The role of utilities in enabling prosumers and flexible distributed energy resources

Daniel Quiggin, Research Fellow, Energy, Environment and Resources, Chatham House
Antony Froggatt, Associate Member, Energy Policy Group, Exeter University and Senior Research Fellow, Chatham House

Abstract

Increasing the flexibility of the electricity system can counter rising system integration costs, incurred as more variable renewables are deployed. While flexibility can be provided through centralized systems, what is new is the ability of distributed energy resources (DERs) in providing flexibility and network services. The integration of variable renewables, combined with traditional drivers of network maintenance during routine replacement and upgrading, are creating the opportunity for new forms of value from the energy services DERs could provide. Prosumers, who own DERs, are currently locked out of the market, due to a lack of mechanisms to discover these new forms of value. A number of factors prevent DERs from supplying services to the distribution system, these principally include; valuing the range of services, and the creation of markets for these complex and locationally specific services. In turn, efficient market places for DER services require these services be quantified and measured – necessitating new system operators at the distribution level of the network. This paper investigates emerging regulatory frameworks and market platforms in New York and Australia, indicating that whilst network utilities will be key in unlocking the complex nature of location specific distribution network values, market platforms are likely to manifest from innovative startups rather than the utilities themselves. These markets are likely to transform over time, increasingly providing more network services with a greater proportion of the value of DERs being determined by locationally specific services. Further, if these markets are sufficiently liquid and grow in size, it will become increasingly important to clearly separate distribution system operators from traditional distribution network operators, especially in relation to the dispatch and coordination of DERs. Without which, DERs will not be competing on an even playing field with traditional network assets.

The declining power of utilities

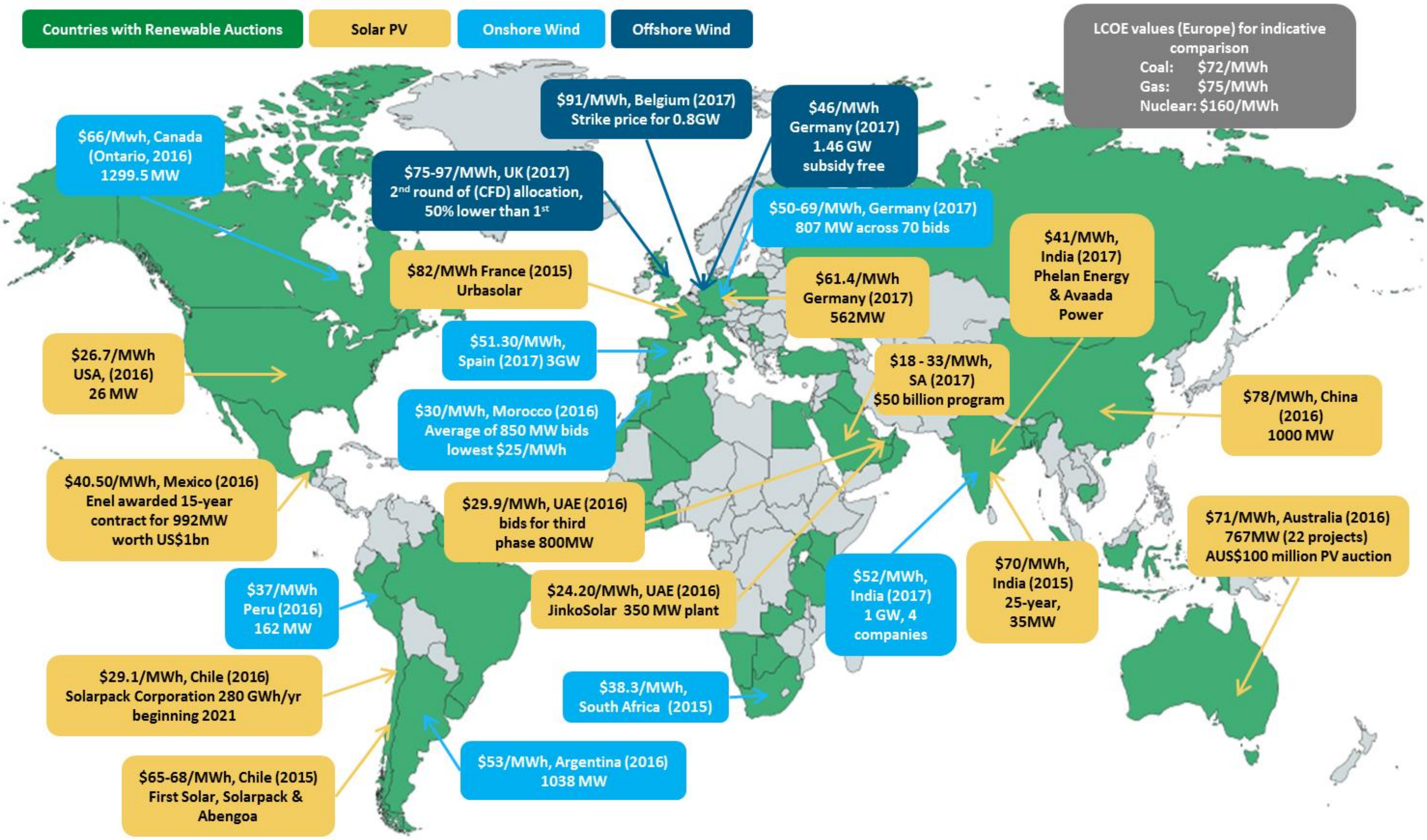
The electricity sector is undergoing a profound transition, due to a confluence of technological innovation, tougher environmental policies and regulatory reform. This is most evident in Australia, the EU28 and parts of North America, where traditional power companies are struggling. However, many see a growing role for those utilities that operate the distribution networks.

