Splitting distribution from transmission to create 21st century Distribution System Operator utilities with a hybrid infrastructure-services business model.

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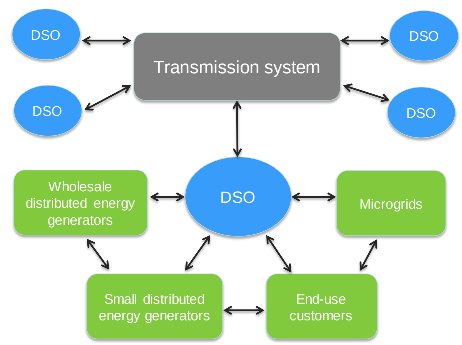
The 21st century high-Distributed Energy Resources world calls for distribution-focused utilities separate from transmission assets

The astonishing progress of distributed energy technologies means that the both the utilities' natural monopolies and the management of the grid will be changing, one way or another. The future will force utilities to develop a renewed, more sophisticated, and focused model as a distribution-grid business. Achieving that vision will require that utilities divest from transmission assets and embrace the full range of distribution-level services, becoming Distribution System Operators (DSOs). Becoming distribution-only companies will force utilities to become fierce innovators focused on achieving maximum value from distributed energy resources (DER) and the distribution grid.

The transformation of utilities into Distribution System Operator utilities will require two fundamental shifts in the utility business model. First, focused Distribution System Operator utilities must shed the conflicts of interest inherent in owning transmission assets while managing distribution grids. Second, utilities will need to reframe their thinking to embrace a hybrid business model that derives income from services and market-making in addition to returns on investment in infrastructure.

The focused Distribution System Operator utility will have four key functions: (1) maintain safety and reliability, (2) maintain and balance power and voltage on local distribution grids, (3) manage the load and frequency[1] profile for the Transmission System Operator (TSO) at the transmission-distribution interface (T-D Interface), and (4) facilitate the dispatch and compensation for all services provided by Distributed Energy Resources (DER). Once the system of Distribution System Operator utilities is implemented, the grid becomes a network of distribution areas connected to the transmission grid, each with independent control to present a single aggregated energy profile to the Transmission System Operator (Figure 1). As a result, the Transmission System Operator needs no visibility into the distribution layer and can manage the transmission grid based on the aggregate profiles managed by the Distribution System Operators. This system will make management of both the transmission and distribution grid more efficient and foster realization of the full set of values DER can provide to the grid.

Figure 1 – The DSO Grid – The Transmission System Operator interacts only with the Distribution System Operators who in turn manage and balance their distribution areas and the Distributed Energy Resources within them.



Three interrelated developing trends of DER on the 21st century grid will compel utilities to adopt a distribution-focused business model: (1) the increasing complexity of a DER-rich distribution grid, (2) the increasing array of services that DER will provide, and (3) the rapid cycle of disruptive new DER technologies.

In this new world, utilities will want to become agile innovators focused on maximizing the value of the distribution grid and distribution-connected resources. These distribution-focused utilities will:

- Leverage their natural distribution monopolies to become agile, distribution-focused organizations.

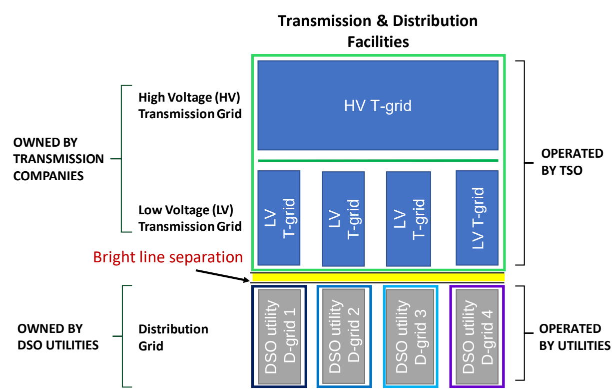
[1] Distribution System Operator utilities would commit to managing and reporting their impacts to frequency regulation to the Transmission System Operator and dispatch frequency regulation services within their distribution grids at the instruction of the Transmission System Operator, since frequency regulation is balanced across the entire grid (unlike power or voltage, which can be balanced locally).

