate one or more of these DERs at customer sites. The “Regulated Utility” customer segment refers to network companies – distribution, transmission, or both. This customer segment also refers to utilities that are vertically integrated such that they are also function as the load-serving entity. Figure 2 shows that the majority of business models are targeting end users directly. DR and EMS companies primarily target larger commercial and industrial customers, while the customer

segments targeted by solar PV and storage companies are more diverse. A smaller number of companies are selling services directly to regulated utilities or independent system operators (ISO).⁶

Figure 2: Customer Segment Summary

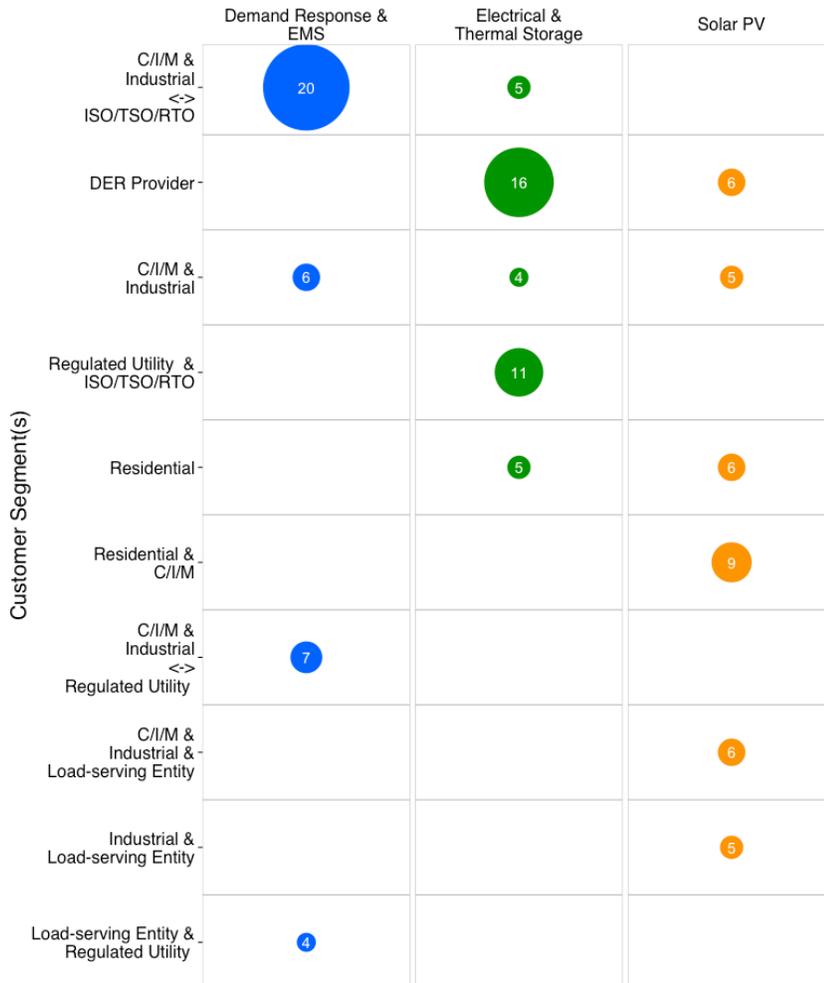
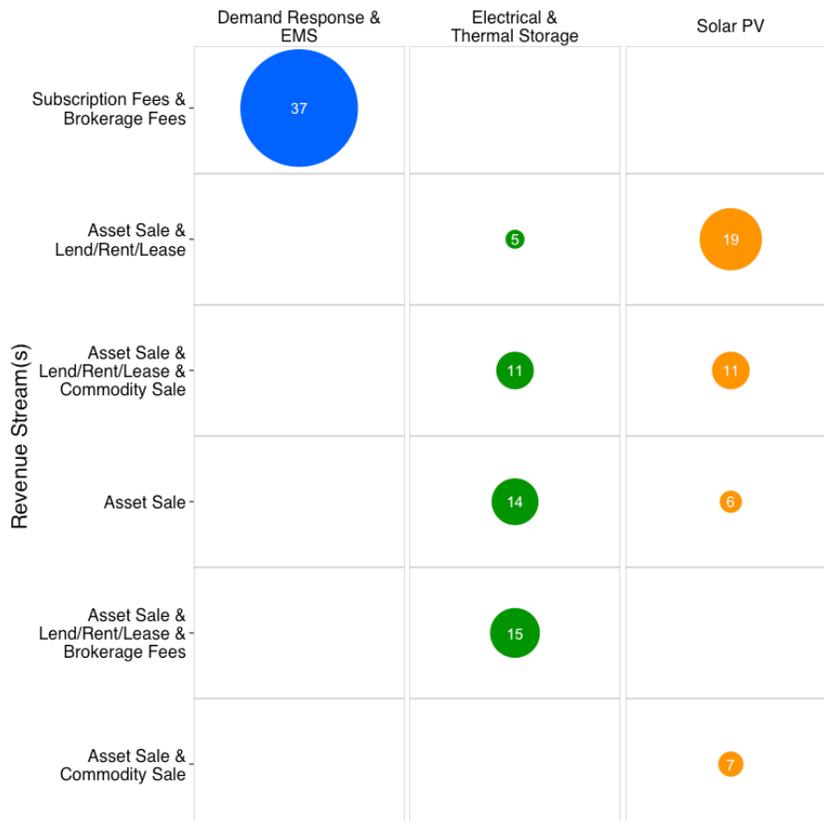


Figure 3 summarizes the revenue streams leveraged by the business models in our sample. Many companies leverage multiple revenue streams. The structure of the revenue streams often depend on the customer segment(s) that is/are targeted. For example, many solar PV integrators offer consumers the option to

⁶ The role and structure of the system operator changes with from system to system. The system operator, referred to in all diagrams with the “ISO/ TSO/ RTO” tag, is the agent responsible for ensuring reliable bulk system operation through scheduling and procurement of services such as operating reserves. The ISO/ TSO/ RTO tag indicates that the business is either selling bulk system services such as operating reserves to the system operator or that the business is selling services such as energy directly to bulk power system markets. While in the United States, power markets are operated by the system operator, in Europe, these markets are typically operated by independent power exchanges. For the sake of conciseness, this has simply been represented as the ISO/ TSO/ RTO tag.

directly purchase their systems, lease them (or sign a power purchase agreement – a related revenue stream discussed below), or take out a loan for the system. Notably, the vast majority of DR companies leverage subscription fees or brokerage fees (or a combination thereof) for their services. Such brokerage fees are typically structured as shared savings arrangements or as fees on payments earned in markets. Given the nascence of the storage market and the difficulties in predicting end user savings, storage business models have so far relied heavily on asset sales or financing.

Figure 3: Revenue Streams Summary



Using the same set of data as that presented in this section, the following sections explore each of the three DER categories in much greater detail. For each of the three DER categories, the following sections define a relatively small set of business model “archetypes,” each encompassing many individual business models. These archetypes circumscribe the key value creation and capture components of the most common DER business models that exist today.

5 DEMAND RESPONSE & ENERGY MANAGEMENT SYSTEMS BUSINESS MODELS

Business models for demand response and energy management systems have received increasing attention in recent years [21,31]. Demand response (DR) encompasses a large category of technologies and applications. It refers to energy loads that can be adjusted to provide electricity services to the power system. DR can be automatically activated in response to price signals, manually in response to a request from the DR business, or via an alternative dispatch signal [32]. Energy management systems (EMS) are computer-based systems for monitoring and controlling energy loads in buildings and are often critical components of demand response business models. DR can be thought of in three, not necessarily mutually exclusive, categories based on the method of activation: reliability, economic, and pricing-based [33]. Reliability DR is typically activated directly by system signals and used in times of scarcity to prevent outages. Economic DR resources participate in energy markets or bilateral trading (and fulfill the associated requirements). Pricing-based DR responds to energy or demand pricing signals (such as real-time pricing tariffs or critical peak pricing incentives) without participating in bilateral or multilateral energy markets.

Figure 4 depicts the DR and EMS business model landscape. The figure shows the customers targeted (horizontal axis), services provided (vertical axis), and revenue streams leveraged (color) by business models. The size of each circle represents the number of business models within a given category.