Within the regions most affected, three factors have impacted utilities most clearly. First, improvements in energy efficiency have dampened the prospects for electricity demand growth. Second, in many OECD countries power sector liberalization has allowed consumers to choose between a growing number of suppliers – thus threatening incumbent utilities'. Third, as renewable generators enter the market, even if they do not have priority access to the grid, their low production costs mean that they can, in a competitive market, underbid fossil fuel generators, which drives down the wholesale price. This is known as the 'merit order effect', and is now widely documented.[1] For example, in Germany, a study of the day-ahead spot market found that prices fell by €1.23 per MWh for each additional gigawatt hour (GWh) of wind power.[2]

Among these three factors, traditional utilities are currently responding most clearly to the continued cost reductions and deployment of renewables. The price of installing solar PV has fallen by 99 per cent since 1976 and by 80 per cent since 2008; it is expected to drop by another 66 per cent by 2040.[3] The most recent price declines can be seen in Figure 1.

[1] Woo, C. K., Moore, J., Schneiderman, B. and Zarnikau, J. (2016), 'Merit-order effects of renewable energy and price divergence in California's day-ahead and real-time electricity markets', *Energy Policy*, 92 doi:10.1016/j.enpol.2016.02.023 (accessed 28 Apr. 2018).
[2] Benhmad, F. and Percebois, J. (2016), 'Wind power feed-in impact on electricity prices in Germany 2009-2013', *The European Journal of Comparative Economics*, 13(1).
[3] Bloomberg New Energy Finance (2017), *New Energy Outlook 2017* (accessed 6 Feb. 2018).

Figure 1: Renewable-power contracts agreed in 2015–17, with comparison of levelized cost of electricity (LCOE)[4] values for coal, gas and nuclear generators.



Note: For sources, see Appendix 1.

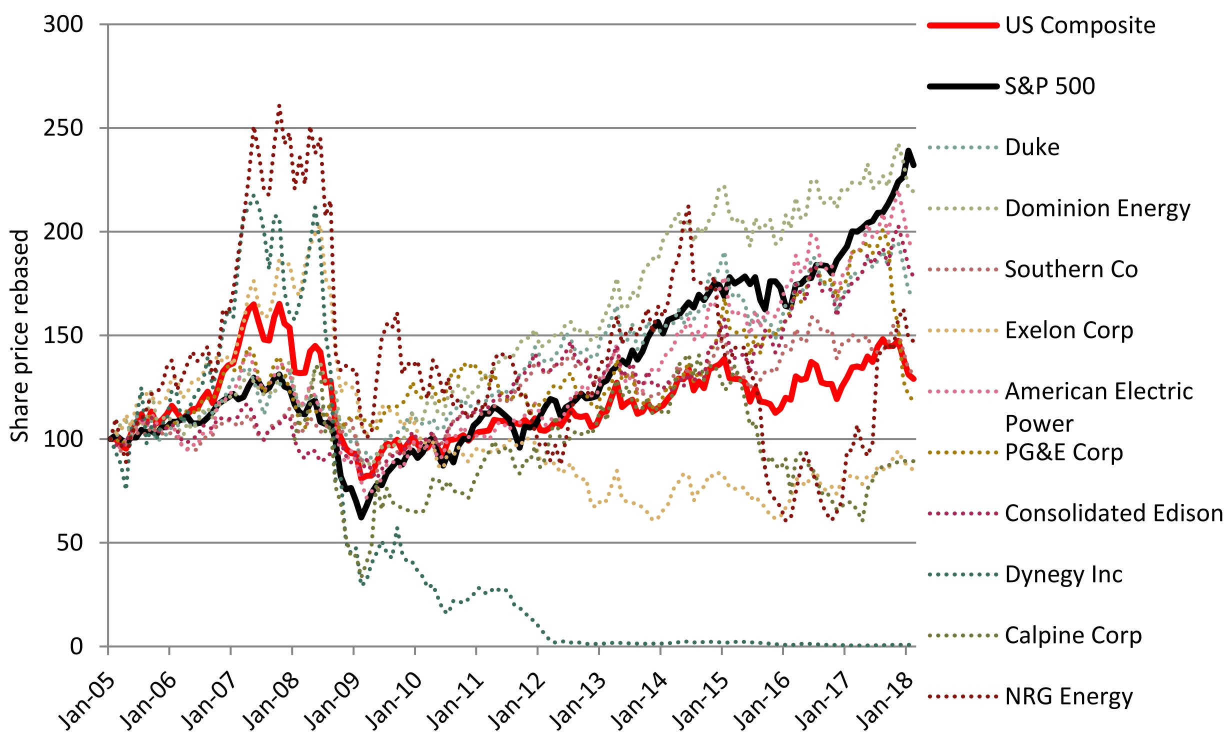
Share prices offer a clear indication of how the perceived value of the power sector has changed. Shares of many traditional utilities, like those of other companies, rose in the second half of the last decade until the 2008 financial crisis, when they fell sharply. Although utilities' share prices briefly picked up after that point, they then declined again even as shares in other sectors rallied. Between the end of 2006 and end of 2016, the average share price of the major power utilities in Europe halved, while the FTSE 100 Index rose by 15 per cent.

The situation is slightly different in the US, depending on the type of market in which a given utility is operating. Those in markets without fixed prices are suffering. The 2018 Moody's outlook for the

[4] For a power plant developer, the LCOE is equivalent to the wholesale price required at commissioning to cover costs (excluding grid connection) while achieving a required return of rate, excluding subsidies.

unregulated power and utility sector has remained negative, due to 'anemic demand, an oversupplied market and low wholesale power prices'. In the U.S. wholesale electricity prices are highly contingent on gas prices, which look set to remain low due to advances in fracking technology and the corresponding low costs of production. Power utilities primarily operating coal and nuclear plants are particularly affected. The composite share price in Figure 2 is an average of the largest listed power utilities in the US.

