Who knows what: information barriers to efficient DER roll-out

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Abstract While academic research on Distributed Energy Resources (DERs) has been mostly focused on first-best systems, we hypothesize that in reality multiple information barriers to efficient DER roll-out exist. We thus study the prevalence and importance of information issues arising in the context of deployment of DERs by reviewing the existing engineering and economic literature on distributed resources, analyzing DER-related regulatory proceedings, and surveying the relevant electricity sector stakeholders for their perception of information relevance and accessibility. Our findings suggest that there are substantial information problems, especially faced by DER owners and developers as well as non-profit organizations such as environmental groups. Some of the problems hinder the efficiency of DER roll-out, warranting new regulation, thereby indicating the role of policymakers for the future DER developments.

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1 Introduction

The rise in Distributed Energy Resources (DERs)—resources that reside in the distribution system, often behind the customer's meter—is reshaping the energy sector. With DERs, consumers become prosumers, altering electricity consumption profiles, potentially in ways that include steep ramp-ups in demand (Sengupta and Keller 2012). The new resources can reduce the power system's carbon-dioxide emissions (Eberle and Heath 2020), increase distribution system resilience and supply reliability against extreme disasters (Zeng et al. 2020, Shi et al. 2021), affect the business model of utilities, and necessitate changes in retail rate design to avoid cost recovery issues (Laws 2017, Kim and Dvorkin 2020). DERs also affect system conditions by imposing a shift away from the unidirectional electricity flows that distribution grids have traditionally been built for.[1]

The changes that DERs bring have spurred investigations into future policies and regulations needed for the energy sector, especially into market design reforms (Newbery et al. 2018, Revesz and Unel 2018), and to adjustments in DER compensation and retail rate design (Satchwell et al. 2015, Revesz and Unel 2020, Revesz and Unel 2017). The bulk of the research on DER-related policies and outcomes focuses on the idealized, "first-best" approaches (Zhou et al. 2013, Georgilakis and Hatziargyriou 2013, Jain et al. 2017, Contreras-Ocaña et al. 2018, Varghese and Shiosansi 2020), which (implicitly) assume complete information, i.e., that information about the existing system and electricity sector participants is common knowledge. Perfect information—agents having access to all information relevant for their decisions—is also a frequent feature of such studies. In practice, however, these assumptions do not hold true in the context of DERs (see for example Kim 2011), and thus the first-best modeling approach may be unsuitable for studying potential problems around the DER roll-out.

The availability of information is important for economic outcomes as, without perfect information, the First Welfare Theorem may not hold and private contracts may not be efficient. Ever since the seminal works of Akerlof (1970) and Mirrlees (1971), a rich theoretical and empirical literature has proven that information failures lead to socially suboptimal outcomes and welfare losses. With the absence or asymmetry of information,

[1] The distribution grid, including voltage regulation equipment, methods, and planning analysis, as well as distribution circuit protection schemes (e.g., fuses, reclosers, and sectionalizers) were designed for one-way power flows. Consequently, with DERs injecting power into the grid, problems might arise that may not be observed or sensed by existing protection systems. See Ros et al. (2018).

regulatory intervention is frequently needed to correct the outcomes (Stiglitz 2000, Armstrong and Sappington 2007, Stiglitz 2017). To correctly predict economic outcomes and compare economic policies, modeling therefore needs to account for the true distribution of information across agents and for the associated strategic behavior opportunities (Jehle and Reny 2001). Models that disregard the informational issues can thus produce distorted a picture of the functioning of the markets.

And while most of the economic literature and policy discussions around DER ignore information issues,[2] the incomplete or imperfect information is a widespread phenomenon in the energy sector. This has been repeatedly documented by the literature on utility price regulation (Baron and Myerson 1982, Lewis and Sappington 1988a, 1988b) and utility investment regulation (Lim and Yurukoglu 2018). Information issues have also been shown to arise in regulation of energy efficiency programs (Settle and Tschirhart 2003) and in the context of dispatch decisions where they affect how much market power the electricity sector participants can exert (Lo Prete et al. 2019, Brown et al. 2018a, Munoz et al. 2018). There also exist other, less documented information issues. Among others, detailed electricity consumption data is often unavailable, even to the serving utility, preventing consumers from performing optimal energy-saving investments (Blasch et al. 2019). Lack of transparent information about tariffs and electricity suppliers causes suboptimally low switching of electricity suppliers (Six et al. 2017). Imperfect foresight also decreases the efficiency of economic outcomes compared to the perfect information case, for instance, by decreasing operation effectiveness of systems such as flexible heating, ventilation, and cooling systems (MIT 2016).

As we argue in the paper, DERs amplify the existing information deficiencies in the electricity sector by introducing a novel set of information issues. And, while great amounts of information are needed for deriving optimal DER targets, compensation, or tariffs, the mechanisms to extract the relevant information are largely missing.

This paper aims to highlight the sources and importance of information barriers around DERs. We identify and examine DER-related information problems and the current policy responses in the U.S. to learn what unavailability of information can imply for the DER energy transition. We also describe what information is needed for the success of the power

[2] There are few notable exceptions such as O'Boyle (2017), Brown and Sappington (2018), Brown and Sappington (2019), Brown and Sappington (2020), Jenkins and Perez-Arriaga (2017) as well as New York Public Service Commission's case 14-M-0101.

sector reforms and how policymakers can help make the information available without imposing unnecessary burdens.

For our analysis, we pull insights from three sources. First, we review engineering and economic literature on DERs for existing findings on the role of information in the context of DERs. Second, we review state-level proceedings where information access emerged as an issue to identify information problems around DERs and the various ways in which policymakers approach those problems. Finally, we survey electricity sector stakeholders—consumers, utilities, DER-focused parties (owners, developers, and aggregators), environmental groups, regulators, and others—in multiple states to inquire about their perception of information relevance and accessibility. Our survey aims at providing insights on the relative importance of the information challenges for various electricity sector actors and the ways with which they deal with them in practice.

Our findings suggest that there are substantial information problems, especially faced by DER owners and developers as well as non-profit organizations such as environmental groups. Some of the problems hinder the efficiency of DER roll-out, warranting new regulation, and thus indicating the role of policymakers for the future DER developments. Our results also mean that economic and engineering literature needs to account for information accessibility when modeling DERs.

The structure of this paper is as follows. In Section 2, we present the methodology of our survey. We then review what new information problems warrant attention in case of DERs, referencing our survey results to illustrate the magnitude of these problems. In Section 4, we discuss in more detail the most prominent DER-related examples of missing information, discussing the solutions proposed by the regulators, whenever a solution was attempted. Finally, we outline the policy implications and conclude.

2 Design of the survey

While academic research on DERs has been mostly focused on electricity systems free of market failures, distortive regulations, or any other features decreasing their efficiency ("fist-best systems"), we hypothesize that in reality multiple information barriers to efficient DER roll-out exist. To investigate this hypothesis, we analyze the literature, regulatory proceedings and design a survey that we distributed among electricity sector stakeholders.

The survey targets the parties directly engaged with DER-related policymaking, e.g., resource owners, regulators, utilities interconnecting the resources. To ensure that we reach such parties, we searched the relevant U.S. trade press for recent state-level proceedings on DER remuneration,[3] of which we identified 14 (listed in in Table 2 in Appendix A), 13 of which had service lists. The service lists are lists of names and contact information of the parties entitled to receive a copy of all documents related to the proceeding and of anyone other than a party who has asked for copies of those documents. In other words, the service lists contain contact information for representatives of organizations that actively engage in a given issue or follow it. As the identified proceedings focus on DERs, we assume that those enlisted are familiar with developments around DER and likely directly involved in them.[4]

We ended up with a total of 1047 valid contact records.[5] We reached out to the identified contacts via email, shortly introducing our study and inviting them to participate in the survey. We informed the participants that their answers would not be shared with third parties and that the results would be aggregated in any publication to protect anonymity. Later, we sent two reminder emails. The invitation email is attached in Appendix B.

The survey is presented in full in Appendix C and consists of two parts. The first one identifies the type of organization represented and asks common questions, such as the strength of impacts of the information issues, the ways in which these issues affect functioning, the sources of information, and the ways of dealing with lacking information. As the survey occurred during the coronavirus pandemic, which could influence the information availability and processing, we also ask respondents whether the coronavirus crisis impacts any of their answers.

The second part of the survey asks questions specific to the type of organization, whereby we differentiate between consumer or representative of consumers, utilities or representatives of utilities, environmental organization, DER-centric organization, regulators, and "others." The organization type-specific questions inquire about the

[3] The search took place in January 2021 and relied mostly on DER-related articles in utilitydive.com and greentechmedia.com. While there exists a multitude of DER-related proceedings, the ones on remuneration usually attract the most participants, they are also the most wide-spread across the states and thus suitable as a search criterion.