Figure 4: Demand Response and Energy Management Systems Business Model Taxonomy

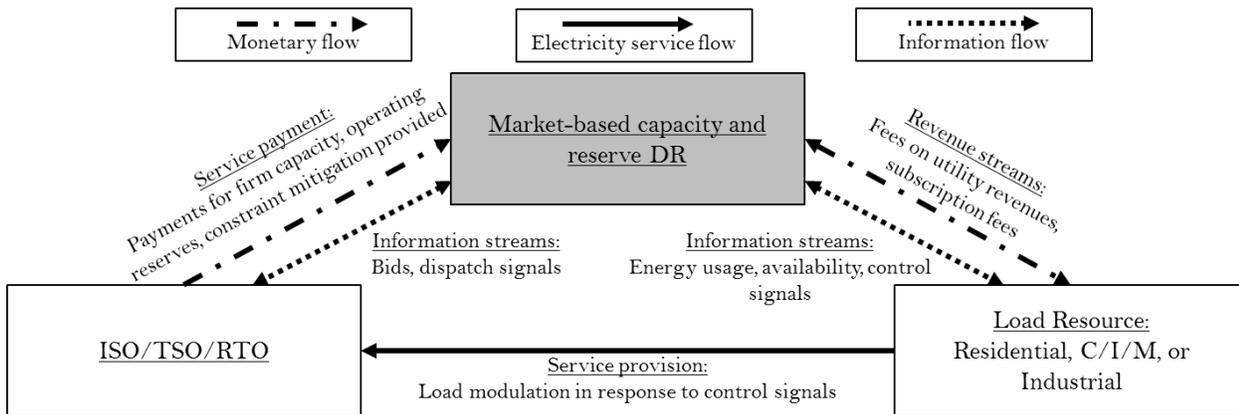


From Figure 4, we can identify three major business model clusters, or archetypes, that share similar characteristics (i.e. that target similar customers and provide similar services). A brief description of each of those business model archetypes is provided below.

5.1 Market-based capacity and reserve DR

The majority of DR and EMS business models have emerged in restructured power markets [32,34,35]. The market rules that will determine the exact structure of products procured from DR business models vary from market to market [21,35]. However, a number of common, market-independent themes can be found among business models that fall within an archetype that we have defined as “market-based capacity and reserve DR.” The generic structure of this business model archetype is depicted in Figure 5 and described below.

Figure 5: Generic market-based demand response business model structure



Businesses within this archetype most commonly target large C/I/M and industrial customer segments. This is due to a number of factors including market rules such as minimum bid-size requirements, transaction costs, and customer acquisition costs [21]. These businesses often provide an EMS (or similar product) to the targeted customer to optimize the customer’s energy consumption (and production in the case of customers with on-site distributed generation); the EMS also enables the customers to participate in ISO-based DR programs, with market interaction facilitated by the DR business. In certain cases, the businesses do not provide an EMS-like product, and loads are simply controlled through alternative measures (e.g. phone calls instructing customers to manually respond). These business models most commonly leverage customer loads such as lighting, HVAC units (chillers and fans), refrigeration units, other variable frequency drive units, idiosyncratic industrial process loads, and customer-sited generation such as backup diesel or gas units, fuel cells, or batteries [31,36]. Among the various types of operating reserves, DR is most commonly deployed for secondary reserves (e.g. “contingency reserves”); however, the provision of primary reserve services is becoming increasingly common [37]. Secondary reserves are favored amongst DR providers, as secondary reserves are dispatched less frequently and the required response time is typically lower than primary reserves.

These businesses typically make a profit by taking a portion of the revenues generated from the sales of these services – that is, by brokering market revenues (brokerage fees) – and/or by charging for the use of the energy management software that enables the demand control (subscription fees). Note that the business model’s revenue is a brokerage fee, rather than a commodity sale; the business distributes the revenues associated with commodity sales to the DR resources under contract.

Table 3 includes several examples of business models that fall under this archetype. EnerNOC and REstore are typical examples of businesses selling to C/I/M and industrial customers. Ohmconnect is an interesting exception in that it explicitly targets residential customers through a user-friendly app. By sending signals

to homeowners directly or communicating with home area network (HAN) connected devices, Ohmconnect enables residential consumers to participate in power system markets. Encycle targets mostly small and midsize C/I/M facilities, which are commonly overlooked amongst DR businesses.

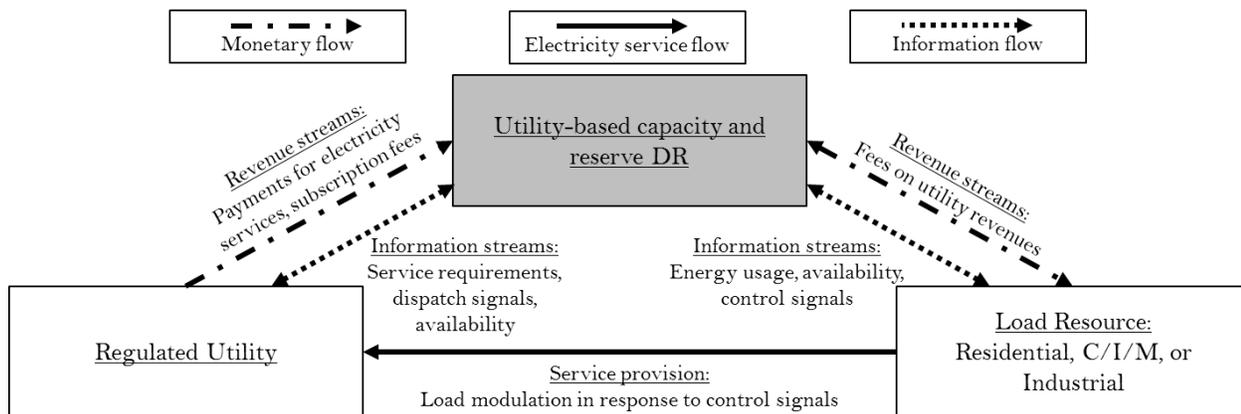
Table 3: Market-based demand response business model examples

Market-based capacity and reserve demand response	
<p><u>Large DR resource business models</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> • C/I/M & Industrial <-> ISO <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> • Firm capacity, operating reserves, & constraint mitigation 	EnerNOC (United States)
	Innovari (United States)
	Restore (Europe)
<p><u>Small DR resource business models</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> • Residential & small C/I/M <-> ISO <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> • Firm capacity, operating reserves, & constraint mitigation 	Ohmconnect (United States)
	Encycle (United States)
	Lichtblick (Europe)

5.2 Utility-based capacity and reserve DR

The second largest cluster of DR and EMS business models, which we have called “utility-based capacity and reserve DR” companies, sell demand response products directly to regulated utilities. The utility customers of these DR businesses tend to operate in vertically integrated or partially restructured markets (i.e. markets without competitive retail supply). Regulated utilities will contract with DR providers to procure (most commonly) firm capacity, operating reserves, and mitigation of network constraints. These utilities will either operate these programs under compulsion from their regulators or, in certain cases, proactively seek regulatory approval (see, for example, Consolidated Edison’s program [38], or Tuscon Electric Power’s program [39]). The generic structure of this business model is depicted in Figure 6.

Figure 6: Generic utility-based demand response business model structure



In these cases, distribution utilities seek an explicit (although sometimes unlimited) capacity of qualifying demand response resources. DR businesses procure DR resources at prices determined by negotiation with the utility and the regulator. In many cases, a single DR business will operate the DR program on behalf of the utility [21]. Participating load resources obtain a share of the revenues earned by the DR aggregators. This represents a strict departure in strategy from the market-driven DR business model archetype described above; the DR provider’s focus is on selling products to the utility and working with the utility to connect with (most commonly) C/I/M and industrial customers. In some cases, the utility will help the DR provider in targeting specific customers or customer classes (DR/customer engagement opportunity identification is a stand-alone service provided by certain ICT companies as well). These DR businesses tend to earn revenues through subscription fees (i.e. payments from the utility linked to the provision of the DR management software, etc.) or brokerage fees (i.e. keeping a share of the revenue earned from the sale of the DR resource to the utility). Many of the businesses operating in market environments also operate in these regulated environments; examples include EnerNOC and Comverge.

While in market-driven environments transaction and customer acquisition costs have driven DR business models to target larger C/I/M and industrial customers, the regulated environment allows for greater participation of residential loads. Many of the businesses provide similar services as business that leverage commercial and industrial loads (i.e. firm capacity, operating reserves, and mitigation of network constraints). However, the technical requirements of coordinating very fast responses from residential loads has limited the majority of the business models in the archetype to providing only capacity and secondary reserves [40]. The most common loads that are leveraged by residential DR companies are HVAC units. Examples of business models of this type include Comverge and EcoFactor. Nest, a residential smart thermostat provider, offers a similar service through its “Rush Hour Rewards” program.