Figure 2: Share prices of major power utilities in the US and the composite (average) share price compared to the S&P 500 Index, rebased to 2005

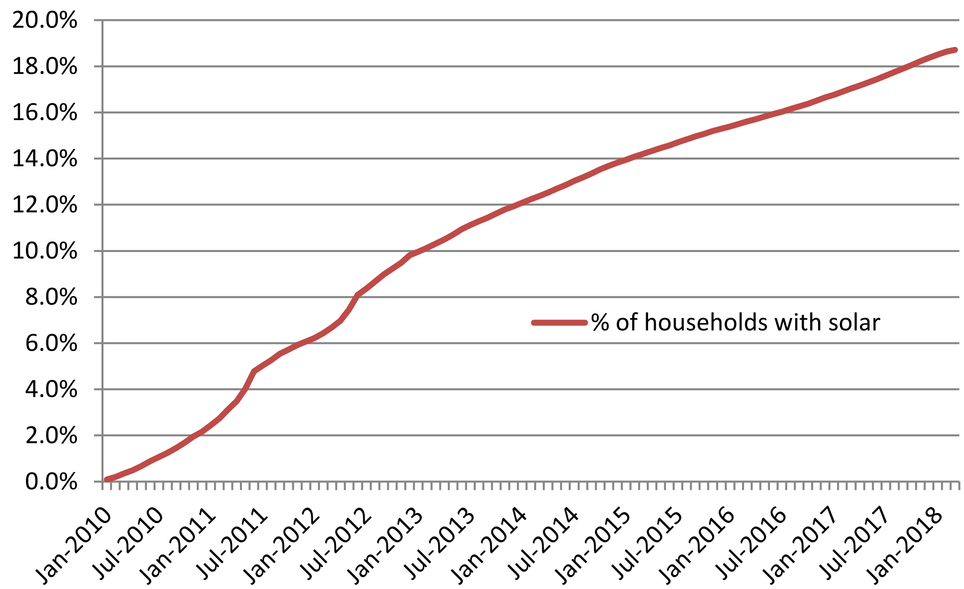


Source: Chatham House analysis of Thomson Reuters data (2018).

The rise of decentralization

An important change is now evident within the electricity sector; deployment is of solar and wind is occurring on relatively small scales. The factory-based manufacturing model of modular renewables enables smaller, low capital cost deployment and broadens the pool of market participants that the capital-intensive centralised power plants then need to compete with. For solar PV, between 2010 and 2016, more than 23 million units of less than 100 W in capacity (also known as pico-solar PV) were sold worldwide for off-grid purposes.[5] In the UK, more than 1 million homes now have solar PV panels, as do more than 1.4 million in Germany. Most recently, Australia has seen a huge uptake in the use of distributed solar PV installations. Since 2010 the share of Australian homes with a solar PV installation has risen from a negligible base to 18.9 per cent as of March 2018 (see Figure 3).

Figure 3: Proportion of households in Australia with solar PV



Note: Residential or household solar PV classified as under 9.5 KW.

Source: Chatham House analysis of data from Australian Photovoltaic Institute (2017), 'Australian PV market since April 2001', http://pv-map.apvi.org.au/analyses (accessed 9 Nov. 2017).

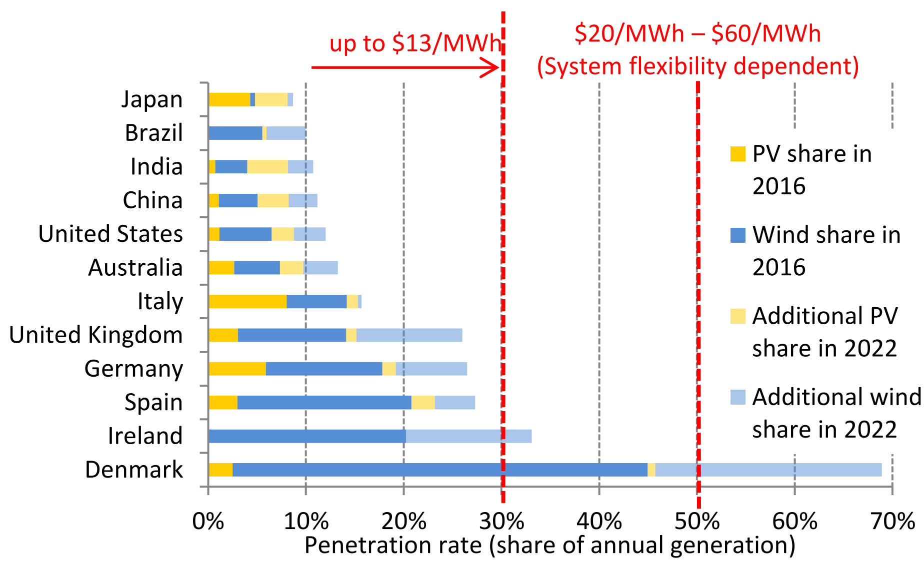
Solar PV is the clearest example of the rise of decentralization of the energy system, but by no means the only example. A raft of distributed energy resources (DERs) are entering the market; Electric Vehicles (EVs), battery storage and flexible demand are beginning to accompany the traditional modular renewable technologies of solar PV and wind.

[5] REN21 (2017), *Renewables 2017 Global Status Report,* Paris: REN21 Secretariat, http://www.ren21.net/wp-content/uploads/2017/06/17-8399_GSR_2017_Full_Report_0621_Opt.pdf (accessed 27 Apr. 2018).