[4] The contacts include mostly representatives of state regulators from public utility commissions, departments of environment and energy, etc., DER developers, aggregators, industrial electricity consumers, consumer advocate groups, environmental organizations, utilities, fossil-fueled generators, as well as consulting and law firms hired to represent the above-mentioned organizations.

[5] This number excludes contacts for whom the email survey invitation was returned with an error, contacts with first or last name missing, and repetitive contacts occurring when an organization representative is listed in more than one service list.

importance of the listed information items and, for information flagged as relevant, about its availability.

The organizations we surveyed are located in various U.S. regions and face different institutional configurations. For instance, some of them operate in regions with deregulated wholesale electricity markets while others are in settings with vertically integrated utilities. Therefore, we formulate the survey questions in a general manner, avoiding references to specific organizational arrangements or market structures. Given the relatively high number of questions and the technical nature of many of them, we use mostly closed-ended questions, reducing survey complexity and avoiding response fatigue.

While we cannot fully exclude potential response biases with such a question structure, especially the acquiescence bias, we believe there are a few factors that mitigate such concerns. First, we base the questions on a thorough review of the literature and regulatory proceedings, as well as on one-on-one in-depth interviews with electricity sector experts to ensure the relevance and the comprehensiveness of the available choices. Second, the responses indicate that respondents were selective with their choices, they are also coherent within an organization type. Finally, many of our insights rest on finding systematic differences in information problems between different organization types. Should biases be present, it is unclear that they would affect different organization types differently.

Our survey uses skip logic to ensure that the participants see only the questions that are relevant to them. As a testing ground for our survey, we used the proceedings in New York. We received 210 responses, out of which 145 were fully completed and the remaining ones were 60% complete (on average).

3 Relevance of information problems for DER roll-out

To provide a measure of the importance of the information issues, we asked survey participants to quantify on a scale between 0 and 10 the effect of missing or incomplete information on the functioning of their organization in the context of DERs (Q42). We also asked them about the need for new regulation to ensure the availability of relevant information for decisions related to DER (Q46), as we assume that organizations experiencing more severe and harder-to-overcome problems will support more regulation.

The results suggest that there are substantial information problems around DERs, but that the severity of those problems varies across stakeholders. Survey participants chose on average 5.9 as the strength of information effect but every fourth of them chose a value of

8 or higher. Introducing new regulations was supported by 61% of respondents, while 17% did not see a need for such measures.

Some of those differences can be explained by the type of organizations. In particular, DERs and environmental groups indicate experiencing systematically greater information barriers than utilities as we show in Table 1 where we regress the two responses on organization types. We find no statistically significant effect of the proceeding taking place in a regulated state or in a state where electricity markets are run by a regional market operator (RTO). While there are marked spatial differences, we find no systematic patterns here.[6] A summary of the responses to those two questions per state is given in Figure 1.

To understand what drives these information issues and why some organizations are particularly affected by them we turn to regulatory proceedings, academic research and survey results. They all point to unique features of DERs, which can induce new information issues in addition to reinforcing the existing ones.

The most distinctive feature of DERs—i.e., the fact that, unlike primarily bulk resources which connect to transmission networks, they are connected to distribution networks—plays an important role in explaining the existence of information issues and their distribution among the sector's actors. While transmission networks tend to be well-documented, with much of the documentation being public-facing, very little information about the topology, components ratings or other distribution network properties is publicly available. Utilities, which have the nearly full purview over distribution systems, have historically avoided releasing such information. As a result, non-utility actors face high information barriers when trying to learn about those networks.

This is a serious limitation for regulators (see Sections 194.3 and 4.4) and non-utility actors developing DERs (Section 4.2) as distribution network characteristics interact with DER assets in determining the location-specific social and private value of DERs. These interactions include the technical feasibility of assets in a given location and thus the cost of its interconnection, the impact of network congestion on the asset's ability to inject energy into the grid, and the assets' impacts on the functioning of the distribution network. Two otherwise identical assets can have very different social and private value if they are attached to geographically close, but separate feeders.

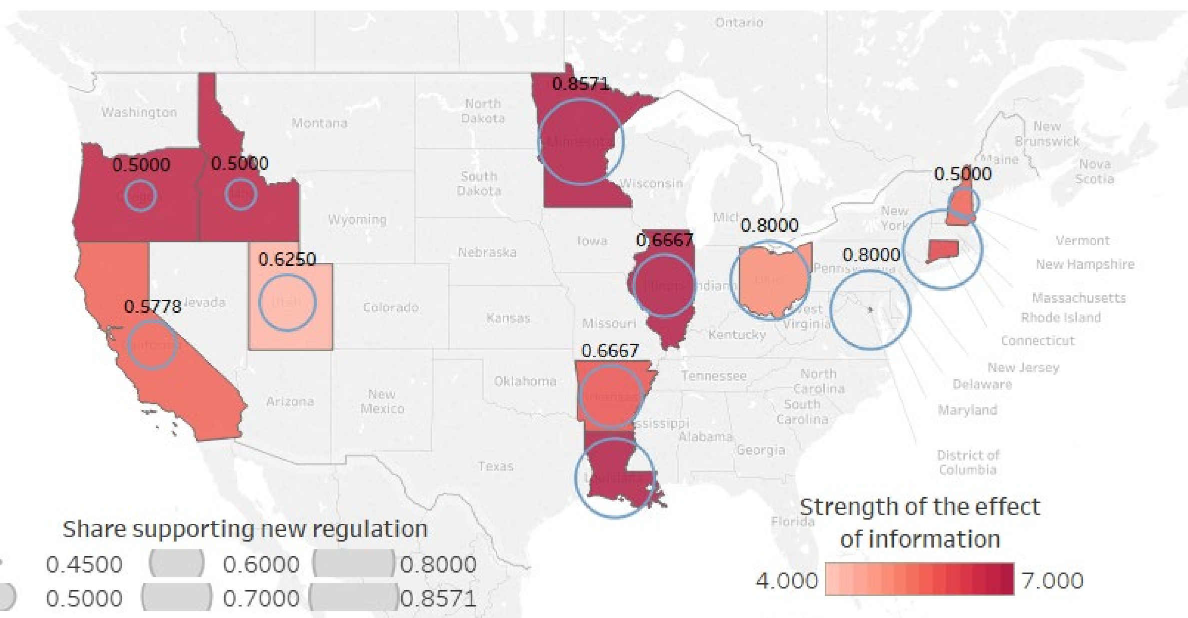
[6] It is worth emphasizing that our spatial and regional measures are very noisy. This happens as many organizations are engaged in multiple regions, such that their responses likely represent an average of experiences from various locations. However, our study assigns the responses only to one state – the state with the proceeding through which we identified the respondent.

Table 1 Importance of information problems across organization types.

Explained variable / Explanatory Variables	Strength of information effect (I)	Strength of information effect (II)	Support for new regulation (I)	Support for new regulation (II)
Constant (DER)	6.61***	6.51***	.833***	.804***
Customers	-.962	-.947	-.271*	-.258*
Utilities	-1.19*	-1.12*	-.533***	-.517***
Environmental groups	-.920	-.885	-.064	-.055
Regulators	-.779	-.821	-.25	-.264*
Others	-1.012	-.988	-.3**	-.288*
Regulated area		.283		.086
No. of observations	110	110	106	106
R^2	.042	.045	.154	.16

*** denotes 1% significance level, ** 5% and * 10%. New York participants were not asked these questions. "Regulated area" is a dummy variable equal to one if the proceeding through which we identified the organization took place in a regulated state and 0 in a deregulated state, i.e., in a state with retail competition.

Figure 1 Importance of information problems – geographical differences.



Color shows average of strength of the effects of missing information on organization's functioning. Size shows share of respondents who believe new regulation is needed to ensure access to missing information (also stated in blue). To protect the anonymity of the answers, the share of respondents supporting new regulation in Louisiana, Ohio and DC is shown as an average over those three regions. For the same reason, strength of the information effect in DC and Ohio shown is an average over answers in those two regions.

To study the importance of distribution network information, we provided participants with lists of potential information items and asked them to mark the ones relevant to them (Q7 for consumers) or evaluate how relevant each of the items is (Q18, Q26, and Q35 for remaining participants). We coded distribution network information as important if, in the case of consumers, "hosting capacity" or "distribution-level congestion" was marked in Q7. For other stakeholders, we coded distribution network information as important if at least one of the network-relevant items was evaluated as "moderately important", "important" or "very important." For non-utilities, we also inquired about the availability of that information (Q9, Q21, Q37). The results confirm the crucial role that distribution network information plays and its lacking availability Figure 2 illustrates.