An exception to the above model is the “behavioral” model. Businesses that use this model tend not to provide explicit control or dispatch signals, but rather provide “nudges” and targeted incentives to create a response [41,42]. These businesses sell their services directly to the regulated utility and do not engage with the consumer outside of the context of the behavioral program. The revenue model is typically based upon subscription fees and shared savings (brokerage fees) charged to the utility. Examples of business models of this type include Opower and Tendril. Table 4 includes several examples of business models within this archetype.

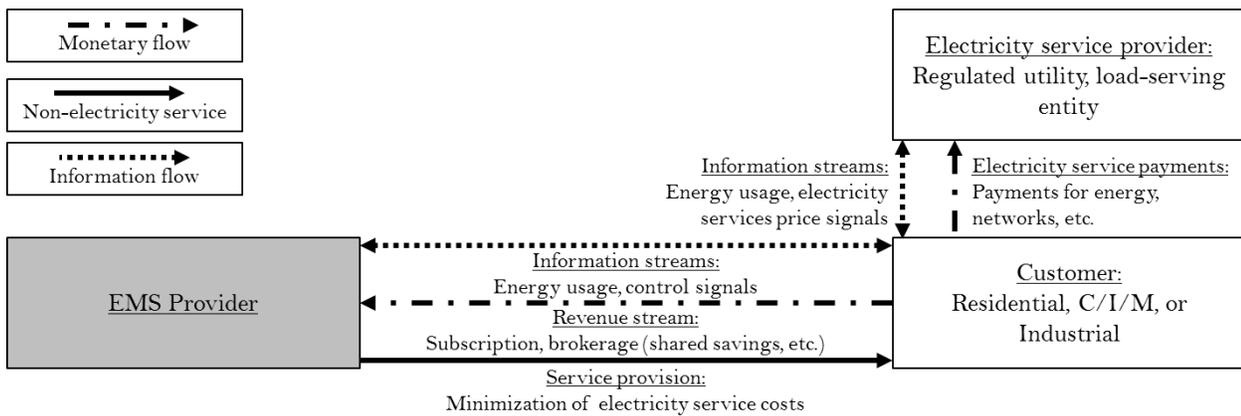
Table 4: Utility-based demand response business model examples

Utility-based capacity and reserve demand response	
<p><u>Traditional utility DR resource business models</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> • C/I/M & Industrial <-> Regulated Utility <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> • Firm capacity, operating reserves, & constraint mitigation 	EnerNOC (United States)
	Comverge (United States)
<p><u>Residential-focused utility DR business models</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> • Residential & C/I/M <-> Regulated Utility <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> • Firm capacity, secondary operating reserves 	EcoFactor (United States)
	Comverge (United States)
<p><u>Behavioral utility DR business models</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> • Residential <-> Regulated Utility <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> • Firm capacity 	Opower (United States)
	Tendril (United States)

5.3 EMS providers

Finally, there are a set of businesses providing energy management systems with a focus on managing on-site operations without market interaction. These business models, which we have called “EMS providers,” are focused primarily on the optimization of local energy usage in response to energy prices and local needs. A generic structure of the EMS business model is depicted in Figure 7.

Figure 7: Generic energy management service business model structure



These businesses tend to target C/I/M and industrial customers [31]. Given that the focus of these business models is primarily on optimizing the consumption of energy services (rather than providing them), we have not considered them as providers of electricity services. Instead, they act as enablers of energy service provision by electricity consumers themselves. These businesses tend to earn revenues from shared savings arrangements (a type of brokerage fee), subscription fees (for the software provided), and asset sales of monitoring and control equipment. Examples of business models of this type for C/I/M and industrial customers include Gridpoint Energy and MeteoViva, and examples for residential customers include Nest and Wiser (a Schneider Electric company). Table 5 provides examples of EMS businesses.

Table 5: Energy management system business model examples

Energy management system providers		
<p>EMS Providers</p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> Residential, C/I/M, Industrial <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> Non-electricity services 	C/I/M & Industrial Providers	Gridpoint Energy (United States)
		Blue Pillar (United States)
		MeteoViva (Europe)
	Residential Providers	Ceiva Energy (United States)
		Rainforest Automation (Canada)
		Wiser/Schneider Electric (Europe)

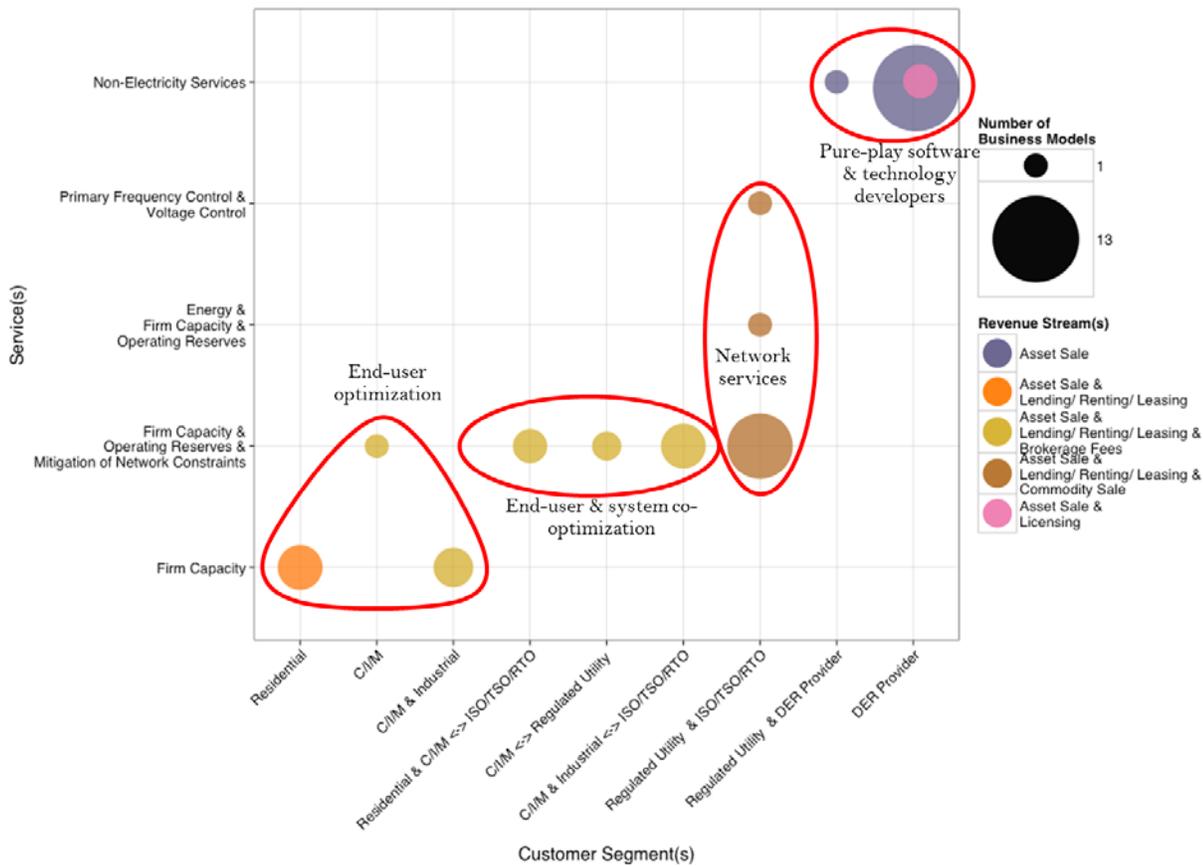
6 ELECTRICITY AND THERMAL STORAGE BUSINESS MODEL ARCHETYPES

Electricity and thermal storage technologies⁷ are often lauded as critical components of a clean energy future. It is not surprising that energy storage deployments have been rapidly increasing [44]. Pumped hydro energy storage and molten salt thermal storage account for the vast majority of installed energy storage capacity to date, but these technologies are poorly suited for distributed applications [44]. Lead-acid technologies make up the bulk of distributed energy storage installations globally, although Lithium-ion (Li-ion) and other advanced technologies are gaining traction [45,46].

Energy storage technologies tend to be relatively modular and are diverse in their use cases [20,47]. However despite such diversity, the business models can be clustered into three major archetypes. Figure 8 shows the electrical and thermal storage business model landscape and clusters. Business models that deploy energy storage technologies in conjunction with solar PV are discussed in the solar PV section below.

⁷ Note that thermal storage technologies in this case excludes the storage of thermal energy in building heating and cooled space, as this is categorized as demand response.