The importance of flexibility

Many electricity sectors are facing a second phase of transformations, characterized by enhanced flexibility and the emergence of new market actors. At their current penetration levels,[6] solar PV and wind power are easily absorbed by existing power systems, with minimal system integration costs (SIC).[7] With these technologies expected to reach a penetration rate of 30 per cent in many countries in the next five years, concerns over the costs of integrating solar PV and wind power into the system have increased. For up to a 30 per cent share of generation, variable renewables' SIC are estimated to be up to \$13/MWh.[8] With wholesale prices in Europe and the US at 10-year lows,[9] SIC of \$13/MWh would represent around 30–40 per cent of current wholesale prices. As Figure 4 indicates, SIC could rise substantially to between \$20/MWh and \$60/MWh at a 50 per cent share of generating capacity. Crucially, this range is dependent on the flexibility of the system.[10]

Figure 4: Solar PV and wind power – share of generation in relation to current and expected system integration costs



Sources: Adapted from IEA (2017), *Renewables 2017*; and UKERC.[11]

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[6] The penetration level is the share of annual generation that a particular type of generator represents.
[7] Heptonstall, Gross and Steiner (2017), *The costs and impacts of intermittency – 2016 update*.
[8] These SIC are the average over the year, taking into account the seasonal and diurnal fluctuations of renewable output; Heptonstall, Gross and Steiner (2017), *The costs and impacts of intermittency – 2016 update*.
[9] US Energy Information Administration (2017), 'Wholesale Electricity and Natural Gas Market Data', https://www.eia.gov/electricity/wholesale/#history (accessed 6 Nov. 2017); European Commission (2017), 'Market analysis – Gas and electricity market reports', https://ec.europa.eu/energy/en/data-analysis/market-analysis (accessed 6 Nov. 2017).
[10] Heptonstall, Gross and Steiner (2017), *The costs and impacts of intermittency – 2016 update*.
[11] Ibid.

Increasing the flexibility of the system as a whole can counter SIC impacts.[12] The impact of system flexibility on SIC and whole-system costs (WSC) can be illustrated by contrasting a scenario of high renewables penetration, in which the system flexibility is enhanced, with a scenario weighted towards nuclear power, which is generally regarded as the least flexible generator. As demonstrated by the shaded areas in Table 1, even a low-flexibility 2030 scenario in which variable renewables account for around 50 per cent of generation could enable the WSC of solar PV and wind power to be lower than the levelized cost of electricity (LCOE) of nuclear power. Under this (UK-focused) scenario, it is assumed that flexibility is provided by 5 GW of battery storage, a 25 per cent uptake of flexible demand, and an expansion of interconnection from 4 GW to 10 GW.[13]

Table 1: LCOE, SIC and WSC of solar PV and wind relative to the LCOE of nuclear power in 2030, at around 50 per cent variable renewable market share, under various flexibility scenarios[14]

	Assumed LCOE ($/MWh)	**System integration costs vs nuclear ($/MWh, real 2015 prices)**			**Whole system costs (LCOE + SIC, $/MWh, real 2015 prices)**		
		No flexibility	Low flexibility	Mega-flexibility	No flexibility	Low flexibility	Mega-flexibility
Nuclear	132.1	-	-	-	-	-	-
Offshore wind	110.1	71.1	16.4	8.1	181.2	126.5	118.2
Onshore wind	88.1	59.0	15.0	10.6	147.1	103.1	98.6
Solar PV	95.4	63.9	25.5	11.9	159.3	121.0	107.3

Note: Conversion to dollars based on historical exchange rate.[15]

Source: Adapted from Strbac and Aunedi (2016), *Whole-system cost of variable renewables in future GB electricity system.*

While flexibility can be provided through centralized systems, what is new is the ability of DERs in providing flexibility. As more DERs are adopted, a growing number of electricity consumers could become ‘prosumers’, also selling power and flexibility services back to the grid in an intelligent manner.

[12] Strbac and Aunedi (2016), *Whole-system cost of variable renewables in future GB electricity system*.
[13] Ibid.
[14] The SIC of wind and solar in this study were quantified against nuclear; this should not, however, be interpreted as the SIC of nuclear being zero.
[15] Internal Revenue Service (2017), ‘Yearly Average Currency Exchange Rates’, https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates (accessed 6 Nov. 2017).

In the near future, we can expect DERs to challenge the stranglehold of power utilities in providing essential grid balancing services. Today, electric vehicles (EVs) and lithium-ion batteries are the best examples of how flexible, DER approaches are challenging the business models of traditional utilities. Lithium-ion batteries have fallen dramatically in cost, and their modular nature means capacity can easily be adjusted for various functions and locations. In May 2018, 2 GW of battery storage and dynamic EV charging was announced in the United Kingdom, equivalent to half the generating capacity of the country's largest power station.[16] Rapid take-up of EVs could further expand flexibility. With smart EV charging, the United Kingdom could benefit from 11 GW of additional flexibility by 2030,[17] equivalent to 18 per cent of current generating capacity.

Decentralized flexibility is attracting new powerful commercial actors to the electricity sector. Google and Amazon are in talks with regulators to introduce time-of-use tariffs to enable flexible demand at the household level.[18] In order to keep pace, utilities are acquiring and investing in start-ups; for instance, Centrica paid £65 million in 2015 for AlertMe, a home energy management system that enables the smart control of wirelessly connected devices and appliances.[19]

The challenges for decentralized flexibility

Prosumers, who own DERs and could provide decentralized flexibility services back to the system, are currently locked out of the market. Millions of DERs communicating simultaneously with the wider system is technically challenging due to the volume of data that requires processing in real time.[20] This is where aggregators such as VCharge come in, acting as intermediaries between electricity end-users and