- Deliver value to ratepayers by cost-effectively managing a complex electrical distribution system and a sophisticated market system. Distribution-focused utilities will be compensated for unlocking this value in a "pay for performance" model in which compensation is tied to meeting performance standards, such as reliability, avoided transmission investment, or slowing peak load growth.
- Stack revenue streams, including the return on investment on physical distribution infrastructure, plus a new suite of local subsystem balancing fees, DER bidding transaction, or transmission services fees for presenting aggregated load and dispatch from their distribution areas.

As appealing as this vision is, two significant impediments need to be addressed: 1) the conflicts of interest inherent between distribution optimization and transmission investment and 2) the business model of utilities as infrastructure investors rather than service providers.

The inherent conflicts of interest between distribution and transmission businesses will hinder the transformation of utilities into fiercely innovative and agile Distribution System Operator utilities. Thus, a key reform will be to create a brightline separation between distribution and transmission businesses (Figure 2).[2] For this transition to be successful, utility interests must align with maximizing the efficiency of the distribution grid and with the interests of ratepayers in an efficient grid.

Figure 2 – The ownership and operation of the grid.

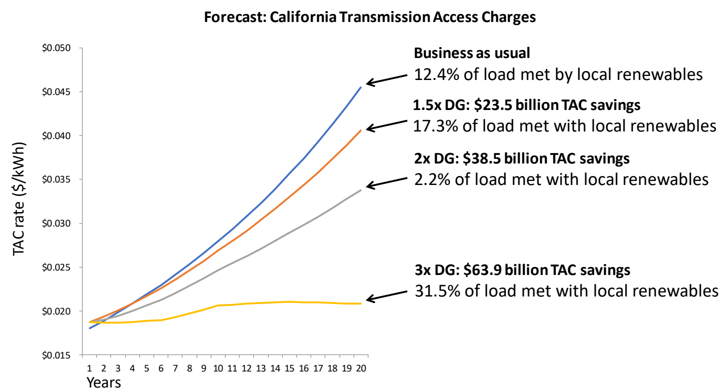


A bright- line separation between transmission and distribution businesses will incentivize aggressive development of distribution grid functionality

[2] Splitting utilities would leave shareholders in an equal or possible better position. Whether shareholders retain ownership in both businesses or the transmission assets are sold to outside transmission companies, shareholders would be whole regardless.

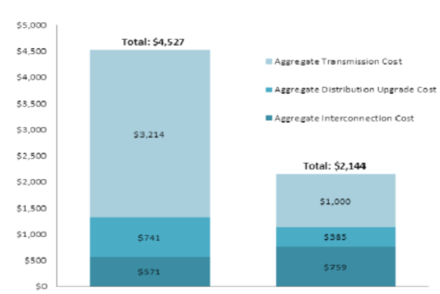
Unleashing the value of DER on the distribution grid will reduce the use of transmission-connected resources and of the transmission grid itself. Any entity that profits from ownership of transmission assets would face a conflict if its successful distribution business reduces returns from its transmission business. At its simplest, increased distributed generation reduces peak transmission flows and overall transmission flows, which reduces future transmission investments and thus returns from those investments. For example, recent modeling of the California transmission grid by the Clean Coalition (Figure 3) suggests that tripling the deployment rate of distributed generation could reduce a current projected 5% real growth rate in transmission charges to near 0% growth, saving ratepayers some $63 billion over twenty years in transmission related costs (Figure 3). Those savings represent future lost profit opportunities for transmission owners.

Figure 3 – Projected Transmission charges growth slows with increased distributed generation deployment



More subtly, intelligent planning by a distribution-focused utility can also reduce the need for transmission and distribution investments. In a 2012 study, Southern California Edison modeled the projected investments under a use case of at-will unplanned DER deployment and under a guided case in which DER is directed at key locations within the grid. The planned deployment of 4 GW of distributed generation represented a savings of some $2.4 billion, mostly from transmission investments. A distribution-focused company, especially one that receives incentives for avoiding investment through non-wires solutions, would favor the planned case. An integrated transmission-distribution utility would

Figure 4 – Investment required for unguided and guided deployment of distribution resources



Source: Southern California Edison (2012) deny itself a guaranteed return on those $2.4 billion and might favor an unplanned case. Without a bright-line separation between the businesses, the utility will inevitably face disincentives to providing value on the distribution grid, if that value comes from savings on transmission that would otherwise be recouped by a different unit of the utility.