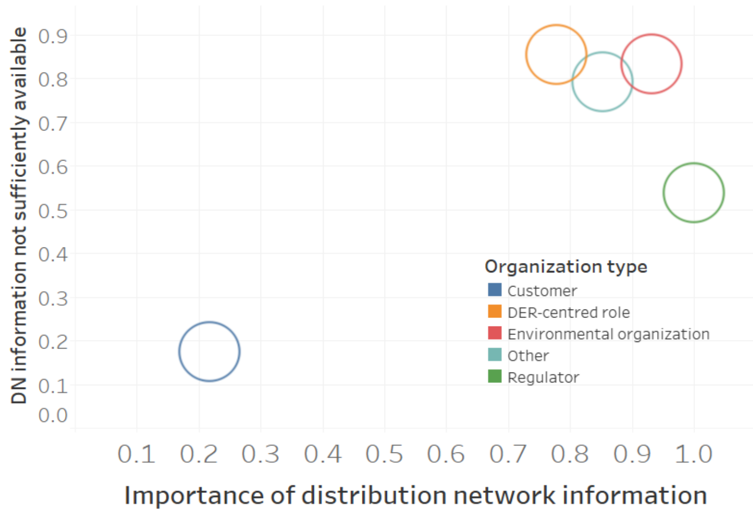
According to our survey (Q19 and Q38), the most important distribution network information relates to hosting capacity: 87% of DER-centered organization, 80% of environmental organizations, 80% of regulators and 72% of others marked it as relevant to their functioning. Other important network characteristics encompass apparent flow limits of the distribution lines (marked by 61% of all organizations), voltage limits of the distribution nodes (52%) and impedances (38%).

Second set of information barriers relates to customer data, which currently is prevalently at the disposal of utilities, in particular to the consumption data. This data is needed for the successful implementation of DERs such as energy efficiency or demand response programs as these programs depend on meter data flowing to aggregators, auditors, and software companies providing energy analytics. It also facilitates individual consumers' decisions about DER investments and regulators' analyses for tariff design and DER remuneration schemes (Sections 4.3 and 4.4). However, as we explain in Section 4.1, utilities face disincentives to sharing this data.[7] Consequently, they tend to refuse requests to release new data.[8] This reluctance to sharing consumer data effectively means that in many places

[7] From the perspective of the utilities, data sharing, apart from decreasing current and future revenue opportunities may also create privacy concerns and security concerns. Sharing information is also burdensome in that it requires devoting resources to the information preparation and distribution.

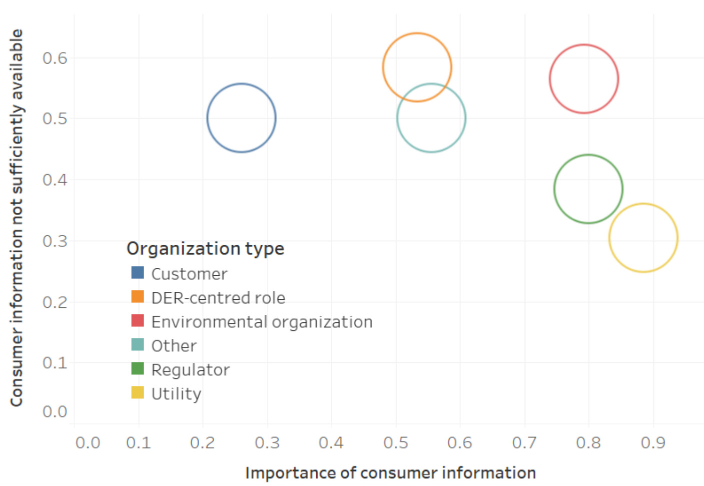
[8] The justifications for the refusal, if given, vary. In some cases, utilities invoke security concerns as was the case when SDG&E refused to release GIS maps and power flow models to the substation level, even under a non-disclosure agreement, as was requested in a proceeding in California (SDG&E 2015). Privacy concerns, purported lack of relevance for the proceeding as part of which the request was submitted (as was in the case of request for Con Edison's data associated with the cost of service and rate design for mass market customer rates "Con Edison and O&R assert that this request is unduly burdensome and irrelevant because it does not contribute to the Commission's goal of developing a successor for Net Energy Metering rates by the end of 2018." (Con Edison 2018)), and other arguments ("From an operational, market risks and logistical standpoint, SDG&E is not prepared to provide or make real-time data available to a third party at this time," "While SDG&E supports a more transparent planning process, the utility also believes that the release of

Figure 2 Importance and availability of distribution network information for selected organization types



Horizontal axis shows the share of organizations of a given type that marked distribution network information as important to their functioning (based on Q7 Q18, or Q35). and vertical axis the share of organizations of that indicated insufficient availability of that information (Q9, Q21, Q37).

Figure 3 Consumer information - importance and accessibility.



The horizontal axis shows the share of survey respondents who indicated relevance of consumer data for their operations in questions Q7 Q18, Q26, or Q35. The vertical axis shows the share of respondents who stated that they do not have sufficient access to consumer information among those who declare consumer data to be important for their operations (Q9, Q21 Q29, Q33 and Q37).

comprehensive modeling data is inappropriate, and may lead to a confusing and antagonistic planning process." (SDG&E 2015, p.97 and 134)) are also used.

of the United States access to consumption data is limited, which is also reflected in our survey results as shown in Figure 3.

Other information issues around DERs relate to the resources' characteristics. First, because of their small size [9] and lack of ownership concentration, information exchange and coordination needed for smart integration of DERs into the grid can become difficult in absence of distribution automation and/or aggregation of DERs (Buchmann 2017). As some DERs encompass non-dispatchable resources, such as wind and solar, their increase will also tend to magnify the existing information problems related to intermittency (Féron et al. 2020). Additionally, DERs' prevalent behind-the-meter location creates new information needs, such as the need for information on correlations between consumption patterns and the DER adoption necessary to predict load and assess distributional impacts of DER policies. Finally, DERs investments, through their interactions with distribution networks, complicate utilities' long-term network planning problem as utilities learn about individual DERs only when they interconnect to the network.

There are also information issues that indirectly relate to DERs. For instance, in some regions, regulators want to compensate DERs for the pollution they avoid (see Section 4.4) but the marginal emissions data is generally not available. In our survey, only 35% of regulators state they have sufficient information to forecast marginal emissions correctly. That share is similar for the remaining organization types. (Q41)

DERs also compound the policy uncertainty that the electricity sector experiences. This is due to their relative novelty which combined with the interest that policymakers take in them, implies that, once DERs are better understood, there will be a change in policies related to them. The sheer number of recent proceedings and academic papers on optimal DER remuneration (New York DPS Case 15-E-0751, Connecticut DEEP Case 19-06-29, Oregon PUC case UM 1716, Shavel et al. 2019, Varghese and Sioshansi 2020, Águila Téllez et al. 2020), optimal rate design in the presence of DERs (AEE 2018, Ros et al. 2018, Maheshwari et al. 2020, Revesz and Unel 2020, Revesz and Unel 2017), and treatment of distributed storage as transmission asset (CAISO 2019, Elliott et al. 2019, Brown and Sappington 2020) suggest that the relevant policies are undergoing a substantial change. Over 90% of our survey respondents characterize future electricity sector policies as

[9] A typical size for residential PV systems is 5 kilowatts (EIA 2015). This implies that the assets are not only too small to meet minimum participation levels in the wholesale markets but also that, given the complexity of energy system, the revenues those resources can make individually may be insufficient to overcome transaction costs for selling services at the distribution network level (Migden-Ostrander et al. 2018).

important for their actions but over 89% also consider them to be uncertain or very uncertain (Q40).

The strength of the information problems reported by regulators may be surprising given their privileged position that allows them to request any information from the regulated actors that is not sensitive for security reasons. At first sight, this could suggest that at least the regulatory processes are free of information problems. However, regulators can fully rely on the provided information under very narrow conditions.[10] Additionally, regulated entities often have an information advantage over regulators such that regulators are unable to ask the right questions. In other words, regulators often do not know what they do not know. For instance, they may not be aware of the willingness of some of the local load to enter contracts that would result in load shaving and thus would circumvent the need for substation upgrades. As a consequence, regulators may be unable to identify alternative actions to the ones proposed by the regulated entities.