[16] Renewables Now (2018), 'Pivot Power plans 2-GW battery, EV charging network in UK', https://renewablesnow.com/news/pivot-power-plans-2-gw-battery-ev-charging-network-in-uk-613535/ (accessed 23 May 2018).
[17] Stoker, L. (2017), 'Electric vehicles could add 11GW of grid flexibility by 2030', Clean Energy News, 24 November, https://www.cleanenergynews.co.uk/news/transport/electric-vehicles-could-add-11gw-of-grid-flexibility-by-2030 (accessed 14 Dec. 2017).
[18] Morley, K. (2017), 'Your energy bills could be controlled by Google or Amazon under Government plans for 'peak pricing'', *Telegraph*, 24 July 2017, http://www.telegraph.co.uk/news/2017/07/24/energy-bills-could-controlled-google-amazon-government-plans/ (accessed 2 Oct. 2017).
[19] Lunden, I. (2015), 'British Gas Buys UK Smart Home Pioneer AlertMe In $100M Deal', TechCrunch, 13 February, https://techcrunch.com/2015/02/13/british-gas-buys-uk-smart-home-pioneer-alertme-for-100m/?guccounter=1 (accessed 25 May 2018).
[20] Burger, S., Chaves-Ávila, J. P., Batlle, C. and Pérez-Arriaga, I. J. (2017), 'A review of the value of aggregators in electricity systems', *Renewable and Sustainable Energy Reviews*, 77(C): pp. 395–405, https://www.sciencedirect.com/science/article/pii/S1364032117305191 (accessed 4 May 2018).

DER owners on one side and power system participants on the other.[21] By combining many small-scale DERs that would otherwise struggle to enter the market, aggregators can begin to buy and sell flexibility services. Kiwi Power, Enernoc and Flexitricity are aggregator platforms to which commercial and industrial consumers already allow third-party control of their systems, enabling their participation in flexible demand markets.

Aggregation is principally a means to enable DERs to provide services to the wider system, mainly ensuring supply-demand balancing via aggregation of flexible demand within wholesale markets. However, there are a number of services that DERs could provide that would minimize SIC, but that current aggregation services don’t enable.

A number of factors prevent DERs from supplying services to the distribution system, beyond simple supply-demand balancing within the wholesale market. These principally include; valuing the range of services DERs could supply at various levels of the transmission and distribution networks, and the creation of markets for these complex and locationally specific services. In turn, efficient market places for DER services require these services to be quantified and measured – necessitating new system operators at the distribution level of the network.

DNOs provide similar services via the utilisation of traditional network assets, hence there is a potential conflict of interest in distribution utilities enabling such services from DERs. Further, some of the services may not become valuable until the penetration of renewables within any particular part of the network reaches around 30%.

Valuing locationally specific DER services

The difficulty in valuing DER services stems from the fact that there are several categories of SIC impacts, the quantification of each depends on the wider system. SIC Impacts also overlap and interact, making quantification complex. Whilst many SIC are associated with the local distribution system, others pertain to the wider system. It should be noted that whilst DER services can help minimize SIC, DER services can also help minimize traditional capital expenditure (CAPEX). For instance, by minimizing the load on a particular substation which would otherwise require replacing due to increased consumer demand in a particular part of the network.

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[21] Ikäheimo, J., Evens, C. and Kärkkäinen, S. (2010), *DER Aggregator Business: the Finnish Case*, Research Report, VTT Technical Research Centre of Finland, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.454.3257&rep=rep1&type=pdf (accessed 28 Apr. 2018).

Many of the services that DERs could provide are inherently linked to the physical constraints and makeup of the distribution system. The required services - principally servicing; voltage constraints and network reliability - are locationally specific. The distribution system hasn't historically had to cater for the provision of markets for energy services from third parties, such as DERs owned by prosumers. As such, most electricity markets lack sufficient pricing mechanisms to appropriately value the locationally specific DER services.[22]

Valuing DER services needs to account for the variations in value depending on where within the system these services are being valued. This "locational value" necessitates locational marginal pricing (LMP) in delivering the appropriate valuation of DER services within the system. The corollary of this is that no DER can have a single set price for these services, throughout the system. Further, the value of DERs will vary depending on the site in question with some sites more valuable than others. As the system changes, this LMP derived value will evolve over various timescales.[23]

LMP could become a key mechanism in determining DER value within the distribution network However, LMP is not the only means by which DERs can be attributed value. It is possible to consider a "value stack",[24] where LMP is one potential element. Due to the other components of the value stack, economies of scale of deployment are still important. As such, a tension exists between the value of deploying DERs at smaller scales - where the distributed value is maximized - and the lowered incremental costs afforded by large scale (or high capacity) deployment.[25]

Importantly, the LMP regimes currently in existence are provided at the transmission level of the network. At the distribution level prices are determined by regulated or competitive network and supply tariffs, which contain much less time and locationally specific information. For instance, in the U.S. LMP is applied in many transmission systems, but these price signals are not communicated to agents within the distribution system.[26]

It should be noted that the highly complex nature of the distribution network makes the determination of distribution level LMP extremely challenging. Further, LMPs could result in equity concerns as low-

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[22] Pérez Arriaga, I. and Knittel et al, C. (2016), *'Utility of the Future. An MIT Energy Initiative response, to an industry in transition'.*
[23] Ibid.
[24] Baldwin, J. (2017), Bumps in the road: Utilities get in the way of New York's clean energy vision, https://www.solarunitedneighbors.org/bumps-road-utilities-get-way-new-yorks-clean-energy-vision/ (accessed 01 Jun. 2018).
[25] Pérez Arriaga, I. and Knittel et al, C. (2016), *'Utility of the Future. An MIT Energy Initiative response, to an industry in transition'.*
[26] Ibid.

income consumers could be exposed to increased costs, depending where they happen to be on the network.

Dispatch and coordination of DERs within distribution networks

Across jurisdictions, transmission and distribution networks are currently operated by different entities. Distribution networks tend to be operated by the distribution network operators (DNOs), who are responsible for overseeing the connection of DERs, but generally do not facilitate dispatch and coordination of system assets, beyond traditional network infrastructure. For DERs to provide services to the distribution network, coordination and dispatch of these services will need to be provided.[27]

The most crucial functions within electricity markets are those provided by three entities; system operators, network providers and market platforms. Clearly defined responsibilities between these separate three entities are vital to the efficient functioning of the market.[28] Until the introduction of DERs, market platforms for distribution level DER network services weren't necessary. Further, with negligible third party actors requiring coordination and dispatch, DNOs have provided the role of system operator and network provider. Crucially, markets for the provision of system services principally manifest from the tasks of the system operator.