Figure 8: Electrical and Thermal Storage Business Model Taxonomy



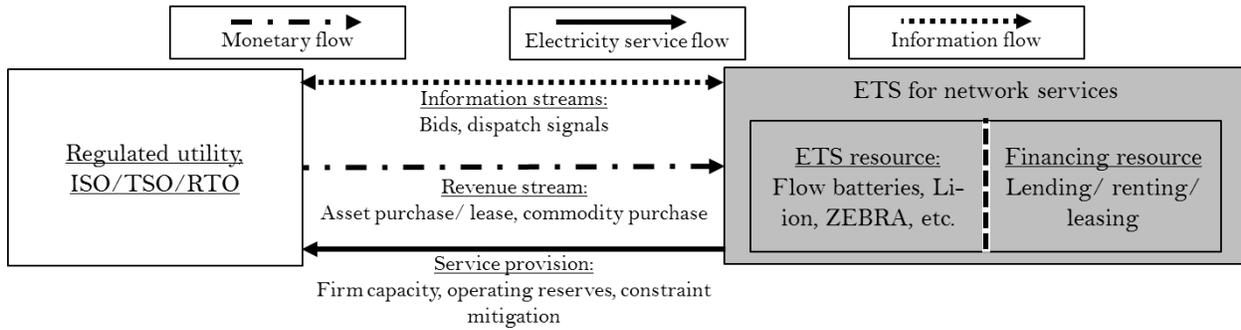
From Figure 8 we see three major (non-manufacturer) archetypes. The primary defining feature of each archetype is its level of integration within power system operations. A number of business models are focused on the provision of ICT-based optimization and control services for energy storage technologies. Some of these businesses actively deploy projects and provide energy services to power system operators, while others simply provide optimization and control products to other businesses or end-users. Business models that fall into the latter category are categorized, along with technology manufactures, as providing non-electricity services.

6.1 Energy storage for network services

Numerous studies have highlighted the value of energy storage technologies for network and system applications, including various network capacity and ancillary services benefits [26,48,49]. Certain states have begun legislatively requiring utilities to procure storage assets; for example, California’s Assembly Bill 2514 requires the state’s largest utilities to procure 1.3GW of storage by 2020 [50]. A cluster of business models, that we have called “energy storage for network services,” have emerged to meet this market. Figure

9 shows the general structure of this business model archetype; dotted lines are used between the financing function and the ETS resource management/deployment function to indicate that this function could be performed internally, or by partners that are external to the business.

Figure 9: Generic network services electricity and thermal storage business model structure



The majority of the businesses in this archetype are either technology-agnostic project developers, project developers with outsourced manufacturing but proprietary technology, or technology developers with downstream integrated project development arms. Business models in this archetype tend to either serve vertically integrated regulated utilities or system operators, or install batteries at industrial sites with the intention of providing network services. These businesses tend to either earn revenues from the sale or financing of the storage assets, or from the sales of the electricity services (typically firm capacity and operating reserves valued at market prices).

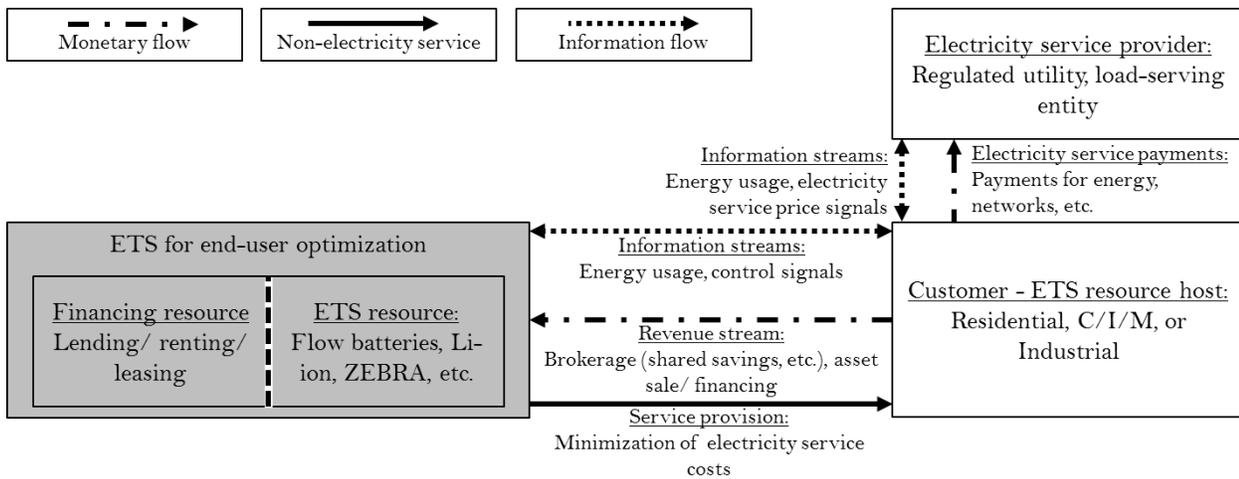
Table 6: Network services electricity and thermal storage business model examples

Electricity and thermal storage for network services business models		
<p>Network services business models</p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> Industrial, Regulated Utility, ISO <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> Firm Capacity, operating reserves, network constraint mitigation 	Technology-agnostic developers	Invenergy (United States)
		SunEdison (United States)
	Proprietary technology, outsourced manufacturing developers	Yunicos (Europe)
		AES Energy Storage (United States)
	Vertically integrated developers	Ecoult (Australia)
		Ambri (United States)

6.2 Energy storage end user optimization

End-user systems involve installing storage assets “behind the meter” at customer sites. These behind-the-meter systems have historically been deployed at customer facilities to manage peak demand charges and arbitrage between low and high energy price hours under time-of-use or real-time pricing tariffs (actions that are collectively referred to as “bill management”) [28,51]. These customers may be eligible to participate in bulk system markets but may desire not to. Alternatively, these customers may be in regions that do not allow for distributed assets to participate in markets. The general structure for this group of companies, which we have called “energy storage end user optimization”, is depicted in Figure 10.

Figure 10: Generic energy storage for end-user optimization business model structure



To date, the primary motive for the deployment of residential energy storage systems has been to increase the profitability of solar PV systems through increasing “self-consumption” (i.e. minimizing the export of energy produced onsite) [28,52,53]. For commercial and industrial customers, the primary motive has been the avoidance of demand-based consumption charges (i.e. charges per-kilowatt of peak demand) [51]. As technology costs have fallen, providing backup power to residential customers and critical commercial and industrial loads has also emerged as a driver [54].

Business models within this archetype typically earn revenues either through a form of shared or guaranteed savings arrangements⁸ – i.e. brokerage fees – or through the sale and financing of the storage assets [55]. Shared or guaranteed savings arrangements are less common at the residential level. Industry analysts expect

⁸ Guaranteed savings arrangements or other variations of performance contracts are brokerage fees with a hedge against non-performance. In these cases, the monetized value is the access to the savings. This brokerage fee differs slightly from those leveraged in demand response business models, where the monetized value is the access to new revenue streams.

that the financing options that contributed to the rapid rise of distributed solar (discussed below) will have the same effect on energy storage [56].

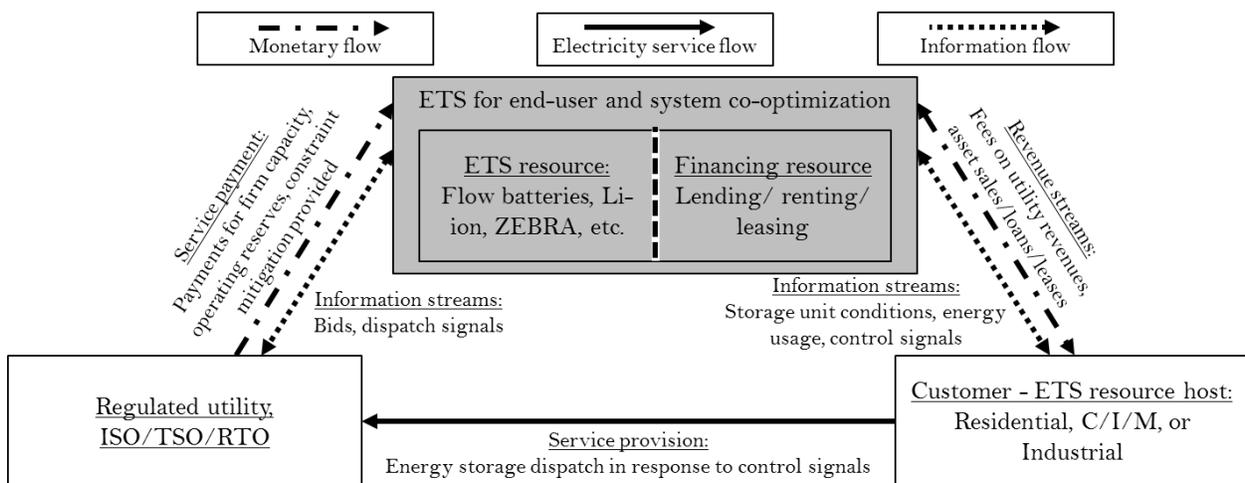
Table 7: Energy storage for end-user optimization business model examples

Energy storage for end-user optimization		
<p><u>Energy storage for end-user optimization</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> Residential, C/I/M, Industrial <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> Firm capacity 	C/I/M & Industrial ETS Providers	Stem (United States)
		Green Charge Networks (United States)
		Younicos (Europe)
	Residential ETS Providers	SolarCity (United States)
		Sungevity (United States)
		Sonnen (Europe)

6.3 Energy storage for end user and system co-optimization

Regulations and market design changes have emerged (or are emerging) to allow distributed resources to be aggregated and bid into power system markets (see, for example, the European Smart Grid Task Force Expert Group 3 recommendations, the New York Reforming the Energy Vision proceeding, the California Independent System Operator’s 2015 telemetry rulings, and ERCOT’s “DREAM” Task Force) [57–59].