And even when regulators gain access to reliable information relevant for DERs, they may not be able to share it with other stakeholders when the revealed information is protected from public disclosure as proprietary or commercially sensitive. For instance, California Public Records Act exempts utilities' "trade secrets" from public disclosure and the disclosure of trade secret information to third parties, even if mandated by statute, may compromise the trade secret privilege.[11]

Our survey suggests that even if particular information is publicly available, it may be cumbersome to get. The majority (86%) of the survey participants declared regulatory submissions as one of the sources of information as summarized in Figure 4 (based on Q45).[12] However, regulatory submissions do not present structured information: they can be multiple-hundred-pages-long documents with the relevant information scattered across the text and their archives usually maintain only a minimum structure and are not easily searchable. Consequently, searching for a particular piece of information in regulatory

[10] Generally, regulators can depend on the provided information if it is either verifiable (contractible) or when the agents are given truth-telling incentives. For a broader discussion of difficulties which regulators face when needing to rely on information from parties affected by their decisions, see Milgrom and Roberts (1986) and Dellis and Oak (2019).

[11] Gov't. Code § 6254(e) ("this chapter does not require the disclosure of…(e) Geological and geophysical data, plant production data, and similar information relating to utility systems development, or market or crop reports, that are obtained in confidence from any person.").

[12] Other source of information are utilities (69%), RTOs' websites (69%), direct inquiries with other sector participants (25%), in-house analytics (67%), and private data companies and consultancies (49%). Federal Energy Regulatory Commission's (FERC) website is useful for only 43% of the surveyed. A few survey participants pointed also to trade press and regulatory counsels as important sources of information.

submissions archives requires close familiarity with the subject of interest, giving information advantage to bigger actors who have the resources to engage with regulatory processes closely. Such lack of transparency also creates barriers to entry as relevant information might be hard to find for an outsider.

All types of organizations indicate experiencing negative consequences of information barriers although the reported type of consequences differs (Q43). Information unavailability slows down the pace of decision-making and actions for everyone but regulators, it also decreases the effectiveness of actions for DER-focused organizations, environmental organizations, utilities, and others, while limiting the set of feasible projects for DERs and utilities. DERs additionally report negative competition, risk, and profits effects, while the majority of consumer respondents mention increased project risk. Only six respondents state that their organization is not affected by missing or incomplete information.

And while the survey indicated that many pieces of information that stakeholders consider important are not accessible for them, the methods of coping with it differ as indicated by responses to Q44. Two thirds of the respondents, in particular utilities and DERs report that in some cases, they fill information gaps with own assumptions. One fourth of respondents, mostly regulators, environmental organizations and some of the other organizations, look to the behavior of similar organizations to compensate for the missing information and 60% of respondents use historical data to forecast future values.

Figure 4 Main sources of information for surveyed organizations.

The graph shows the share of organizations using a given information source based on answers to question Q45.

4 Examples of information problems hindering DER adoption

4.1 Consumer information

Information relevance

Consumer data, in particular electricity consumption data, is highly relevant for multiple organization types in the context of DERs. High-granularity consumption profiles data allows developers offering energy efficiency and demand response products to learn when and where there is consumption flexibility that could help cut system or consumer costs. Timely access to the smart meter data allows the DER operators to manage the customer's energy use and help them best respond to price signals—with real-time-meter information software-based disaggregation down to the level of individual appliances is possible, enabling identification of concrete ways of reducing energy bills (Garcia et al. 2020).

Consumption data is also relevant for consumers making decisions about DERs as it constitutes a basis for investment decisions. If consumers only see their monthly bills and do not know their hourly consumption profiles, they will not be able to predict the savings from resources such as rooftop photovoltaics when a time-granular compensation for injections is offered to them,[13] and may thus be discouraged from the investment.

Third, data on electricity consumption patterns is crucial for innovative retail rates which in turn are needed for socially optimal DER adoption (chap. 4 in MIT 2016). With rate design elements such as coincident or non-coincident demand charges and time-of-use rates, consumption profiles are a necessary input for calculating the proper values of the elements.[14] And detailed consumption information is necessary for consumers to react to the rates (AEE 2018). For instance, when exposed to demand charges, consumers need usage data split into time intervals relevant for the tariff (usually 15 minutes), in a form that is accessible and understandable.

Finally, the electricity consumption data combined with sociodemographic records is a prerequisite for distributional evaluations of various rate designs and policies. This information on distributional impacts is already crucial for policymaking (Burger et al. 2018)

[13] The DER renumeration scheme currently pursued in New York and described in Subsection 3c is an example of a time-granular scheme.

[14] Spiller et al. (2020) illustrates how one can use consumption data to design retail rates.

and is going to increase in importance as DERs may increase inequities present in the power system (Burger et al 2020).

Reasons for information problems

While consumer data facilitates optimal DER build-out, its availability to the public is limited as indicated by regulatory proceedings and our survey results (Figure 3). This happens as electricity consumption data is gathered and managed by utilities which generally perceive it as part of their monopoly rights (DOE 2010, p.27) and are reluctant towards making consumption information available, even to its own customers.

Currently, utilities can sell the data to third parties or monetize it in other ways. Sharing any consumer information, even with research community, can thus mean lost revenue opportunity. Releasing information also threatens the utility core business model in two ways. First, it decreases barriers to non-utility DER investments and demand response programs. Those, in turn, decrease the demand for electricity from the grid and can thus cut into the utility's profits (Jenkins and Perez-Arriaga 2017). Second, rich consumer and grid data is a prerequisite for more cost-reflective rate designs. While socially desirable, such rate designs can decrease utility's profits. This happens as cost-reflective rate designs decrease the annual peak demand, which reduces the needed transmission and distribution expenses and thus the return that the utility can earn on those expenses (Beaufils and Pineau 2019).[15]

Current solutions

Regulators strive to increase the access of consumers to their consumption data. Many states, like California, Colorado, and Texas, passed legislation that gives consumers a right to receive the data from their own meter and share it with third parties of their choice (CPUC 2011, Colorado PUC 2021, section 3026, Texas PUC 2020). There has also been a federal policy response to the consumer data problem. In 2012, the White House launched the so-called "Green Button initiative" that encourages utilities to provide consumers with easy access to their own metered usage data in a standardized, computer-readable format. With the "Green Button", consumers can also authorize third-parties to view their data. As many utilities have been unwilling to join the initiative, there have been additional

[15] From the perspective of the utilities, data sharing may also create privacy concerns for consumer data and security concerns for grid and operations data. Sharing information is also burdensome in that it requires devoting resources to the information preparation and distribution.

attempts at the federal level to regulate access to consumer information[16] but they remain largely unsuccessful.

At the state level, there have also been efforts to make the consumer data available to the broader public. In Illinois, for instance, with the passage of an Energy Infrastructure Modernization Act in 2011 (Public Act 097-0616), regulators conditioned the return on smart meters investments for the local utility on the public having access to meter data. This resulted in development of Anonymous Data Service that allows access to anonymized interval energy usage data in 30-minute intervals for all zip codes where AMI has been deployed. In New Hampshire, work on utility data sharing started at the initiative of the Office of the Consumer Advocate in March 2017 in connection with an electric distribution rate case (Docket No. DE 16-384). In 2019, New Hampshire's General Court passed a bill directing the state's Public Utilities Commission to establish a statewide "Multi-Use Energy Data Platform" to standardize gas and electric customer usage data (Docket No. DE 19-197). Finally, New York put forward a comprehensive approach to consumer data availability. As a part of the Reforming the Energy Vision (REV) proceeding, the state is creating a platform for stakeholder access to customer data. In addition to detailed time-series interval data describing customer energy consumption, New York intends to make other customer-specific information available for sharing.[17]

The solution to information problems around consumer data has thus been to impose data release obligations. However, as utilities' disincentives to data sharing have remained largely unchanged, it is unsurprising that the information release has generally been slow. Business models that (partly) decouple utility profits from electricity sales and tie them to outcomes such as DER installations could encourage increased data release.

4.2 Interconnection information

Information relevance

[16] See for instance Access to Consumer Energy Information Act introduced by Representative Peter Welch 04/22/2015 (H.R.1980) and 02/06/2020 (H.R. 5796) to the Congress to "encourage and support the adoption of policies that allow electricity consumers access to their own electricity data."

[17] Proposed items include customer category, service address, service voltage, service configuration, billing rate, meter type(s), NYISO zone, NYISO transmission node, substation, substation transformer ID, distribution circuit, circuit phase(s), distribution transformer ID, local hosting capacity, DER details, EV charging details, applicable NAICS code, building characteristics, municipality, and applicable zoning (NY DPS 2020).

Potential DER impacts on the distribution system depend mostly on characteristics of the feeder they connect to: load, voltage regulation, and impedance (EPRI 2012). Inappropriately located DERs can result in power losses, degraded voltage profile, and mis-coordination between distribution network's protection devices (Sa'ed et al. 2018). Therefore, when a new DER intends to connect to a distribution network, it has to undergo an interconnection process, during which the utility determines whether distribution network upgrades are needed for the interconnection.[18] For a given feeder, hosting capacity describes the maximum amount of DER that can be accommodated without adversely impacting power quality or reliability and without upgrades.