DER services are likely to be in competition with services currently provided by DNO assets, and owned by third parties such as prosumers. As such, an even playing field is required between network assets owned by the DNO and DERs. Therefore, any coordination and dispatch function is likely to require the formation of a new agent – a distribution system operator (DSO) – independent of the DNO.[29]

Overhauling the manner in which utilities are compensated for their services, is critical to enabling the appropriate valuation of DER energy services to emerge. The regulated allowed returns of utilities are generally calculated on the basis of a utility's "rate base". This includes capital expenditure (CAPEX) on network assets. As such, the regime of cost of service regulation discourages utility's from reducing CAPEX as this may reduce their rate base and hence allowed returns. Whilst most countries employ incentives for utility's to reduce their costs, these are generally not as strong as the incentive to maintain their rate base. As a result utilities are unlikely to pursue efficient trade-offs between

[27] Newton, P. (2017), 'Turning distribution network operators into system operators', *Utility Week*, 28 June 2017, https://utilityweek.co.uk/turning-distribution-network-operators-into-system-operators/ (accessed 12 Jan. 2018)
[28] Pérez Arriaga, I. and Knittel et al, C. (2016), *'Utility of the Future. An MIT Energy Initiative response, to an industry in transition'.*
[29] Western Power Distribution (2017), DNO Transition, https://www.westernpower.co.uk/docs/About-us/Our-business/Our-network/Strategic-network-investment/DSO-Strategy/DSO-Transition-Strategy.aspx (accessed 07 Aug. 2018).

operational expenditure (OPEX) and CAPEX.[30] Given that the services DERs could provide may reduce the need for traditional network CAPEX, it is against the interests of DNOs to enable DERs to provide these services.

As the consideration of the rate base illustrates, dispatch and coordination of DERs in providing services to the system is likely to require some form of separation of system operator (DSO) and network provider (DNO) functions. An alternative would be to overhaul the cost of service regulatory regime to ensure network utilities efficiently value OPEX-CAPEX trade-offs. Without the separation of roles, establishing an even playing field between DERs and network providers in the provision of energy services, will likely prove challenging. The creation of DSOs, responsible for dispatch and coordination of third party DERs would likely satisfy this requirement, with DNOs still responsible for overseeing connection of DERs.

Currently, within transmission systems, the Transmission/Independent System Operator (TSO/ISO) is both the network provider and operator, with regulations ensuring the financial separation of the competitive market elements of the market agents/provider. A combined DNO/SO could replicate this model; creating and maintaining the network, operating the system, including the traditional network assets and dispatching DERs. As the DNO/SO would own and operate traditional network assets, it would need to be regulated in a manner that created an equal playing field between those assets and DERs in the competitive provision of energy services.

Turning to the wholesale market for lessons, shows that distribution systems are orders of magnitude more complex. This complexity increases the difficulty in separating network operation and planning.

An alternative model would see the creation of an independent distribution system operator (IDSO), which would function in a similar manner to ISOs in the U.S. This would have the advantage that the IDSO could own and operate DERs as it would be entirely separate from the DNO, who would continue to own and operate network assets. This model would likely require the legal unbundling of the DSO from the DNO, rather than the more light touch regulations required for financial separation.[31]

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[30] Pérez Arriaga, I. and Knittel et al, C. (2016), *'Utility of the Future. An MIT Energy Initiative response, to an industry in transition'.*
[31] Ibid.

Market Platforms with the distribution network

Modern economies are built on a series of interacting market platforms, the most successful of which tend to enable the greatest number of participants to compete in a given marketplace, much like the platforms of Uber, AirBnB, Ebay, Amazon and Alibaba. In response to the growing number of potential prosumers, a new business model and system agent could emerge: energy service platforms (ESPs) for DER-owning prosumers. These market platforms could connect and aggregate multiple DER-owning prosumers; providing tools, services and rules to enable them to be efficiently coordinated and dispatched by the DSO.

Market platforms (or ESPs) will likely require the formation of DSOs in order to measure, coordinate and dispatch such services, be that an IDSO or a combined DNO/SO. During the initial market reforms of wholesale markets, it was thought that establishing a competitive market platform or “Power Pool” would lead to competitive prices. However, the lack of separation between system operator and network provider impacted the ability of market agents in efficient price discovery.[32]

Not only are distribution systems more complex than the transmission system and hence the valuation of energy services difficult to achieve, the markets for these services within the distribution system may prove less liquid. In the transmission system, ancillary services, balancing and capacity can be procured from a large pool of actors. However, the locationally specific nature of services within the distribution network is likely to result in a handful of actors in any one area being able to provide them, potentially preventing sufficient liquidity.[33]

Market platforms by themselves are an inadequate tool to incentivize system evolution. Market platforms alone cannot provide the means to evolve the market towards the appropriate valuation of energy services as the system undergoes transformations. The functions of both the system operator and network provider can impact market agents in buying and selling energy services. Therefore, independence of the market platform from the network provider and system operator is likely necessary to ensure a competitive market place.

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[32] Thomas, S. (2001), The Wholesale Electricity Market in Britain – 1990-2001, www.psiru.org/sites/default/files/2001-09-E-Uk-market.doc.

[33] Pérez Arriaga, I. and Knittel et al, C. (2016), *'Utility of the Future. An MIT Energy Initiative response, to an industry in transition'.*

New approaches

In the previous sections it was established that for DERs and their prosumer owners to participate in the electricity market, selling the services their DERs can provide, then at the scale of the distribution system new pricing mechanisms would need to be developed alongside establishing DSOs and new market places, or "energy service platforms". The complexity of these transformations requires experimentation and learning lessons from pilot projects that are unlikely to fully address all these issues. Whilst electricity systems are functionally similar between jurisdictions, no two countries are entirely equivalent. Hence, it is worth comparing differing approaches.