A successful Distribution System Operator utility would also displace some transmission-connected services by delivering more efficient and cost-effective energy services with DER. When transmission-connected resources are called on less to deliver services, the pressure for increased transmission upgrades would be similarly reduced. For example, in addition to avoiding transmission investment by substituting distribution connected generation for remote generation, other DER services can also reduce use of the transmission grid. Local voltage support, freeing up transmission capacity, or deployment of Renewable Portfolio Standard eligible distributed generation can reduce the need for transmission connected-resources above and beyond the reductions that will take place when transmission-connected capacity is displaced by distribution-connected capacity. While an agile and effective Distribution System Operator utility would have strong incentives to maximize the value of DER (and get compensated accordingly), an integrated transmission-distribution utility would face the prospect of potentially undercutting the need for its transmission grid or transmission-connected resources. Again, owning the transmission assets poses a real barrier to the Distribution System Operator utility's success.

The roles and responsibilities of the Distribution System Operator utility

Divestment from transmission assets would set the stage for utilities to meet the challenges of a high-DER grid. Separation of distribution from transmission will create an exclusively distribution-focused utility that will embrace both the management of the distribution grid and the facilitation of energy services markets to become full-function Distribution System Operators. By creating competition between the Distribution System Operator utilities and transmission connected resources to provide the most cost-effective resources, the creation of Distribution System Operator utilities will bring down costs for ratepayers.

The full Distribution System Operator utility will be critical to meeting the coming trends in DER growth. First, the Distribution System Operator's key management of the distribution grid will make management of the overall energy system far more efficient and reliable, addressing the issues that come with the growing complexity associated with the profusion of distribution-edge connected resources. Second, the full-function Distribution System Operator utility will facilitate the kinds of markets and mechanisms that will be required to ensure orderly provision of DER services and provide for revenue streams to support DER. Finally, an innovative full-function will have the agility to effectively deal with new disruptive technologies as they arise.

Trend 1: Complexity of a Distributed Energy Resource-rich grid demands a Distribution System Operator

The Distribution System Operator utility will resolve emerging issues of grid complexity that come from increasing DER penetration. As customers respond to new rate structures, and deploy generation, new loads, especially electric vehicles (EVs), and storage behind their meters, their load profiles will change sharply. The complexity of managing the transmission grid will increase as millions of new devices create potentially volatile or unpredicted responses to price signals and opportunities, especially where the Transmission System Operator (TSO) has limited visibility into the distribution grids. Past patterns and projections can only go so far in helping transmission operators manage an increasingly unruly grid. For example, a customer purchasing an EV will see their load jump to a new profile literally overnight. As EVs develop the capacity to discharge to the grid, load shapes may change even more dramatically, especially as fleets change location. Where these devices are deployed will be a function of socioeconomic status, political culture, policy changes (for example, if a city or organization is awarded a grant for DER deployment), and even fads if neighbors influence each other to deploy DER. With continued price drops in solar and storage, wholesale in-front-of-the-meter resources and net energy metering exports will become increasingly important contributors to generation. Old assumptions for load forecasting will become obsolete, and loads may see increased volatility as resources switch on or off in response to customer needs unrelated to the management of the grid. The transmission operator may be faced with an array of distribution substations with complex profiles to manage.

As DER owners participate in delivering energy services to the transmission grid, such as frequency response or voltage support, distribution systems may face congestion or other issues if the dispatch is not well managed. Since transmission operators or schedulers lack visibility into the distribution grid, dispatching DER ancillary services to the transmission system risks exacerbating distribution issues as they dispatch or curtail energy in response to system-wide conditions. In the worst cases, DER operators may face conflicting orders from the transmission operator and the utility distribution company based on the constraints each operator is facing at a given moment in what could be termed the "two masters problem."

Ultimately, as DER proliferate, the Transmission System Operators will likely face too much complexity at the distribution edge to manage easily. Combined with potentially conflicting constraints on the distribution grid, this variability will present one of the key challenges that a distribution-focused utility can address and be compensated to manage.

Trend 1: Solving the problem with a Distribution System Operator utility: Local subsystem balancing to reduce complexity

Assigning responsibility for managing the distribution grid to a Distribution System Operator utility would greatly alleviate these issues. Two of the most basic functions of a Distribution System Operator utility would be to provide local subsystem balancing and to maintain reliable distribution service. As a local subsystem balancing authority, the Distribution System Operator utility would manage this complexity and present the transmission operator with an aggregated profile that it commits to maintaining within certain parameters. In continuing its role as the utility distribution company, the Distribution System Operator utility would also continue to maintain poles and wires and provide fault detection and repair services.