Figure 11: Generic end-user and system co-optimization business model structure



In response to these emerging market-based opportunities, businesses are attempting to deploy storage technologies behind the customer meter that simultaneously attempt to lower costs to the end-user and

participate in power system markets. These businesses most commonly attempt to connect C/I/M and industrial customers with ISO markets, providing firm capacity, operating reserves, and mitigating network constraints. These businesses tend to earn revenues on the sales of the storage assets, and/or through brokerage fees on market-based revenues (e.g. fees leveraged for managing market interaction on behalf of the battery-host). Certain business models earn revenues on a shared savings basis (an alternative type of brokerage fee) [60]. A general structure for this business model archetype is presented in Figure 11, and examples of companies within the archetype are given in Table 8.

A subset of businesses have emerged to aggregate customer-sited storage assets and either allow direct utility control of these assets, or to provide control on behalf of the distribution utility. These business models have historically targeted commercial customers and have tended to operate on a similar asset sale and brokerage fee basis.

Finally, there exists a small subset of companies that are attempting to provide operating reserves to system operators through the use of thermal storage in bricks and water heaters. Given the large potential for the use of residential water heaters, these businesses have targeted not only commercial and industrial loads, but also residential loads. These companies tend to operate on a brokerage fee-basis similar to their larger storage counterparts.

Table 8: Storage for end-user and system co-optimization business model examples

Storage for end-user and system co-optimization business models		
<p><u>Storage for end-user and system co-optimization</u> <u>Typical customers:</u></p> <ul style="list-style-type: none"> Residential, C/I/M, Industrial <-> Regulated utility, ISO/TSO/RTO <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> Firm Capacity, operating reserves, network constraint mitigation 	C/I/M & Industrial providers	Stem (United States)
		Green Charge Networks (United States)
	Direct-utility control providers	Ice Energy (United States)
		Advanced Microgrid Solutions (United States)
	Residential and small C/I/M providers	Vcharge (United States)
		Steffes Corp. (United States)

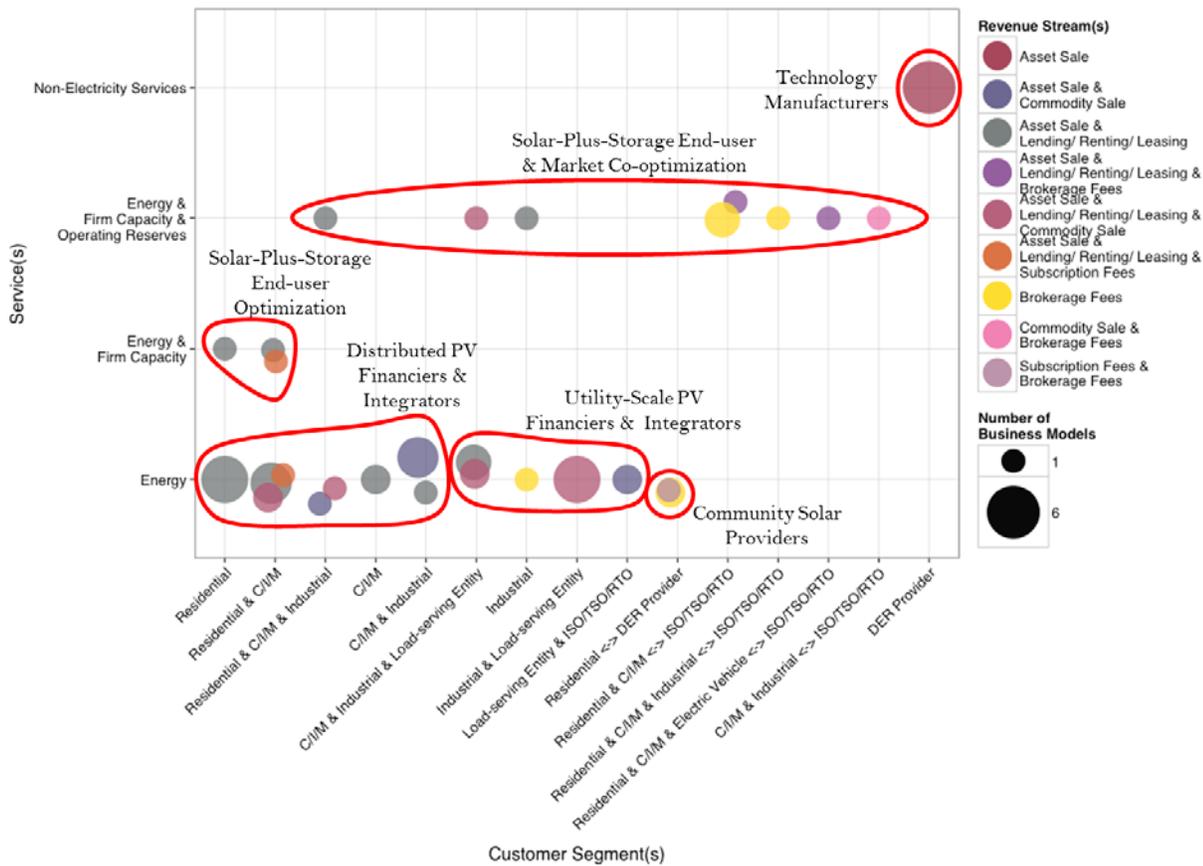
7 SOLAR PV AND SOLAR-PLUS-STORAGE BUSINESS MODEL ARCHETYPES

Solar photovoltaic (PV) technologies can be classified into two broad technology categories: wafer based and thin film [61]⁹. Crystalline Silicon (c-Si) modules currently account for roughly 90% of global manufacturing capacity, while thin film modules, led by Cadmium Telluride (CdTe), make up the remainder of the global manufacturing capacity [62]. Due to a number of factors including their higher efficiency, c-Si modules have historically dominated the relatively small distributed generation market [63]. Outside of niche distributed applications such as building-integrated PV and transparent PV, thin film technologies are largely used in utility-scale plants.

Figure 12 below depicts the solar PV and solar-plus-storage business model landscape, as well as clusters within it. Solar PV and solar-plus-storage business models target a diverse group of customer segments and use many different revenue models. Below we describe the solar PV and solar-plus-storage business model archetypes and explore some of the diversity within each archetype.

⁹ Note that solar thermal technologies, including Concentrated Solar Power (CSP) technologies are excluded in this review. Solar PV technologies account for over 98% of installed solar capacity, and nearly 100% of the global distributed solar capacity [99].

Figure 12: Solar PV and Solar-Plus Storage Business Model Taxonomy



7.1 Solar-plus-storage business model archetypes

Solar-plus storage systems have similar deployment trends to their storage-only counterparts; certain integrators are focused on connecting distributed PV and storage assets with bulk power system markets or system operations, while others are focused primarily on maximizing the system owner’s financial returns without integrating with markets or system operations.