Reforming the Energy Vision

New York's Reforming the Energy Vision (REV) is perhaps the most all-encompassing set of reforms to attempt to move traditional utilities from a cost-of-service business model to a 'service platform' model in which providers create marketplaces, sell system data, charge transaction fees and create flexibility. REV differs from reforms in other US states. For instance, California has set specific targets, such as for storage and EVs, whereas REV has taken a system-wide approach that targets the transformation of the actors underpinning and operating the electricity system itself, whilst also stimulating the deployment of DERs.[34]

REV reforms recognize that 'macrogrid' entities serve a public good in decentralizing the energy system.[35] REV provides for incumbent utilities to continue as distributors of energy even as they become marketplace operators. The DNOs themselves become Distribution System Platforms (DSPs), these DSPs are similar to the combined DNO/SO discussed above, rather than an IDSO. The DSP also provides the platform between suppliers and consumers of energy. The combined DNO/SO model under REV risks DERs being owned by the DNO/SO and hence reducing the competitiveness of the market. As such the New York Public Service Commission (PSC) prevents the DSP from owning DERs, apart from in exceptional circumstances.

Since its formation in 2014, REV has stimulated innovation and experimentation. Of 17 REV projects, five principally involve utilities creating market and service platforms. Not all projects have been successful,

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[34] Bade, G. (2017), Zibelman exit interview: How the New York REV is paving the way for transactive energy, Utility Dive, https://www.utilitydive.com/news/zibelman-exit-interview-how-the-new-york-rev-is-paving-the-way-for-transac/435252/ (accessed 05 Aug. 2018).

[35] Sturtevant, J. L. (2016), 'New York's reforming the energy vision— opportunities and obstacles on the horizon', Sullivan & Worcester LLP, Lexology, 11 May 2016, https://www.lexology.com/library/detail.aspx?g=bbeb89a4-810f-47fc-bae1-c6271e366f99 (accessed 14 Jan. 2018).

and market platforms or ESPs for the purposes of selling energy services from DERs, are yet to fully manifest. ConEdison began implementing a 'virtual power plant', consisting of 300 households that was supposed to integrate DERs such as solar PV and storage. But the project ran into difficulties and was suspended in April 2017.[36] The suspended Clean Virtual Power Plant Project was perhaps the closest to realizing an ESP for DERs. The Flexible Interconnect Capacity Solution project, whilst offering "infrastructure as a service" as an alternative to traditional interconnection, principally serves large renewable generators, rather than household level DERs.

The Brooklyn Microgrid project is often held up as "Exhibit A" of REV.[37] Whilst it is anticipated that 800 prosumers will eventually participate in a blockchain enabled market place, by the summer of 2017 only 60 prosumers and their DERs were participating.[38] This is partly because the 1,200 kWh lithium-ion battery, 400 kW of solar PV and the 400 kW fuel cell were deployed by the utility - Consolidated Edison. The project is part of a wider Brooklyn-Queens Demand Management program. The $200 million project is aimed at deferring and reducing the cost of replacing a critically over-loaded substation, which would otherwise have cost $1.2 billion. These exceptional circumstances appear to have allowed the utility to deploy and own the majority of the DERs, whilst also creating the business case. The question becomes – does this project represent the desired model of a future in which vast numbers of prosumers own their own DERs and participate in the market?

There are a number of pitfalls under REV, due in part to the lack of unbundling rules.[39] However, the framework is attempting to ensure utilities explore DER alternatives to CAPEX on network assets ("non-wire" alternatives), to provide cost savings to the consumer. From the perspective of the utilities the REV incentivizes DER alternatives by setting the base rate on planned (forward-looking) CAPEX and removes a "clawback" mechanism that was historically used to ensure the utilities didn't sweat the network assets. Thus, with the base rate (and hence the utilities allowed returns) set into the future, the utilities earnings will increase if they pursue DER alternatives to costly network CAPEX.[40] In the next regulatory period, the base rates reflect expenses incurred due to pursuing DER alternatives and

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[36] conEdison (2017), *REV Demonstration Project: Clean Virtual Power Plant 2017 1Q Quarterly Progress Report*.
[37] Blade, D (2016), ConEd Brooklyn-Queens non-wire alternative project installs first microgrid, https://www.utilitydive.com/news/coned-brooklyn-queens-non-wire-alternative-project-installs-first-microgrid/432380/
[38] Rosenberg, M (2017), LO3's Brooklyn Microgrid - Energy REV Ground Zero, https://www.theenergytimes.com/microgrid/lo3s-brooklyn-microgrid-energy-rev-ground-zero
[39] Pérez Arriaga, I. and Knittel et al, C. (2016), *'Utility of the Future*. An MIT Energy Initiative response, *to an industry in transition'.*
[40] Ibid

earnings due to avoided network CAPEX are removed, thus consumers benefit from a net saving in total expenditure.

REV's Ratemaking Order[41] that dictates the manner in which the base rates change overtime, goes beyond changes to the traditional cost of service regulations. It provides for earnings derived from DSPs providing market platforms – platform service revenues (PSR) – and revenues from the DSP meeting a range of performance targets, termed Earning Adjustment Mechanisms (EAMs). These EAMs include;[42] reducing GHG emissions, consumer engagement and energy efficiency.

These changes in the way utilities derive their earnings parallels a phased transition in the value of DERs (VDER), away from net metering.[43,44] Currently, the VDER value stack is based on five key components;[45,46]

1. Energy (kWh) - market value of delivered united of energy
2. Capacity (kW) - market value of delivered capacity
3. Environmental - reduced emissions
4. Distribution System Value - value of avoiding new distribution system capacity due to reducing distribution system peak demand
5. Locational System Relief - location-specific value based on for example voltage support or avoiding infrastructure upgrades.