Whether energy is provided from local or remote resources, power, voltage, and frequency must be balanced at all times. As the local subsystem balancing authority, the Distribution System Operator utility would be responsible and accountable for balancing power, managing local voltage support, and contributing to frequency balancing for the whole grid. The Distribution System Operator utility would be responsible for presenting an aggregate energy profile of its service area to the transmission grid at the distribution substation (or whatever component represents the transmission-distribution interface.) Ultimately, the Distribution System Operator would commit to a load profile on its transmission-distribution interface, and be accountable for any deviations.

First, the Distribution System Operator would balance power, matching load and generation (including imports from transmission-connected resources) within its area. The Distribution System Operator utility would act as a local scheduling coordinator for local generation, automated demand response, storage, and other DER to meet its balancing and profile obligations. By managing that profile to fit parameters than can be relied upon by the Transmission System Operator, the Distribution System Operator utility would greatly simplify the management of the transmission grid.

The Distribution System Operator utility would also use its resources to assist the Transmission Operator by providing service. For example, the Transmission System Operator could instruct a Distribution System Operator utility to depart from its planned load profile by increasing load through inverse demand response (DR) or EV fleet management should spot prices go negative, or by releasing energy or reducing load to support the transmission grid. By acting as a large variable resource that can become either dispatchable load or generation, the Distribution System Operator could be incredibly valuable resource to the overall energy system. When the Distribution System Operator utility can provide needed services cost-effectively by calling on its resources, the Transmission System Operator can call upon those aggregated resources (without necessarily knowing what those resources are). Alternatively, when other resources are more cost effective, those would be called upon, ensuring an efficient grid.

The Distribution System Operator would be in a position to take over some grid services from the transmission operator. For example, the Distribution System Operator would be particularly well-situated to manage voltage support through advanced inverters on DER within its distribution area. Advanced inverters allow various DER to provide variable amounts of reactive power to support voltage in their local areas of the grid. Since reactive power decays quickly with distance, voltage management with remote resources can be highly inefficient. By taking advantage of high DER penetration, the Distribution System Operator would likely supplant much of the needed voltage support currently managed over the grid. Similarly, the DSO utility would be able to assist the Transmission System Operator with frequency support by delivering promised profiles to allow better frequency control on the transmission grid. The DSO-utility-as-balancing-authority would also be able to dispatch distribution-connected storage, one of the best resources for frequency-balancing on the grid, as enhanced frequency response (with under-one second response times).

Critically, these valuable services could represent additional revenue streams in the value stack of a DSO utility. As noted earlier, a Distribution System Operator utility would retain responsibility for maintaining the physical infrastructure of the distribution grid, including maintenance, fault detection and repair, and upgrade investments, and the compensation for those investments. However, additional revenue opportunities would open where policymakers compensate Distribution System Operators for the value delivered in avoiding transmission management costs, congestion charges, or transmission investments.

Trend 2: Distributed Energy Resources will be called on to solve the problems of the electricity system through the delivery of services.

Full -function Distribution System Operator utilities will also allow DER to play an increasingly important role in vital grid services. By developing and implementing clear and practical market mechanisms for DER to capture the value of those services, the Distribution System Operator utility will remove economic barriers to DER deployment to provide these services.

Today, DER can provide a range of services cost-effectively, but won't if those services are uncompensated. For example, as flexible capacity, DER can provide a range of rapid energy services from imbalance energy to demand charge or time-of-use charge management. DER can meet reliability needs through real power capacity of solar+storage combined with the provision of reactive power from advanced inverters.[3] Similarly, DER, especially battery storage, can provide much faster frequency responses to prevent small frequency excursions from becoming large ones as spinning ramp up or non-spinning reserve comes online. DER can meet locational needs to alleviate congestion and free up capacity on both the transmission and distribution grids by strategic placement of highly modular facilities. DER can also provide resiliency, backup power, and black start services in cases of outages. DER can assist both distribution and transmission operators with load-balancing and peak management by acting in aggregate as either generation or load, depending on the needs of the transmission grid.

