Energy Transition, Distributed Energy Resources, and the Need for Information

BY BURCIN UNEL, SYLWIA BIALEK, JIP KIM AND YURY DVORKIN

Modernizing the U.S. power grid to advance the clean energy transition, to increase the deployment of new technologies such as smart and controllable appliances, electric vehicles, and energy storage, and to reduce emissions is the mainstream discussion in today's utility regulation (Proudlove, Lips, and Sarkisian 2020). Policymakers around the country are implementing various types of reforms ranging from technology mandates to new tariffs aimed at unlocking competitive forces to achieve their policy goals.

At least 35 states and D.C. are considering new retail rate designs both to take advantage of the demand flexibility that smart appliances offer and to better accommodate distributed energy resources (DERs) such as rooftop solar panels and electric vehicles, all of which can have short- and long-term cost consequences for the distribution network. Some states are trying to reform DER compensation by implementing "Value of DERs" tariffs, which can vary based on location and time that align with the underlying value, to provide better price signals to drive socially desirable DER investments that could, for example, reduce congestion or peak demand. States, as diverse as New York, Oklahoma, and Hawaii, are exploring performance-based regulation to incentivize a faster DER deployment. Other states are imposing technology-specific mandates for energy storage or rooftop solar to achieve their goals.

At the same time, researchers are suggesting alternative policies such as cost sharing (Brown and Sappington 2018) or new tools such as the use of Distributed Locational Marginal Prices (DLMPs) (Caramanis et al. 2016). And, all stakeholders and policymakers discuss which, if any, of these policies should be implemented in great lengths during regulatory proceedings that last years.

However, one aspect crucial to a fast, cost-effective transition is usually overlooked: Information, or lack thereof. All the policy recommendations for DER roll out are based on a "first-best" framework, assuming all the actors have all the information they need to make the "optimal" decisions. Modeling solutions for distribution system planning mainly focus on modeling physical aspects of electric power transmission and distribution and neglect information asymmetry by assuming that all actors involved have access to the same amount and quality of information (Cappers et al. 2016). Consequently, discussions about what types of information are needed to ramp up the deployment of DERs, as well as to regulate them, and how much this lack of information is hurting the transition have been lacking.

But, most types of information that would be necessary to implement these reforms, such as network characteristics, power flow and voltage information, and consumer preferences, are private information of market actors. Of course, information asymmetry in regulation is not a new topic. The role, consequences, and policy corrections to the information asymmetry in the typical two-actor setting between utilities and regulators has been well established (Armstrong and Sappington 2007). Typically, the regulator is uninformed about true costs and demand observed by the utility, or cannot perfectly observe its actions. As the literature shows, under all these settings, an optimally designed regulatory policy could limit the information advantage that a utility has, reducing cost to customers.

Burcin Unel and **Sylwia Bialek** are with the Institute for Policy at NYU School of Law, Unel may be eached at burcin.unel@nyu.edu, **Jip Kim** and **Yury Dvorkin** are with the Department of Electrical and Computer Engineering, NYU Tandon School of Engineering.

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See footnotes at end of text

The emergence of new technology introduced new actors into this traditional two-party utility regulation framework: prosumers, and third-party DER owners and aggregators. And, with these new actors, comes new dimensions of information asymmetries and principal-agent relationships that might require additional regulatory interventions. Furthermore, because the behavior of each actor, through its influence on the power system, affects all the other actors, a policy that might be optimal when considered in a full information setting for only that one actor, might not be optimal, or even detrimental, when the behavior of all actors are considered holistically under available information. Therefore, unless addressed in a well-thought manner in policymaking, these information problems can hinder the efficient operation of distribution networks and cost-effective energy transition as DER deployment increases.

Below, we briefly overview the potential information problems that can arise, discuss the importance of information in energy policy design for DER deployment, and then conclude by suggesting directions for future policy research.

Information in Distribution Grids

Information problems are inherent in electricity markets and stem both from the uncertainty on stochastic variables (e.g., the amount of solar and wind generation per installed capacity on a given day) and from the private information that different actors have about their own characteristics and actions (e.g., production costs of utilities, power flow and other operational constraints of distribution networks, preferences of consumers).