While the interconnection process is important for reliable functioning of distribution networks, it is also one of the obstacles to DER deployment. The challenges the process imposes on DER developers are multiple: a lack of clarity about the application process and necessary documents, delays that increase project development time, high interconnection application fees and additional costs for studies.[19] But the main identified barrier associated with interconnection is a lack of information about the distribution network (Bird et al. 2018).

Developers and end-use customers need the distribution network information to estimate the likelihood and costs of interconnections, potential technical requirements for the equipment, as well as the time horizon for the interconnection process. That information is also helpful for developers when screening locations for proposed projects. Additionally, without public access to grid information, the decisions of utilities concerning interconnections cannot be audited, i.e., the parties need to trust the decisions of utilities. The importance of distribution network information, in particular of the hosting capacity is confirmed in our survey (see Figure 2 and the surrounding discussion).

Reasons for information problems

Utilities have been reluctant to make the distribution network data public, such that DER investors have often been able to learn about the potential to interconnect solely through initiating a costly and time-consuming interconnection process.[20] One of the reasons for that

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[18] Upgrades can entail various actions, such as adding equipment to the network, e.g., recloser or remote terminal unit at the Point of Common Coupling, putting ground fault protection at substation level, or replacing equipment to allow for reverse power flows.

[19] The interconnection processes are typically simplified and standardized for installations smaller than 300kW. But the challenges are still substantial for bigger resources, which usually are installed by commercial and industrial consumers.

[20] While the speed of interconnection studies has improved significantly compared to, say, the end of the previous century where a quarter of projects had to wait over 4 months for interconnection decisions (Alderfer et al. 2000), larger projects

reluctance could be the fact that the currently prevailing utility business models give utilities no rewards for such information sharing, only disincentives. This happens as, under standard utility regulation, independently owned DERs tend to decrease utility earnings. Withholding the information relevant for interconnection detracts DER investments, maintaining the utility profits.

Current solutions

To deal with that information problem, some states delegated utilities to publish capacity hosting maps – maps that illustrate hosting capacity in the distribution system. Such maps are available among others in California, New York, Nevada, Minnesota and D.C. and new states are joining soon. For instance, in May 2019, solar advocates in Georgia requested the Georgia Public Service Commission to require Georgia Power to produce a hosting capacity map to help DER projects (Leader and Tucker 2019). Over time, the requirements for hosting capacity release can get more stringent—stakeholders in D.C. requested in 2019 that the map update frequency increases from a quarter to a month (MEDSIS 2019).

However, regulated units tend to be uncooperative at implementing the mandated information release whenever they have poor economic incentives to do so. Under current regulations, sharing information usually can decrease utilities profits, while bringing no compensating benefits. It is thus unsurprising that in the case of the capacity hosting maps, for instance, the released data usually just meet legal requirements, even when more detailed information would be more appropriate.[21] The utilities may also put little effort in preparing such maps, potentially resulting in outright wrong information. For instance, in January of 2019 the California utility PG&E published a first hosting capacity map, showing little or no room for new DERs on most of its feeders. After an intervention of one of the stakeholders, the utility admitted publishing erroneous analyses and corrected the data to reveal available interconnection capacity (Zakai 2020).

And while requirements for hosting capacity release provide the public with valuable maps, other approaches may be more efficient at providing needed information needed for the DER roll-out, especially when used to complement the information release requirements.

with customized reports need to frequently wait over 4 weeks for interconnection study results (Horowitz 2019). The interconnection itself can take multiple years for larger projects that require network upgrades. (Prevost 2021)

[21] This is well illustrated by the situation in New York where some of the released maps represent the overall sub-feeder level hosting capacity only, and do not account for all factors that could impact interconnection costs, including substation constraints. Hosting Capacity Analysis Methodology and Assumptions https://www.cenhud.com/my-energy/distributed-generation/hosting-capacity-map/

For instance, by implementing performance-based regulation tied to DER adoption and rewarding utility for reaching a DERs goal or using a lost revenue adjustment mechanism, regulators can provide incentives for utilities to voluntarily provide DER investors with the distribution system information.[22] Incentive mechanisms are explored, among others, in Colorado (Proceeding 19M-0661EG) and New York (Case 14-M-0101).

4.3 Value of Non-wire alternatives

Information relevance

Annually, U.S. utilities spent over $25 billion in upgrading and replacing their electricity distribution infrastructure (EIA 2018) and those costs can be particularly high in congested metropolitan areas (Gil and Joos 2006).[23] Traditionally, utilities have added new investments or upgraded distribution networks in response to the load growth within their areas. In recent policy and academic debates, however, the idea of using DERs for decreasing the distribution network expenses has emerged: DERs can serve as non-wire alternatives (NWAs) to the investments and upgrades when they avoid or delay traditional expansion projects through managing peak load (Contreras-Ocaña et al. 2020). By optimizing a portfolio of DER and grid investment projects, NWA may provide substantial savings over traditional ways to deal with load growth.[24]

Social value and financial viability of NWAs are location- and time-dependent. With perfectly designed tariffs and DER remuneration, DER projects would automatically occur where they create added value, including the value from avoiding the distribution network costs. However, if correct market signals are not available, another approach is needed to select DER projects that maximize welfare given the distribution network characteristics.

Reasons for information problems

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[22] For an introduction into performance-based regulation, see Lowry and Woolf (2016). See also Section 5.

[23] For instance, when the Con Edison utility forecasted in 2014 that its networks in Brooklyn and Queens in New York would experience an increase in demand of 52 MW over the maximum system capacity, it proposed a solution which included a new distribution substation, expanding an existing 345 kV switching station and constructing a sub-transmission feeder to connect the two stations at an estimated cost of $1 billion (Coddington et al. 2017).

[24] In the above discussed case of Brooklyn and Queens network, regulators directed Con Edison to use DER-based solutions to the problem. The final project included reduction of 69 MW of peak demand through NWAs. There were also 17 MW of traditional capacitor and load transfer solutions. The project ended up with a $200 million budget (plus $305 million for the traditional solutions).

Distribution network information remains largely in hands of utilities as our surveys confirm (see Figure 2 and the surrounding discussion). Given that, utilities are best equipped to make decisions about when and what NWAs save costs, while maintaining network reliability. And indeed, in most states, utilities are tasked with identifying and evaluating the NWAs when considering distribution network investments. The utilities' information advantage, though, means that it is hard for outsiders, including regulators, to understand the NWA selection process. In New York, complaints emerged about the relatively low transparency of NWA solicitations and the process for identifying NWAs. Some parties alleged that utilities have failed to provide transparent feedback to DER developers who were not selected, making it difficult for DER providers to understand how to design solutions that are competitive with the utilities' traditional infrastructure (Clean Energy Parties 2019).

With NWAs, there are also information asymmetries around assessing the social optimality of utilities' decisions, and the magnitude of the asymmetries is even more pronounced than with traditional distribution network investments regulation. This is true as with NWAs, regulators need to judge not the necessity of a given grid investment option, such as an additional power line. Instead, assessing the prudency of a decision involves evaluating a choice of the portfolio of NWA and traditional solutions, whereby there may exist a multitude of potential decentralized projects and each of them may require different accompanying grid investments. Additionally, a comprehensive review of NWA decision would also include determination of whether all possible DER options are accounted for. If utilities are tasked with the deployment of DERs (as opposed to being tasked with procuring DERs through tenders), they may forgo certain options, e.g. those related to customer-sited generation (O'Boyle 2017, O'Boyle 2016). The information asymmetry created by those complexities makes it impossible for regulators to oversee the utilities' choice of NWAs, applying the standard cost-of-service approach.[25]

As a consequence, it is crucial to provide utilities with incentives that push them towards socially optimal choices. Currently, though, most utilities face financial disincentives for procuring NWAs as their earnings are based on capital investments and NWAs decrease the investments needed.

[25] This was recognized among others in California, where the Public Utility Commission wrote: "Given the complexity of the distribution system, this Commission is ill-equipped, at least at present, to determine with the necessary specificity exactly when and where such DER deployment opportunities may exist. [...] Practically speaking, command-and-control regulation faces major challenges in this context." (CPUC 2016)

Current solutions

The problems have been acknowledged by some regulators, among others in California, New York, and Illinois, resulting in attempts to reform utility's remuneration scheme.[26] Academic literature points to the need for innovative, cost-sharing contracts for solving the issue (Brown and Sappington 2018, Sappington and Weisman 2021), possibly implemented as a menu of compensation structures (Jenkins and Perez-Arriaga 2017). As long as change utilities' financial incentives are not indifferent to utility and DER solutions, the application of NWAs will not be efficient.