Distributed energy storage paired with solar PV has become the focus of intense academic and industry study. Academic studies have focused on the potential technical benefits of distributed energy storage and solar PV [64–67] and, to a lesser degree, the economics of deploying these systems [52,68]. Industry and trade organizations have focused on the economic attractiveness and system-wide economic implications of PV and storage systems for network service providers and vertically integrated utilities [69–73]. Of particular interest is the ability for these systems to enable the system host to significantly reduce or eliminate their total consumption of energy from the bulk power system, thereby reducing network congestion and deferring

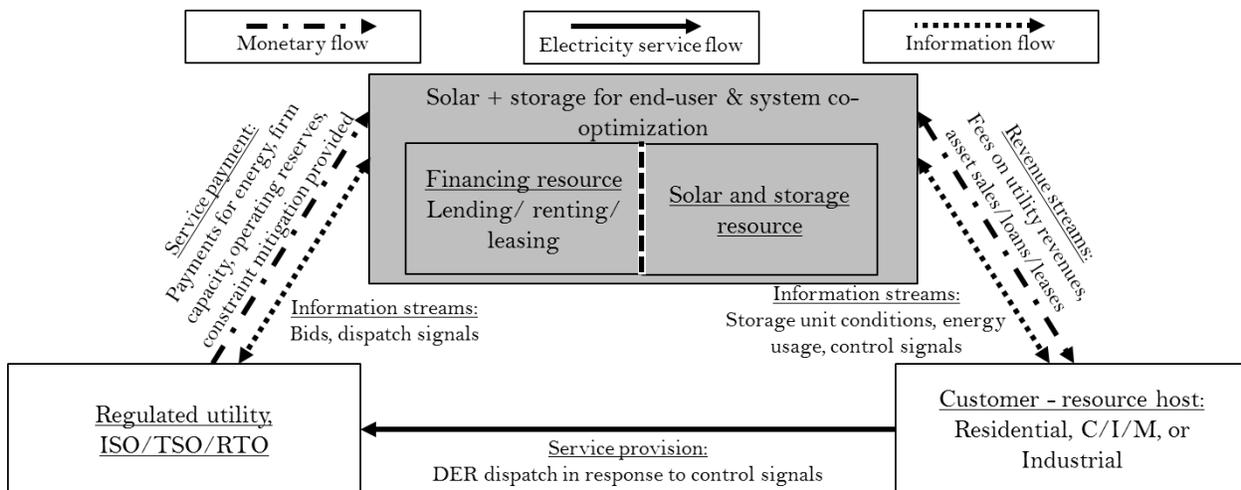
investments in network reinforcements (but also commonly resulting in a shift of sunk network costs from the system hosts to other network users) [51,69,70,73].

The interest in energy storage and solar PV is not purely academic. Many electricity storage companies are forming partnerships with solar PV companies and deploying their technologies. Several major solar PV and electricity storage businesses have formed partnerships over the past several years [74]. Furthermore, global investment banks such as Barclays and Morgan Stanley have downgraded the corporate bond ratings for certain utilities, due largely to the threat of solar PV and storage systems [71,75]. Electric vehicle manufacturer Tesla has announced plans to build a \$5 billion battery manufacturing facility, with the goal of producing stationary batteries for pairing with solar PV [45].

7.1.1 Solar-plus-storage end-user & system co-optimization

Solar-plus-storage systems deployed at customer sites are subject to many of the same market integration regulations and market rules as the storage systems discussed above. Certain system operators, such as the California ISO, have different rules for aggregations of multiple DER types (e.g. solar and storage) as they do for aggregations of single DER types (e.g. storage only) [76]. Figure 13 demonstrates the generic structure of the business model archetype that we call “solar-plus-storage end-user & system co-optimization.” Again, dotted lines are used between the financing function and the solar-plus-storage resource management/deployment function to indicate that this function could be performed internally, or by partners that are external to the business.

Figure 13: Generic solar plus storage for end-user and system co-optimization business model structure



A number of business models have emerged attempting to bring “firm” solar PV resources to market by pairing solar PV and storage technologies. The aggregations of PV and storage (and, in some cases, other technologies, such as demand response and distributed generators) are often termed “virtual power plants,”

or “VPPs.” Revenue streams are structured around the sales and financing of the assets and fees for brokering market interactions on behalf of the system hosts. In certain cases, businesses will own the projects and earn revenues on the sales of energy (most often under long term power purchase agreements), operating reserve, and capacity services (i.e. commodity sales revenues). Table 9 presents some examples of the businesses currently operating within this archetype.

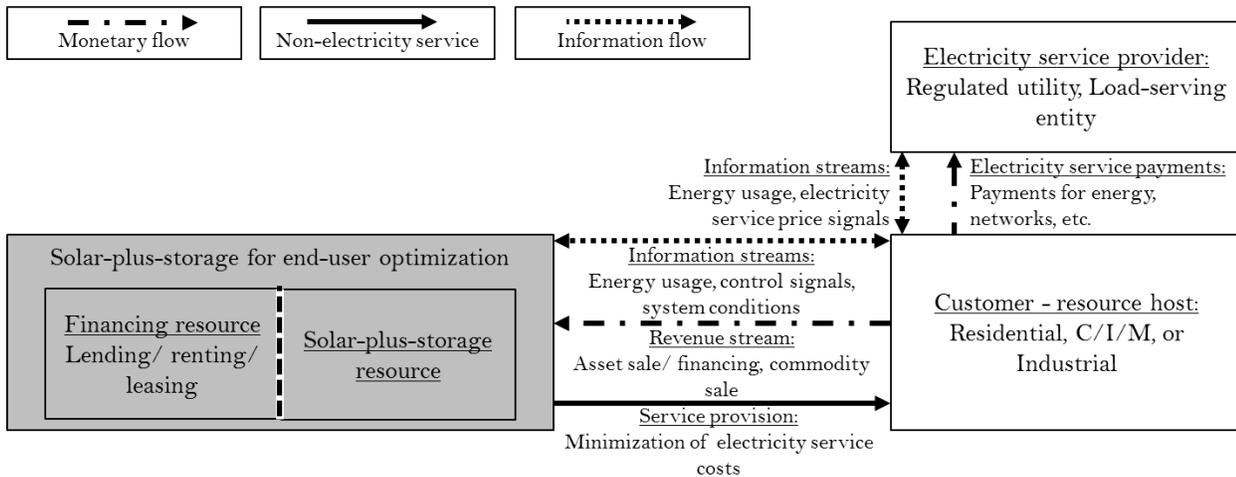
Table 9: Solar-plus-storage for end-user and system co-optimization business model examples

Solar-plus-storage for end-user and system co-optimization business models		
<p>Solar-plus-storage for end-user and system co-optimization</p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> Residential, C/I/M, Industrial <-> Regulated utility, ISO/TSO/RTO <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> Energy, firm capacity, operating reserves 	Solar-plus-storage developers	Sunverge (United States)
		Solar Grid Storage/ SunEdison (United States)
	Virtual power plant developers	Lichtblick (Europe)
		DONG Powerhub (Europe)

7.1.2 Solar-plus-storage end-user optimization

As noted above, solar-plus-storage systems have been most commonly deployed at customer sites to increase self-consumption (most often in the face of explicit incentives to do so), provide backup power, and minimize electricity demand charges. Figure 14 presents a general structure of this business model archetype, which we have called “solar-plus-storage end-user optimization.”

Figure 14: Generic solar-plus-storage for end-user optimization business model structure



Many U.S. states have explicit subsidies for energy storage technologies. In recent years, governments, including the German government, have begun offering subsidies for solar PV paired with energy storage [77]. These businesses operate very similarly to their pure-play storage or solar counterparts. They tend to sell products directly to residential and C/I/M customers and structure revenue streams around the sales and financing of solar and storage assets. Examples of companies within this business model archetype are presented in Table 10.

Table 10: Solar-plus-storage for end-user optimization business model examples

Solar-plus-storage for end-user optimization business model examples	
<p><u>Solar-plus-storage for end-user optimization</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> • Residential, C/I/M, Industrial <p><u>Typical Services:</u></p> <p>Energy, firm capacity</p>	<p>SolarCity (United States)</p>
	<p>Juicebox Energy (United States)</p>

7.2 Solar PV business model archetypes

PV system integrators fall into three key archetypes, each with significant internal nuances, which are explored below. All grid connected PV systems operate with a DC/AC inverter. These inverters have the capability to modulate their power factor, providing or consuming real power (during producing hours) and reactive power (at all hours). Modulating the power factor of distributed PV and storage systems has been shown to be effective at distribution voltage maintenance in certain cases [78,79]. Furthermore, Volt/VAR Control through PV inverters has been shown to enable conservation voltage reduction and line loss reduction, leading to significant power savings [80]. However, the economic opportunity of voltage support and CVR is currently considered to be rather small [49]. Furthermore, PV inverters have historically been required to operate at a power factor of unity in the U.S. Standards are currently being developed to allow for power factor control in the distribution system [81]. Germany has mandated that all PV inverters be capable of providing voltage support through reactive power control since 2009 [82]. Despite these recent developments, however, few frameworks have been developed to decide whether or not (and if so, how) to remunerate distributed PV systems for providing voltage support. For these reasons, no prominent business models exist to enable PV systems to provide these services, and all PV business models are currently focused primarily on energy provision.