The first type of information problem, even if can be better accommodated with better technology and methods (Mieth and Dvorkin 2019; Lubin, Dvorkin, and Backhaus 2016), will lead to inefficiencies that can never be fully resolved, although they could lead to a competitive advantage only to the extent that one party has higher quality information than others. The second type of information problem, however, can create incentives for different parties to try to extract rents for their information advantage. And, because the new types of strategic actors equipped with DERs introduce new principal-agent problems among different actors (e.g., third-party aggregators and consumers; regulators and DER developers), aligning all actors' incentives with a socially beneficial DER deployment requires more consideration. Below, we focus on the second type of information problems, and provide a simple overview of information asymmetries between four types of actors.

Utilities maximize their profit given regulatory policies, while building and maintaining their distribution network to ensure reliability. Utilities can observe net loads of consumers, but not the underlying consumer preferences. While the utility has all information about the distribution network such as power flow constraints and hosting capacity, it is unaware of the decisions made by DER operators. Further, because revealing information about the distribution network might lead to different DER adoption levels, reduce the amount of capital investment approved by the regulator, and, in turn, reduce its profits, utilities may hesitate to provide any information to the other actors.

Customers make consumption and DER investment decisions to maximize their net surplus. They know their preferences, but they do not know the specifics of distribution network operations to fully evaluate the revenue opportunities for DER investments. Furthermore, they are neither fully informed about the resource costs of their electricity use, nor do they know how their DER operation might affect the local distribution system, and, in turn, future costs.

Third-party developers and aggregators make investments to maximize their profits given current and expected future regulatory policies. They have to decide which type of asset to invest in, where to make that investment, how to operate existing assets, while recruiting customers. However, they do not have information about either the grid or the customer preferences.

Finally, **regulators**, aim to maximize the social welfare by selecting the optimal regulatory policy such as retail electricity rate design, compensation policies for DERs, technology mandates, and the type of utility regulation (e.g., rate of return, shared savings mechanism, performance based regulation, etc.) However, they do not observe the key decision-making parameters of other actors, such as utility costs, network characteristics, or consumer preferences. They mostly rely on the information provided by utilities in rate cases.

Table 1 summarizes these different dimensions of information needs. When strategic actors lack information, they have to make decisions based on their beliefs about the others, which may lead to inefficient outcomes. Further, there are multiple dimensions of information asymmetries between different actors, which can make it more challenging for a regulator to find an optimal regulatory policy that can achieve an efficient DER rollout, while limiting the information rents to the parties with superior information, and, hence the cost to customers.

Table 1. A summary of the types of information that each actor has and needs.

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Needs \ Knows	Consumers	Third-party Developers and Aggregators	Utilities	Regulator
Consumers		Revenue opportunities	Future rates, resource costs	Future regulatory policy
Third-party Developers and Aggregators	Ability and willingness to participate		Network characteristics, power flow, load profiles	Future regulatory policy
Utilities	Consumption and DER investment preferences	Operation preferences		Future regulatory policy
Regulator	Consumption and DER investment preferences	Operation preferences, investment costs	Costs, network characteristics, power flow, load profiles	

Discussion

Understanding how these different types of information asymmetry affects the behavior of these actors, and accounting for them in policy design is crucial for an economically efficient DER rollout that is transparent and acceptable to all the parties. Such DER deployment requires a technology-neutral approach based on when and where the resources bring the highest societal value for the services they can provide (Revesz and Unel 2017; 2018; Gundlach and Unel 2019; Burger et al. 2019).

In other words, the regulatory policies should consider all the value DERs can provide such as energy, capacity, congestion relief, emission reductions, frequency regulation, resilience, etc. Achieving this social optimum requires information on wholesale energy and capacity market operations, transmission and distribution network power flow, and consumers' self-valuation for energy use during different times, among others. Yet, most actors do not have the relevant information.