The full Distribution System Operator utility can provide the missing compensation mechanisms that DER need to be economically viable by creating and managing a series of energy

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[3] C. Loutan et al., *Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant* National Renewable Energy Laboratories (March 2017), available at https://www.nrel.gov/docs/fy17osti/67799.pdf.

markets. These mechanisms will need to have a few key characteristics. Most clearly, the Distribution System Operator will need to match services to buyers. For example, the DSO utility can procure energy from distributed generation within its distribution area for its own load at market prices or preferential pricing for local generation, possibly facilitate it for other load serving entities in its area, or bid it into wholesale markets on behalf the DER owners.[4] Second, the compensation mechanism should have low transaction costs to allow relatively smaller DER providers to participate. The modular nature of DER means that services may involve many relatively smaller providers. Third, the compensation mechanism will need to provide clear market rules for interacting with transmission-level markets. Although the Distribution System Operator will be the sole entity interacting with the Transmission System Operator to capture the values of grid simplicity, DER providers must have opportunities to seek the highest value among the services that could potentially be provided. For example, energy storage facilities could provide distribution-level services, such a local peak shaving, congestion management, or voltage support, as well as transmission-level services, such as frequency response or merchant power. Since the Distribution System Operator has primary responsibility for balancing local resources first, the Distribution System Operator may pay a price matching the forgone price in transmission markets, for example. Ultimately, the DSO will be balancing its distribution grids to present profiles to the transmission grid, so any market rules will likely have to provide the DSO with the authority to manage the distribution area and DER to provide services within that context.

As with the balancing services, the significant number of transactions and market services provided opens opportunities for Distribution System Operator utilities to add to the value stack from their distribution grid management. The Distribution System Operator utility will be involved in many energy and services transactions both within the distribution system and into the bulk power system. Since these energy and services transactions will occur only when these services are cost-effective relative to alternatives, these will save ratepayers costs by reducing investment and operations costs across the entire grid. Charging a small transaction fee (no larger than the cost savings) would allow stacking small transaction fees or service fees from market participants and

[4] Since DER would be captive within its area with respect to qualifying as local generation, policymakers may need to devise some inter-distribution area location-adjusted pricing mechanism to avoid price discrimination due to the utility monopsony.

rate payers, allowing utilities to expand their business model beyond the traditional investment-based model.

Trend 3: Emerging distributed energy technologies will call for novel technical and business structures.

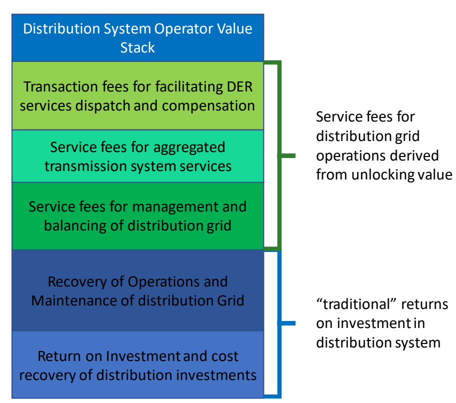
Finally, agile Distribution System Operator utilities will be critical in preventing barriers to the emergence of disruptive technologies. It is virtually certain that new technologies will emerge that drive new considerations and needs. (For example, we can foresee that EV2Grid technologies will be emerging, but how consumers will actually use these capabilities and what services they may end up providing is less clear.) Today, integrated utilities (and policymakers) are grappling to various degrees with the technical and business constraints for maturing technologies, such as energy storage or solar+storage facilities. However, as discussed above, the speed with which these technologies are integrated may be slowed by a lack of focus on the part of utilities that don't have sharp incentives to maximize the value of DER. Thus, the DSO will be better suited to address such needs more quickly than a traditional integrated transmission and distribution utility. Indeed, when a Distribution System Operator views new services as a revenue opportunity rather than as a threat to existing business models and reliability practices, we will find that innovation is likely to be incorporated into the energy system more quickly.

The Distribution System Operator Utility business model

From the perspective of modernizing the utility business model, utilities need to expand beyond the limited concept of being a wires investment company to become a hybrid investment company, services provider, and local subsystem balancing authority. This expanded role will open new potential revenue streams for the Distribution System Operator utility based on its expanded ability to derive value from distribution-connected resources.

In this hybrid model, the Distribution System Operator will assemble a stack of revenue streams to make

Figure 5 – The Distribution System Operator Utility Value Stack



Distribution System Operator utilities will combine traditional revenue with service fees to generate income up the full compensation (See Figure 5.) The Distribution System Operator utility will naturally continue to generate revenue from its basic distribution investments, as well as operations and maintenance. As rate-based assets with guaranteed return, most distribution assets will represent roughly the same guaranteed revenue stream under this scenario as they do now.