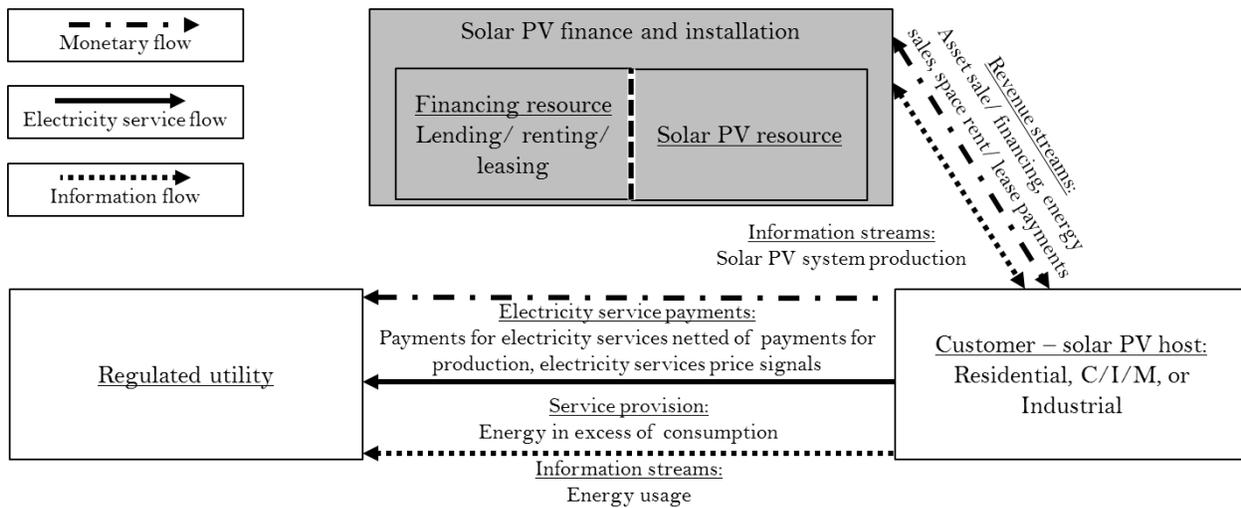
7.2.1 Distributed PV finance and installation

Historically, high capital costs have been a major impediment to PV adoption. Over the past decade, however, technology costs have fallen, and financing solutions have emerged to combat the challenge of high initial costs. Such “distributed PV finance and installation” companies comprise the largest solar PV business model archetype. The two dominant methods of financing distributed PV are direct ownership (through direct purchase or a debt product) and third party ownership models¹⁰ [83,84]. In 2014, third party ownership financing structures were employed in 60%-90% of installations in the largest residential PV markets in the U.S. [83]. Indeed, available financing has been shown to be a major driver of distributed PV investment [85]. Historically, third party ownership structures have been more popular in the U.S. than in the E.U. However, some industry analysts are predicting growth in these types of financing models as feed-in-tariff policies wane in Europe [86].

The exact structure of the financing option depends on the policy environment, the degree of technological development, and many other factors. In the U.S., the largest single explicit subsidy for distributed PV systems is the Investment Tax Credit (ITC). The ITC is a credit applied to the income taxes of the ITC claimant that is based on the capital cost of the installed system (for a basic review of the ITC, see [87]). However, many homeowners and small business owners do not have the “tax appetite” (i.e. do not pay enough in taxes) to fully benefit from this subsidy [84]. Business models have emerged to capture this subsidy and enable the customer to procure the PV system for low or no up-front costs. Typically the installer and a third party (i.e. neither the installer nor the PV system host) own the PV system and monetize the ITC [84]. The PV system host then pays the installer/owner a lease payment or a payment for the energy produced (the two payment methods are functionally identical) [84]. In feed-in-tariff (“FIT”) and net-metering environments, the business’ revenue stream can be generated directly from the sales of energy at the FIT or net-metered rate; in these cases, the business will typically rent or lease the real estate (including rooftops) from the system host. Finally, in European markets and with increasing regularity in the U.S., loan products offer a path to reducing upfront investment barriers [83,88]. Figure 15 reflects the generic structure of this business model archetype.

¹⁰ Niche financing options such as Property Assessed Clean Energy are emerging, but the dominant methods remain direct and third party ownership.

Figure 15: Generic solar PV finance and installation business model structure



The exact structure of the project deployment financing may dramatically change the economics of projects. However, the financing structure does not change the basic components of the business model (i.e. the business is still earning revenues through a lease-like payment). For a detailed description of deployment financing methods for solar PV, see Lutton [89] and Speer [84]. Furthermore, there are a number of methods for selling bundles of solar PV projects after the projects have been installed; these options fall into the categories of securitization and bonding. These methods can significantly lower the cost of capital for the businesses installing the assets [90]. However, these post-installation bundling and sales methods do not dramatically change the electricity services aspects of the business models discussed. That is, the business must still identify/locate a customer, install a system, and deliver an electricity service which generates a revenue stream sufficient to justify the cost of capital.

A significant amount of variation exists in the role and the degree of vertical and horizontal integration of the solar PV integrator. For example, some small installers partner with larger financiers; others outsource the installation of the systems. Still others perform the installation and financing functions themselves. SolarCity has announced plans to further vertically integrate into manufacturing. Certain businesses have undergone horizontal integration. For example, a number of load-serving entities (LSEs) have begun to provide solar PV. In these cases, the LSE earns revenues on the sale or financing of the asset as well as on subscription fees that are typically levied on retail customers. Some companies that have traditionally focused on home security services, such as Vivint Solar and Alarm.com, have also horizontally integrated into solar PV installation.

Finally, a significant number of business models have emerged that provide supporting services, such as generating sales leads, performing pure financing functions, or performing system maintenance. These services are categorized as non-electricity services.

Table 11 presents examples of some of the companies in this diverse solar PV business model archetype.

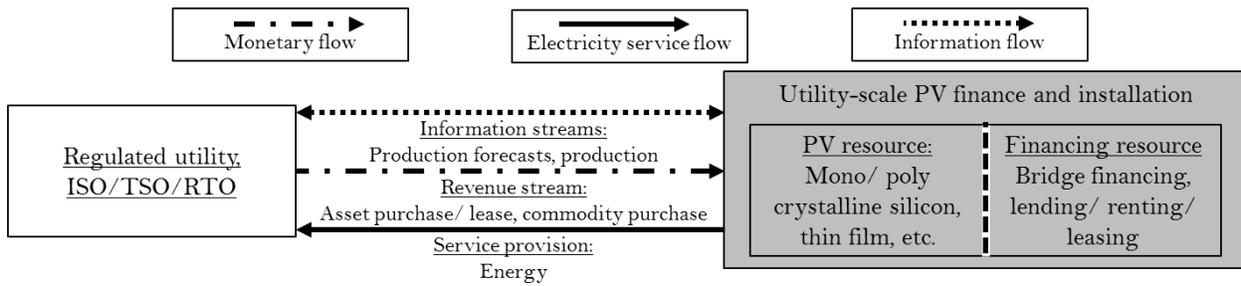
Table 11: Distributed solar PV finance and installation business model examples

Distributed solar PV finance and installation business model examples		
<p><u>Distributed solar PV finance and installation business model examples</u></p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> Residential, C/I/M, Industrial <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> Energy 	Vertically integrated providers	SolarCity (United States)
		Solairedirect (Europe)
	Non-vertically integrated providers	SunRun (United States)
		Clean Power Finance (United States)
	Horizontally integrated providers	Vivint Solar (United States)
		Vector (New Zealand)

7.2.2 Utility-scale PV finance and installation

It is difficult to demarcate the scale of installation that should be considered “utility scale,” as many “utility scale” plants are connected at distribution voltages [82]; for example, as of March 2013, 95% of solar PV capacity in Germany was connected to low and medium voltage networks, despite the significant number of multi-MW scale plants [91]. Nonetheless, many businesses focus exclusively on developing large, multi-MW scale PV plants. The primary driver behind these types of installations in the U.S. has been the fulfillment of “renewable portfolio standards” that require utilities or other agents (commonly the load-serving entity) to procure a certain quantity of solar PV (or credits associated with solar) by a certain date [92]. Therefore, large scale solar businesses commonly sell to multiple parties: the energy is sold through market or directly under PPA to industrial or regulated utility customers, while the renewable energy credits (RECs) associated with the energy are sold to another party. In certain cases, these businesses sell large projects to commercial or industrial customers and then sell credits associated with the energy produced to utilities [93]. These business models require financing structures that are often quite different from those deployed at smaller scale plants. Utility scale PV business models tend to be focused on the establishment of long-term power purchase agreements (PPAs, i.e., commodity sales). Figure 16 presents a general structure of such “utility-scale PV finance and installation” business models.