This lack of information might hinder the energy transition in different ways. First, it may lead to suboptimal policy instrument choices. For example, when regulators do not have information about the distribution network flows and hosting capacity, yet believe that DERs will provide value, they can implement technology-specific mandates without any locational differentiation or operational limits. However, higher DER deployment might not only be unsuccessful in avoiding costs if they are not located at congested nodes of the distribution network, but might even lead to higher costs if they require updates to the hosting capacity of the lines. Information about the distribution network congestion could help alleviate such perverse outcomes.

Second, not having enough information will hurt the ability of regulators to design its policy instrument effectively. For example, a regulator who wants to implement market-based policies would need operational information about the distribution network and the bulk electric system to be able to provide value-based price signals (e.g., DLMPs) for different types of services provided. Consumers, without understanding the underlying social value of their consumption and investment, will make their decisions based on the prices they see and their own utility maximization, leading to inefficiently high consumption during peak hours or inefficiently low DER deployment (Revesz and Unel 2020; Radoszynski, Dvorkin, and Pinson 2019). An energy storage owner will make its operation decision based on its profit maximization, even if it leads to higher emissions (Olsen and Kirschen 2019; Hittinger and Azevedo 2015). A third-party demand response aggregator might try to recruit participants at the socially undesirable locations because it does not observe where the distribution network is congested. Or, might focus on providing one kind of service such as energy, while another such as capacity or frequency regulation might be more needed at that location.

Third, information asymmetries might lead to multiple types of principal-agent problems in the sector, which can be inefficiently costly. For example, consider a customer who wants to participate in a demand response program and gets paid to reduce energy consumption in peak summer time hours. But, this customer, while reducing demand on average, might not be willing to reduce their demand at especially critical times, such as extreme heat or cold, because of personal preferences, hindering the performance of the program.

Finally, better informed parties, mostly utilities, can exploit their information to put third-parties at competitive disadvantage, detriment to social welfare. Indeed, utilities might consider information, especially consumer information, as part of their "monopoly". And, because they have a better understanding of their network, they can rollout more profitable DERs, potentially hindering competition from third parties. Furthermore, trying to maximize information rents might even lead to informed parties endogenously creating information asymmetries, intentionally introducing complexities to reduce transparency, similar to those that can be observed in financial markets (Stiglitz 2017). In addition, when there are multiple markets, informed parties can use their information advantage for manipulating market outcomes (Lo Prete et al. 2019; Guo and Lo Prete 2019).

Understanding all these incentives is crucial to energy policy design as policymakers aim to better enable multiplicity of DERs, and networks that can support this transition. Most of the new actors will be located at the distribution level, with assets behind-the-meter and plenty of private information. Hence, policy solutions that would incentivize these actors, as well utilities, to reveal their information will be crucial to speed up the transition. While there are already some elementary programs like Green Button programs that aim to improve information availability by making consumer data available, their limited scope and opt-in requirements do not allow them to fully alleviate the information problems we discussed above.

Importantly, policymakers should account for these incentives in their analyses to avoid implementing policies that might hinder or otherwise impede the transition. Even though a policy could be economically efficient in a first-best, full information setting, it may be inferior when information asymmetries are taken into account. It might even be the case that more coarse instruments are preferable to more granular instruments that rely on private information when information rents are taken into account. However, none of these could be understood without a thorough analyses of the distribution networks, DERs, and the incentives of different actors under information asymmetry.

Conclusion

A cost-effective energy transition requires a rethinking of electricity sector regulation with an eye towards understanding the information structures between the existing and new actors in the electricity sector, and the resulting incentives. As we briefly discussed above, ignoring information asymmetries, while setting regulatory policy for the future of the grid, can lead to inefficient outcomes. So, researchers should start incorporating information asymmetries into their distribution network modeling. And, as policymakers think about grid modernization, they should also think about complementary information policies that can help speed up this transition.

Footnotes

[1] For example, both the utility and the wholesale system operator will necessarily have to react to the DER aggregator's behavior (e.g., injections) to ensure that the physical constraints of the grid such as voltage and power flow are met.

[2] We consider only four types of actors for simplicity. In reality, there are more types. For example, energy service companies in deregulated states, large commercial & industrial customers, multiple types of policymakers (public utility commissioners, federal energy regulators, state legislations)

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