Unlike that of most contemporary utilities, this business model will add a significant fee-based component as a hybrid model. The additional value for the Distribution System Operator will come from two categories of fees. First, the Distribution System Operator will generate fees based on the services provided through its role as local subsystem balancing authority and scheduling coordinator within each distribution area. Second, the Distribution System Operator utility will generate small transaction fees on DER owner transactions. Although the economics of DER is marginal in some cases (keeping in mind that DER are increasingly able to displace both wires solutions and traditional fossil fuel power on a cost basis today), these costs to DER owners will represent a fraction of the additional value DER can capture through opportunities facilitated by the DSO utility. For example, by facilitating a distribution wholesale market with less costly transaction costs (such as expensive bid preparation) or facilitating entirely new pathways into transmission frequency response markets, the Distribution System Operator should be able to provide value to the DER owners. As the Distribution System Operator utility collects for aggregated services bid into transmission markets, it can take a commission and pass the remainder on to the DER it aggregated. Although the transaction fees will have to be small to prevent them from becoming a barrier, summed over many transactions these fees can drive significant revenues to the Distribution System Operator utility.

With a hybrid compensation model, Distribution System Operator utilities will face more diverse incentives, allowing for a more flexible array of new opportunities to realize value from the distribution grid. Furthermore, a model in which utilities drive revenue through achieving value rather than building ever more infrastructure will move utility business models into closer alignment with the public. Accomplishing that requires unwinding the conflicts of interest.

Profound impacts of the Distribution System Operator model on the regulatory landscape

Splitting transmission and distribution could have profound and positive impacts on the regulatory environment. As described above, the Distribution System Operator utility would stand to implement a host of measures with significant potential to make the grid more efficient. While those changes could potentially be accomplished by a motivated integrated utility, a truly distribution-focused- Distribution System Operator utility would have greater incentives to aggressively find new value. The Distribution System Operator utility would be a fierce advocate for distribution-based innovations that could lead to ratepayer savings that an integrated utility might neglect. To the extent that adversarial processes and competition work to uncover the most cost-effective approaches, having separate distribution and transmission businesses would provide for a far more open debate on the relative value of resources for each level of the larger energy system. As DER come to represent a larger share of generation and a larger share of energy services, this debate will be unavoidable, but currently it falls to outside advocates with imperfect information to advocate for what stand to be major ratepayer savings. With separate business entities, those best placed to make these arguments would have real and substantial incentives to do so.

A hybrid service-based business model opens the door for policymakers to align utility interests with public interests. Although the details of how such fees are recovered will differ between different utilities and jurisdictions, policymakers have a powerful lever by expressly tying compensation to performance standards. Such standards might include traditional metrics, such as reliability metrics, but also metrics such as resilience capabilities, reductions in congestion or avoided transmission or distribution investments through intelligent deployment of DER. In this sense, a hybrid fee model is potentially a more flexible model that can incentivize cost savings and efficiencies through bonuses or compensation proportional to the cost differential of distribution solutions relative to more expensive alternatives. By partially decoupling utility revenues from a pure infrastructure build model, regulators and the public would have an entirely new set of tools to influence utility decision-making with greater flexibility for regulators and utilities alike, and would have a business ally with every incentive to support innovative approaches.

The future utility will have to become a Distribution System Operator

Today, a high-DER world is emerging rapidly, and there is every indication that the traditional investment-based business model of the utility will not be agile enough to provide the services and management that a more complex electric grid and business ecosystem will need. Making a change requires aligning utility business interests with the development of innovative approaches, and that requires changing the existing compensation structure. Divesting utilities from transmission assets is an important step toward creating full-function Distribution System Operator utilities. While a full transition will require a range of additional regulatory and legislative efforts, aligning the interests of a distribution utility with those efforts is among the surest approaches to bringing them to fruition quickly. Ultimately, regulators and policymakers, business leaders, and the public must commit to developing a new business model that focuses on the new opportunities and is agile and influential enough to create new realities. The future is coming; whether utilities and the public succeed in benefitting depends on a willingness to meet change with change. In this time of increasing complexity and opportunity, we must adapt and lead.