An alternative approach to optimal NWAs was attempted in Washington, D.C. with a proposed Distributed Energy Resources Authority Act (2018-04-20 - Notice of Intent to Act on B22-0779). The Act envisioned creating a non-utility nonprofit entity called a DER Authority which would be financed through a special fund and which would take over responsibilities for increasing the efficiency of the distribution system, analyzing NWA proposals, developing policy recommendations to improve DER integration, etc. However, while that entity might face the correct incentives concerning the DER projects, it would still have information problems similar to that of a regulator - the utilities would need to share real-time data about system operations, infrastructure needs and energy demand for the DER Authority to make the correct decisions.

4.4 Optimal remuneration for DERs

Information relevance

Traditionally, DERs in the U.S. have faced payments based on the net metering approach: for every unit of energy injected, DER owners receive a credit on their energy bill based on the retail rate they face. This approach, however, is inefficient. Economic theory prescribes that DERs should face remuneration that reflects the social value of their generation (Revesz and Unel 2017, Gundlach and Unel 2019, Ros et al. 2018). Approximating such first-best approaches has been attempted, among others, in New York, where the compensation for projects is based on their energy, capacity, and environmental value as well as the costs they avoid due to reduced peak demand and congestion (Case 15-E-0751).

[26] For instance, Central Hudson Gas and Electric utility in New York were offered an investment saving model under which 70% of benefits from NWA procurement go to ratepayers through rate moderation, and 30% of benefits are provided to the utility. We note though that such approach may give incentives to overstate the counterfactual costs of traditional distribution network upgrades.

California and Hawaii also have payments tailored to the social value of injections and further states like Maine and Minnesota, are exploring similar remuneration options.

Reasons for information problems

While payments reflecting the social value of DER are conceptually superior, in practice they present a challenge for regulators due to a lack of crucial information, such as information about distribution network or about marginal generators. Our survey confirms those information problems (see Figure 2 and the surrounding discussion and the discussion on marginal emissions in Section 3). With missing information, assigning correct social values becomes impossible. As a consequence, the payments may depart significantly from the actual social value of DER.

And indeed, in New York, many components of the DER remuneration have a constant monthly value that changes little within a utility's service territory (Con Edison 2020), suggesting a significant deviation from the first-best values that would be highly granular both in time and space dimensions. The regulatory process failed so far to secure real-time information on marginal emissions, which is necessary to compute environmental damages avoided by DERs accurately at a given location and time. Instead, the current environmental value is calculated based on an annual estimated rate of avoided emissions. As utilities have the distribution network information, they became responsible for computing some of the elements that flow into the DER compensation, e.g., the value of reduced peak demand. This was frequently criticized as lacking public information about the distribution system means unpredictable future DER remuneration schemes (and thus greater financing costs for DER projects), but also inability to challenge the values provided by utilities.[27]

Current solutions

Many regulators started value of DER proceedings to set the optimal remuneration for power injections from distributed generation. In the course of those proceedings, whenever possible, regulators extract the information they perceive as needed from the stakeholders

[27] For instance, in one of the comments to New York State Public Service Commission, solar developers complained that "The utilities have the data needed to identify these avoidable costs and to build out tariffs that enable the monetization of DER functionality. It is much harder to design customer products and finance projects if there are key values that are unpredictable, irretrievable, or subject to utility interpretation. It is natural that the incumbent is disinclined to provide this data. However, it is imperative that the relevant data be provided, and that it be done in a format that allows stakeholders sufficient opportunity to review and challenge the data and assumptions put forward by the distribution companies." (Clean Energy Parties RE: CASE 15-E-0751Regarding the VDER Phase 1 Implementation Plans of the Joint Utilities, July 24, 2017)

and replace the unavailable information by fixed approximate values. New York, however, plans to take a much more comprehensive approach to setting the DER remuneration in the long-term as it intends to implement a distributed service platform that DER sellers and retail customers will use to buy and sell electricity (NYPSC 2015). This solution combined with proper participation incentives for utilities, would shift the need for information away from regulators in the context of DER remuneration, assuaging many information problems around it.

5 Policy implications

DERs can provide substantial value for the grid. Not only do they avoid transmission-level generation costs, and increase integration of clean energy but also, through services like load shaping, shifting, shedding and shimmy,[28] they can avoid transmission and distribution network costs, while providing ancillary services or frequency regulation.

Overcoming information problems is necessary for the DER roll-out to be cost-effective. Missing information can result in suboptimal amount of DERs, and build-out of the wrong resource types at the wrong locations. It also has distributional impacts, with additional rents flowing to the agents with an information advantage. Finally, information problems may have implications for DER ownership: under scenarios with significant information barriers, utility ownership of DER may be more efficient despite its potential anticompetitive effects.

Inefficiencies associated with information problems can be overcome in a variety of ways. The most straightforward way, which has also been widely chosen by regulators in the DER context so far, is to direct stakeholders to publicly share some of the information they own. Such strategies can overcome barriers to efficient DER adoption if the information is verifiable, contractible and not too complex to process. This is the case, for instance, with consumer profile information. However, the approach may face resistance from agents who face disincentives to providing information. It will be in the best interest of such agents to provide as little information as possible, resulting in information releases limited to the legally defined minimum. Protraction of information release (within legal limits) is another consequence to be expected in such a setting. The regulators need to ensure that they

[28] For the explanation of those services and explanation of how they create value for the system on the example of California, see (LBNL 2017)

correctly foresee the information needs when specifying the requirements or be ready to update the requirements regularly. Additionally, imposing information requirements may not work for very complex information, such as value of DER for the distribution network, or non-verifiable information, such as the planned start time of the interconnecting project. Alternatively, regulators can provide incentives for the parties to truthfully reveal their information. For utilities, this can happen through replacing traditional cost-of-service regulation with performance-based regulation that conditions utilities' profits on reaching some pre-defined DER deployment targets. By setting performance targets such as avoidance of distribution network costs and providing rewards independent of the incurred costs, regulator incentivizes utility to use all of the information available to it to identify the set of most cost-effective DER projects of the needed size.

Regulators could also offer a menu of cost-sharing (or profit-sharing) contracts for utilities to choose from (Cossent and Gómez 2013, Jenkins and Perez-Arriaga 2017, Brown and Sappington 2018). Such a menu of contracts defines an *ex ante* regulatory allowance for the regulated indicator, e.g. for capital expenditure. It also specifies how the actual realization of the regulated indicator adjusts the final remuneration that a utility receives (Jenkins and Perez-Arriaga 2017). This adjustment mechanism creates incentives for utilities to reveal information they have to achieve the relevant cost reductions in a cost-efficient way.

The voluntary release of information does not come for free – regulators must cede rents to utilities to incentivize their efficient behavior. Additionally, it is not trivial that with lacking information, regulators are able to establish socially desirable performance targets or choose a correct cost-sharing scheme. For instance, too generous cost-sharing scheme will result in excessive rents to utilities. Whether the information requirement approach or the incentive approach is superior in a given setting is an empirical question.

6 Conclusions

This article contributes to the understanding of information problems around DER-rollout. It reviews the main areas where lacking information access has emerged as an issue, pulling insights from academic literature, regulatory proceedings and a survey of DER stakeholders. While the list of the issues is not exhaustive, it points to the relevance of information for roll-out of DER. The information problems will tend to decrease the efficiency of the DER rollout compared to full information case – for instance, if regulators provide wrong value stack parameters, there might be overbuilt of DERs in some regions and underbuilt in others leading to efficiency losses. The information advantage of utilities, combined with lacking incentives for them for supporting DERs may imply that, generally, suboptimally few DERs get built.

More discussion is needed around the role of information and optimal policies targeting information. The policymakers need to also consider providing mechanisms that will incentivize the agents to truthfully reveal the information they possess.

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Appendix A. Identified proceedings

Table 1 List of identified current proceedings on DER remuneration.