Figure 16: Generic utility-scale solar PV finance and installation business model structure



There are, as one would expect, many supporting roles and distinctions within the category of utility scale PV providers. Certain businesses are focused entirely on procuring the rights to land, ensuring that PPAs are signed, and sourcing contractors to perform construction. These “developers” will often eschew any ownership of the project after construction. Other engineering, procurement, and construction companies (EPCs) focus on exactly what their name suggests – engineering, procuring supplies for, and constructing the projects. EPCs tend not to take ownership stakes in the projects that they participate in.

Business models within this archetype utilize securitization methods similar to those deployed by the distributed PV business models discussed above [90]. As with the distributed business models, the method of securitization, bonding, or direct sale of the assets after installation functions primarily to lower the cost of capital for the installation, and does not significantly change the manner in which the electricity services are provided. Table 12 presents examples of companies within this archetype.

Table 12: Solar-plus-storage for end-user optimization business model examples

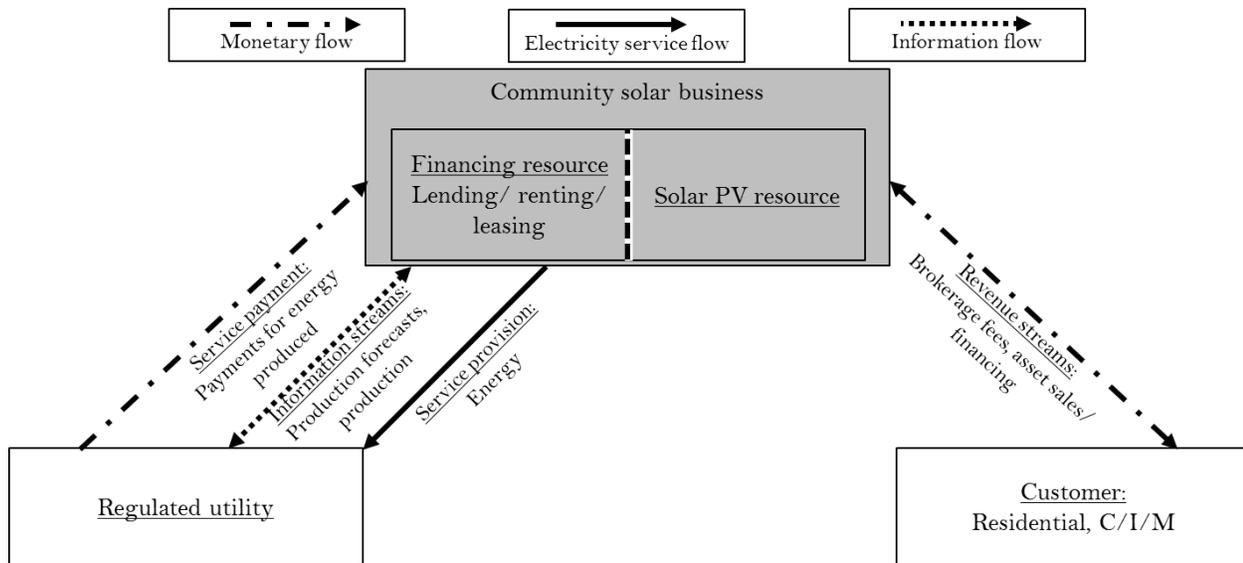
Utility-scale solar PV finance and installation business model examples	
<p>Utility-scale solar PV finance and installation</p> <p><u>Typical customers:</u></p> <ul style="list-style-type: none"> Industrial, Regulated utility, ISO/TSO/RTO <p><u>Typical Services:</u></p> <ul style="list-style-type: none"> Energy 	SunEdison (United States)
	First Solar (United States)
	Juwi Solar (Europe)
	Sainty Solar (China)

7.2.3 Community solar providers

Many residences or businesses are not proper sites for distributed PV installations because of shading, building ownership challenges, and other factors. “Community solar providers” have emerged to capitalize on economies of unit scale or to enable consumers located in unsuitable areas to procure solar PV. Community solar involves installing large solar PV plants located away from the customer site. Customers can purchase

the rights to a portion of the output of the solar plant, or can purchase an equity stake or share in revenues from a portion of the plant outright [94]. The business earns revenues by charging the customer for access to the PV system outputs (brokerage fees). The community solar provider will typically sell the plant’s output under a long term PPA, and distribute the associated revenues to the project’s shareholders [94]. Figure 17 provides a general structure of this business model archetype.

Figure 17: Generic community solar business model structure



The community solar provider approach has been particularly popular among regulated utilities that see it as an option to leverage their strengths and provide a value-added solar service [95]. The community solar market is still relatively small (tens to hundreds of MWs in the United States) and geographically restricted to policy-friendly environments, but is expected to grow robustly over the next decade [96]. An interesting and related model is that of solar “crowd funding” startup, Mosaic. Mosaic allows individuals (e.g. homeowners or business owners as opposed to banks) to offer funds (typically in the form of debt) to finance the construction of solar projects. In this way, Mosaic acts as a bridge between financiers (individuals) and system owners (other individuals), and charges a fee for offering this service (brokerage). Mosaic has used this same model to allow individuals to own parts of centralized plants – a form of community solar.

Table 13 provides examples of companies operating within the community solar provider business model archetype.

Table 13: Community solar business model examples

Community solar business model examples	
Community solar	NexAmp (United States)

<u>Typical customers:</u> <ul style="list-style-type: none"> Residential <-> DER Provider <u>Typical Services:</u> <ul style="list-style-type: none"> Energy 	Next Step Living (United States)
	Blue Wave Renewables (United States)
	Mosaic (United States)

8 DISCUSSION AND CONCLUSIONS

In this paper we have identified the key value capture and creation components of 144 distributed energy business models that are associated with three DER technology categories: demand response and energy management systems, electrical and thermal storage, and solar PV. Expanding upon an ontological approach developed by Osterwalder and Pigneur [18], we have identified the key electricity services, customer segments, and revenue streams for each of the business models in our sample. Within each of our three DER technology categories, we have identified a small number of distinct business model archetypes that are characterized by a relatively predictable set of value capture and creation components. Finally, we have explored in some detail the characteristics for each archetype in an attempt to surface the diversity within each archetype. Our analysis has led us to four observations about the DER business model landscape that we believe have important implications for electric utilities, DER entrepreneurs, policymakers, and regulators.

First, the fact that there exists a relatively small set of well-defined DER business model archetypes is an important observation in-and-of-itself. One might expect that, given the thousands of individual DER business models operating today, we would find a great degree of diversity in business models. However, our results show that today's DER business models cluster into a relatively small number of groupings that share key value-capture and creation components. This result suggests that the determinants of business success within a given archetype may include executional capabilities, culture, partnerships, and other activities that are not captured in our framework. Ontological differences alone do not appear to distinguish successful DER companies from their similarly-structured rivals.

Second, current DER business model archetypes appear to be driven more by regulatory and policy factors than by technological factors. This is arguably most evident with the solar PV business model archetypes but applies to all. In the U.S., the necessity of exploiting and monetizing the Investment Tax Credit has led to the emergence of the three solar PV archetypes described above. Moreover, solar PV growth has depended on state net metering policies. In Germany and much of Europe, solar PV growth has depended on feed-in tariff policies. Without these key policy and regulatory elements, we would not have seen the widespread emergence of the three solar PV archetypes described in this paper. To give another example, the majority of

business model within the “market-based capacity & reserve DR” archetype depend upon the existence of capacity remuneration mechanisms established by regulators and legislatures.

This, however, does not necessarily suggest that the DER business model landscape will continue to be defined and driven by regulation and policy. Continued cost declines and technological innovation may well lead to markets for DERs that are less defined by policy and regulatory conditions. Nor does it suggest that the archetypes that we have identified in this paper are here to stay. Indeed, the fact that archetypes are sensitive to regulation and policy suggests that they are very likely to change, as new regulations and policies are introduced, old ones expire, and existing ones change. These facts lead us to our third observation, which is that the business model landscape of 10, 15, or 20 years from now will likely look very different than the landscape of today.

Finally, to the degree that relatively static business model archetypes remain in place (e.g. because policy and regulatory conditions do not change), DER business models compete within those archetypes for market share in providing a limited set of commodity electricity services. Moreover, as DER business models and technologies become increasingly mature, business models will compete across archetypes. In particular, we can expect to see increasing competition between business models providing the same commodity electricity services. For example, demand response and energy storage technologies will compete to provide capacity-based services. We might also expect distributed PV businesses to face competition from utility-scale PV businesses. The services provided by these business models are by and large commodity services, indicating that differentiation beyond price may be difficult to realize. Given the regulatory- and policy-driven nature of these business models, only time will tell what the impact of this competition will be on the DER business model landscape.

Acknowledgements

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