State	Proceeding	Docket	Number of valid contacts found
Arkansas	In The Matter Of Net Metering And The Implementation Of Act 827 Of 2015	16-027-R	41
DC	In the Matter of the Investigation into Modernizing the Energy Delivery System for Increased Sustainability	fc1130	9
California	Order Instituting Rulemaking to Develop a Successor to Existing Net Energy Metering Tariffs Pursuant to Public Utilities Code Section 2827.1, and to Address Other Issues Related to Net Energy Metering	R1407002	355
California	Order Instituting Rulemaking to Revisit Net Energy Metering Tariffs Pursuant to Decision 16-01-044, and to Address Other Issues Related to Net Energy Metering	R2008020	
Connecticut	DEEP and PURA Joint Proceeding on the Value of Distributed Energy Resources	19-06-29	41
Idaho	Idaho Power--Application To Study Net Excess Energy From Customer On-Site Generation	IPC-E-18-15	15
Illinois	Illinois Value of DER Proceeding	P2020-0389	39
Louisiana	Review of policies related to customer-owned solar generation and possible modification of the Commission's current net metering rules.	R-33929	41
Minnesota	Value of Solar	E-002/M-13-867	55
Missouri	In the Matter of a Working Case to Explore Emerging Issues in Utility Regulation	EW-2017-0245	0
New Hampshire	Development of New Alternative Net Metering Tariffs and/or Other Regulatory Mechanisms and Tariffs for Customer-Generators	DE 16-576	132
New York	Motion of the Commission in Regard to Reforming the Energy Vision	14-M-0101	232
Ohio	In The Matter Of Net Metering And The Implementation Of Act 827 Of 2015	12-2050-EL-ORD	30
Oregon	Investigation to Determine the Resource Value of Solar	UM 1716	22
Utah	Application of Rocky Mountain Power to Establish Export Credits for Customer Generated Electricity	17-035-61	28

Appendix B. Survey invitation

Dear <Participant Name>,

I am reaching out to you about a research project on the role of information in policies related to distributed energy resources. This academic project aims to find out how information about the electricity sector, or lack thereof, affects decisionmaking, and, in turn, the roll-out of distributed energy resources.

We believe that your experience in the sector, including your experience as a party or regulator in the <name of the proceeding>, we would like to learn from your experiences. The survey below is designed to help us understand what kind of information stakeholders and regulators need, how they access that information, and where the information bottlenecks are, if any.

The average time needed for the survey is 6 minutes. The answers will not be shared with third-parties. The questions are not proceeding-specific and results from the surveys will be aggregated in any publication to protect anonymity.

For the survey link please go here:
<Link to the Survey>

This project is funded by the Alfred P. Sloan Foundation (primary) and National Science Foundation (secondary), and is an effort by the Institute for Policy Integrity at New York University School of Law and the Department of Electrical and Computer Engineering at New York University's Tandon School of Engineering. If you have any questions about this survey or the project, please do not hesitate to contact me.

Thank you for your time.

Sincerely,
Sylwia

Sylwia Bialek, Ph.D. | Economist
Institute for Policy Integrity | New York University School of Law
sylwia.bialek@nyu.edu | 212.992.6285

Appendix C. Survey text

<text in brackets> describes the conditional logic behind the questions shown "*not asked in NY*" marks questions that were not shown to participants identified through the New York proceeding

1. Which of the following best describes your role?
   a) I represent my organization/clients in regulatory proceedings
   b) I analyze policy on behalf of my organization/clients
   c) I am in a supervisory or a decision-making position
   d) Other: ____

2. Which of the following describes your organization?
   a) Electricity customer or a representative of electricity customers
   b) Owner of distributed energy resources (DER), a representative of DER owners, DER aggregator, PV contractor or other DER-centered role
   c) Utility or a representative of utilities
   d) Organization centered around environmental protection
   e) Regulator
   f) Other (owner of transmission-level generation, competitive retail supplier etc.)

Customers block

<block of questions shown to those who choose answer a) in Q2>

3. Does your organization/clients buy electricity directly from wholesale markets?
   a) Yes, it buys electricity in wholesale energy markets.
   b) No, my organization is solely a retail customer.

4. Do you agree that the future electricity sector policies, such as subsidy programs and emission pricing, are important for your organization/clients?
   a) Strongly agree
   b) Somewhat agree
   c) Neither agree nor disagree
   d) Somewhat disagree
   e) Strongly disagree

5. Has your organization/clients considered investing or already invested in distributed energy resources (DERs), such as solar PV, batteries, combined heat and power etc.?
   a) Yes
   b) No

6. What factors were important in your organization's/clients' decisions about DER investments? (Select all that apply)
<show if answer to Q7 is "Yes">

f) Ability to hedge electricity price risk
g) Backup power
h) Organizational sustainability goals
i) State incentives
j) Other (please briefly describe important factors below):
____

7. What information does your organization/clients need to decide whether to invest in DER? (Select all that apply)
<show if answer to Q5 is "Yes">
a) Expected retail rates 1 to 10 years from now *<show if chosen answer b) to Q3>*
b) Expected wholesale energy prices 1 to 10 years from now *<show if chosen answer a) to Q3>*
c) Expected capacity market prices
d) Expected distributed energy resources tariffs
e) Expected grid mix
f) The waiting time in the interconnection queue or the interconnection cost
g) Hosting capacity
h) Distribution-level congestion
i) Transmission-level congestion
j) Emissions from the grid
k) Consumer demand
l) Other (please briefly describe desired information below):
____

8. Of the kinds of information you listed as important for DER investment, what information is **easily accessible** for your organization/clients?
<show only the options marked in Q7 as relevant>

a) Expected retail rates 1 to 10 years from now
b) Expected wholesale energy prices 1 to 10 years from now
c) Expected capacity market prices
d) Expected distributed energy resources tariffs
e) Expected grid mix
f) The waiting time in the interconnection queue or the interconnection cost
g) Hosting capacity
h) Distribution-level congestion
i) Transmission-level congestion
j) Emissions from the grid
k) Consumer demand
l) <option typed in as "Other" in Q7>
m) None of the above

9. Of the kinds of information you listed as important for DER investment, what information is **<u>not</u> accessible** for your organization/clients?
<show only the options marked in Q7 as relevant>

a) Expected retail rates 1 to 10 years from now
b) Expected wholesale energy prices 1 to 10 years from now
c) Expected capacity market prices
d) Expected distributed energy resources tariffs
e) Expected grid mix
f) The waiting time in the interconnection queue or the interconnection cost
g) Hosting capacity
h) Distribution-level congestion
i) Transmission-level congestion
j) Emissions from the grid
k) Consumer demand
l) <option typed in as "Other" in Q7>
m) All relevant information is available

10. Are there demand-response programs in which you organization/clients can participate?
a) Yes
b) No

11. What factors are important in your organization's/clients' decisions about participation in demand response programs? (Select all that apply)
<show if answered "Yes" to Q10>
a) Expected electricity costs savings
b) The minimum required duration of the response
c) The expected frequency of response events
d) The event notification time (10 minutes prior, 90 minutes prior, etc.)
e) Penalties for failing to participate during a response event
f) The complexity of the participation rules
g) Limited discomfort/disturbance to main operations during the actual response
h) Successful stories of demand response programs in other organizations of the same type
i) Other: ____

12. When deciding whether to participate in a demand response program, did your organization/clients have access to all the information you needed to properly evaluate those factors?
<show if answered "Yes" to Q10>
a) Yes
b) No

13. What information about the demand response is **not accessible** for your organization/clients? (Select all that apply)
<show if answered "Yes" to Q10 & answered "No" to Q12>
    a) Expected electricity costs savings
    b) The minimum required duration of the response
    c) The expected frequency of response events
    d) The event notification time (10 minutes prior, 90 minutes prior, etc.)
    e) Penalties for failing to participate during a response event
    f) The complexity of the participation rules
    g) Disturbance to main operations during the actual response
    h) <show "Other" from Q11 >
    i) All relevant information is available

<next question – Q40>

DER block

<block of questions shown to those who choose answer b) in Q2>

14. Which of the following resources does your organization/clients manage? (Select all that apply)
    a) Renewable generation – solar or wind
    b) Aggregation of distributed generation resources
    c) Aggregation of demand response programs
    d) Batteries or other storage resources
    e) Other role around distributed energy resources

15. Does your organization/clients participate in wholesale markets?
    a) Yes
    b) No, but it might in the future
    c) No

16. Do you agree that your organization/clients have sufficient information to accurately forecast their own generation a day in advance?
<show if answered a) or b) to Q14>
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

17. Do you agree that your organization/clients have sufficient information to correctly forecast the amount of demand response available a day in advance?
<show if answered c) to Q14>
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

18. Please mark how important the following issues are for your organization's/clients' operations.

	Not important	Slightly important	Moderately important	Important	Very important
a) Current characteristics of local distribution network, such as hosting capacity, flow limits, or voltage limits	○	○	○	○	○
b) Future characteristics of the local distribution network, such as hosting capacity in 5 years	○	○	○	○	○
c) Information on behavior of electricity consumers, e.g., consumption profiles	○	○	○	○	○
d) Future electricity sector policies, such as subsidy programs and emission pricing	○	○	○	○	○

19. Which of the following properties of local distribution network are relevant for your organization/clients? (Select all that apply)
<show question if either future characteristics or current characteristics of distribution network marked higher than "Not significant" in Q18>
    a) Hosting capacity
    b) Impendences in distribution networks
    c) Voltage limits of the distribution nodes
    d) Apparent flow limits of the distribution lines
    e) Line losses
    f) The amount or characteristics of other DERs connected to that grid
    g) Other: ____

20. Of the following, what information is **easily accessible** to your organization/clients?
    a) Current characteristics of the local distribution network, such as hosting capacity, flow limits, or voltage limits
    b) Future characteristics of the local distribution network, such as hosting capacity in 5 years
    c) Information on behavior of electricity consumers, e.g., consumption profiles
    d) Future electricity sector policies, such as subsidy programs and emission pricing
    e) None of the above.

21. Of the following, what information is **<u>not</u> sufficiently available** to your organization/clients?
    a) Current characteristics of the local distribution network, such as hosting capacity, flow limits, or voltage limits
    b) Future characteristics of the local distribution network, such as hosting capacity in 5 years
    c) Information on behavior of electricity consumers, e.g., consumption profiles
    d) Future electricity sector policies, such as subsidy programs and emission pricing
    e) All the listed information is available to my organization/clients.

22. How does your organization/clients get information about electricity consumers' behavior?
<show if marked 18c) higher than 1>

   a) The information is public
   b) It is made readily available by local utilities, regulators or other parties
   c) It is made partly available by local utilities, regulators or other parties
   d) It is not available publicly but my organization/clients can get that data reliably
   e) It is not available publicly but my organization/clients can get that data somewhat reliably
   f) It is not available at all

23. What other type of information is your organization/clients missing when making decisions around distributed energy resources?

   ____

24. How does the lack of information about local distribution networks affect your organization'/clients' investments in distributed energy resources? (Select all that apply)
   a) My organization/clients can invest only when they have all the information they need
   b) Investments take longer
   c) Investments become more risky
   d) It does not affect investments

25. Does the lack of information about local distribution networks affect how your organization/clients operates its storage resources?
<show if answered d) in Q14>

   a) Yes
   b) No

<Next Question Q40>

Utilities block

<block of questions shown to those who choose answer c) in Q2>

26. Please mark how important the following issues are for your organization's/clients' operations.

	Not important	Slightly important	Moderately important	Important	Very important
a) DER projects planned by residential customers in the utility's service area	○	○	○	○	○
b) DER projects planned by commercial and industrial customers in the utility's service area	○	○	○	○	○
c) Load growth over the next 5 years	○	○	○	○	○
d) The need for distribution grid investments over the next 5 years	○	○	○	○	○
e) Electricity consumption profiles	○	○	○	○	○
f) The future electricity sector policies, such as subsidy programs and emission pricing	○	○	○	○	○

27. Do you agree that your organization/clients are well informed about the planned DER projects undertaken by residential customers in the utilities' service area?
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

28. Do you agree that your organization/clients are well informed about the DER projects planned by commercial and industrial consumers independently of utility in its service area?
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

29. Do you agree that your organization/clients have sufficient information to correctly forecast the load growth over 5 years' time?
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

30. Do you agree that your organization/clients have sufficient information to correctly forecast what the needs for distribution grid investments are going to be in 5 years?
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

31. What type of information is your organization missing to forecast what the needs for investment in distribution grid are going to be in 5 years?
    <shown if answered "somewhat disagree" or "strongly disagree" in Q30>

    Response: ____

32. Do you agree that your organization/clients have sufficient information to correctly forecast what the rates for retail consumers are going to be in five years' time?
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

33. How well can your organization /clients forecast the response of consumers to various rate changes?
    a) Very well
    b) My organization/clients have a good general understanding of consumer behavior but providing numerical forecast would be challenging
    c) My organization/clients have a basic understanding of consumer behavior but they cannot forecast the response to rate changes
    d) Consumer behavior is very hard to understand for my organization/clients
    e) My organization/clients have not studied consumer behavior.

34. What other type of information is your organization/clients missing when making decisions around DERs and distribution networks?

    ____

<next question -> Q40>

NGO/regulators/others block

<block of questions shown to those who choose answer other than a), b) or c) in Q2>

35. Please mark how important the following issues are for your organization's work.

	Not important	Slightly important	Moderately important	Important	Very important
a) Current characteristics of the local distribution networks	○	○	○	○	○
b) Future characteristics of the local distribution network, such as hosting capacity in 5 years	○	○	○	○	○
c) Costs of running and maintaining the distribution network	○	○	○	○	○
d) Behavior of electricity consumers, e.g., the consumption profiles	○	○	○	○	○
e) Wholesale market outcomes, such as the dispatch order or marginal generator	○	○	○	○	○
f) Investment costs or marginal generation costs of future resources	○	○	○	○	○
g) Future electricity sector policies, such as subsidy programs and emission pricing	○	○	○	○	○
h) Distribution grid investment needs over the next 5 years	○	○	○	○	○
i) Future rates for retail consumers	○	○	○	○	○

36. Of the kinds of information you listed as important, what information is **easily accessible** for your organization/clients? (Select all that apply)

<show only the options marked in Q35 as at least slightly important>

a) Current characteristics of the local distribution networks
b) Future characteristics of the local distribution network, such as hosting capacity in 5 years
c) Costs of running and maintaining the distribution network
d) Behavior of electricity consumers, e.g., the consumption profiles
e) Wholesale market outcomes, such as the dispatch order or the marginal generator
f) Investment costs or marginal generation costs of future resources
g) Future electricity sector policies, such as subsidy programs and emission pricing
h) Distribution grid investment needs over the next 5 years
i) Future rates for retail consumers
j) None of the above

37. Of the kinds of information you listed as important, what information is **not accessible** for your organization/clients? (Select all that apply)

<show only the options marked in Q35 as at least slightly important>

a) Current characteristics of the local distribution networks
b) Future characteristics of the local distribution network, such as hosting capacity in 5 years
c) Costs of running and maintaining the distribution network
d) Behavior of electricity consumers, e.g., the consumption profiles
e) Wholesale market outcomes, such as the dispatch order or the marginal generator
f) Investment costs or marginal generation costs of future resources
g) Future electricity sector policies, such as subsidy programs and emission pricing
h) Distribution grid investment needs over the next 5 years
i) Future rates for retail consumers
j) There is no such information

38. Which of the following properties of local distribution network is relevant for your organization/clients? (Select all that apply)

<show only if distribution grid investments, current or future characteristics marked in Q35 as at least slightly important>

a) Hosting capacity
b) Impedances
c) Voltage limits of the distribution nodes
d) Apparent flow limits of the distribution lines
e) Other: ____

39. What other type of information is your organization/clients missing when making decisions around distributed energy resources?

____

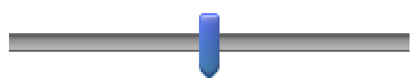
Block of questions for all

<show to all>

40. Do you agree that, from the perspective of your organization/clients, the future electricity sector policies, such as subsidy programs and emission pricing, are uncertain?
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

41. Do you agree that your organization/clients have sufficient information to correctly forecast marginal emissions for the electricity sector in any period?
    a) Strongly agree
    b) Somewhat agree
    c) Neither agree nor disagree
    d) Somewhat disagree
    e) Strongly disagree

42. How strong is the impact of missing or incomplete information identified in the questions above on the functioning of your organization/clients?
    (0- there is no effect, 10- information problems are making a successful operation of my organization/my clients' organizations almost impossible)
    not asked in NY



(respondent moves the gauge on a scale between 0 and 10)

43. How does the missing or incomplete information affect your organization/clients? (Select all that apply)
    not asked in NY
    a) it changes the achievable profits
    b) it changes the effectiveness of actions
    c) it affects competitiveness
    d) it affects the pace of decision-making or actions
    e) it affects what projects are feasible
    f) it affects the risk profile of the projects
    g) it doesn't affect my organization/clients
    h) other ____

44. How does your organization/clients compensate for lack of information? (Select all that apply)
    a) It ignores the missing piece of information
    b) It replaces the lacking information with own assumptions
    c) It follows the assumptions or approaches used by other organizations to deal with lacking information
    d) It uses historical data to forecast the future values
    e) Other: ____

45. Where does your organization/clients usually get the information about electricity sector? (Select all that apply)
    a) Regulatory submissions
    b) websites of RTOs/ISOs (e.g. MISO, SPP, CAISO)
    c) FERC data
    d) Private data companies and consultancies
    e) In-house analytics
    f) The local utility
    g) Direct inquiries with other sector's participants
    h) Other ____

46. Do you think there is a need for new regulation that would ensure the availability of information that is relevant for your organization/clients for making decisions related to distributed energy resources?
    not asked in NY
    a) Yes
    b) No
    c) I have no opinion

47. Has the coronavirus pandemic changed your responses to any of the above questions?
    a) Yes, to many of them
    b) Yes, to some of them
    c) No