This value stack is currently undergoing refinements, but further hurdles are yet to be overcome. Within the current "Phase 2" of REV, a clear methodology to calculate VDER from the various components of

[41] State of New York Public Service Comission (2016), Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision., http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BD6EC8F0B-6141-4A82-A857-B79CF0A71BF0%7D (accessed 02 Jul. 2018).
[42] Rev Connect (2016), Track Two: REV Financial Mechanisms, https://nyrevconnect.com/rev-briefings/track-two-rev-financial-mechanisms/ (accessed 12 Mar. 2018)
[43] Bayles, J. (2017), Reforming the Energy Vision, Energy Business Law, https://www.energybusinesslaw.com/tags/reforming-the-energy-vision/ (accessed 17 Apr. 2018).
[44] Baldwin, J. (2017), Bumps in the road: Utilities get in the way of New York's clean energy vision, https://www.solarunitedneighbors.org/bumps-road-utilities-get-way-new-yorks-clean-energy-vision/ (accessed 01 Jun. 2018).
[45] REV Connect (2017), Value of DER: Pricing Distributed Resources - REV Connect, https://nyrevconnect.com/rev-briefings/value-der-pricing-distributed-resources/ (accessed 04 Aug. 2018).
[46] Baldwin, J. (2017), Bumps in the road: Utilities get in the way of New York's clean energy vision, https://www.solarunitedneighbors.org/bumps-road-utilities-get-way-new-yorks-clean-energy-vision/ (accessed 01 Jun. 2018).

the value stack is yet to emerge.[47,48,49] This lack of clarity is leading some to argue that the utilities working with the regulators in New York to operationalize this new VDER are "undercount[ing] the value of solar resources".[50] Further, whilst the value stack component of "locational system relief" requires the utiltisation of LMP. Currently LMPs are only applied at the transmission level, by the New York independent system operator (NYISO), for wholesale prices. More granular, distribution level LMPs are yet to develop. Given that significant DER value rests within their ability to provide cost savings alternatives to distribution network CAPEX, this lack of distribution level LMP combined with a lack of clear VDER calculation methodology, is undermining the transformational power of REV.

Having said this, given that many of the services DERs could provide to the distribution network manifest, in part, through the integration of a large number of distributed variable renewables (which in turn are one segment of DERs), it could be said that REV is ahead of its time in attempting to create part of the value stack from locational distribution level services. As Table 2 illustrates, 7.3% of households currently have solar PV in New York state, compared to 18.9% in Australia.

The difference in penetration levels of household solar PV between NY state and Australia is also observable when considering household battery storage (Table 1). Whilst affordable household batteries are a much more recent phenomenon than that of solar PV, 0.3% of Australia homes currently have batteries, with that proportion likely to double in the next 12 months.[51] Australian residential consumers have experienced significant increases to their electricity prices, rising 30% over the last decade.[52] These costs have primarily been driven by overinvestment in networks - a so called "gold plating" - due in part to network utilities taking advantage of incentives.[53] This in turn has created a greater incentive for

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[47] Department of Public Service Staff (2017), VDER Value Stack and Rate Design Working Group Process and 2018 Schedule, http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/8a5f3592472a270c8525808800517bdd/$FILE/Staff VDER WG Process and Schedule.pdf (accessed 27 Jul. 2018).

[48] Bayles, J. (2017), Reforming the Energy Vision, Energy Business Law, https://www.energybusinesslaw.com/tags/reforming-the-energy-vision/ (accessed 17 Apr. 2018).

[49] Department of Public Service (2018), Case 15-E-0751: Value of Distributed Energy Resources (VDER), http://www3.dps.ny.gov/W/PSCWeb.nsf/All/8A5F3592472A270C8525808800517BDD?OpenDocument (accessed 16 Aug. 2018).

[50] Baldwin, J. (2017), Bumps in the road: Utilities get in the way of New York's clean energy vision, https://www.solarunitedneighbors.org/bumps-road-utilities-get-way-new-yorks-clean-energy-vision/ (accessed 01 Jun. 2018).

[51] Ibid.

[52] Gartrell, A. (2017), Network costs the main driver of electricity prices, consumer watchdog finds, The Sydney Morning Herald, https://www.smh.com.au/politics/federal/network-costs-the-main-driver-of-electricity-prices-consumer-watchdog-finds-20171015-gz17m3.html (accessed 04 Aug. 2018).

[53] Solgen Energy Group (2017), The National Energy Guarantee and what we know so far, https://solgen.com.au/news/national-energy-guarantee-know-far/ (accessed 04 Aug. 2018).

households to self-supply by means of installing solar PV, and a greater need to reduce network costs via the application of DER supplied network services.

Table 2: Proportion of households with solar and batteries in New York State and Australia

DER Type	New York State	Australia
Solar PV	7.3% as of June 2018[54]	18.9% as of March 2018[55]
Batteries	Negligible	0.3% or ~30,000 households[56] (20,000 in 2017 alone)[57,58]

There are clear differences between the regions, both in terms of climate and policy incentives. However, crucial questions are arising – given that an important component of REV's newly constructed VDER is reliant on reducing traditional network costs, at what point in time can this value be expected to manifest? And further, will some of this value be reliant on a greater penetration rate of variable distributed renewables in the first instance?

Further, whilst reforms of regulations and policies to stimulate DER deployment in a manner that is beneficial to the wider system is welcome. Conflicting policies need to be dealt with. Whilst the NY governor has pledged to build 1,500 MW of battery capacity by 2025,[59] and batteries are a key DER technology under REV, fire safety codes are preventing such deployment.[60]

Australia – a test bed for market platforms

Australia's electricity system is at the vanguard of DER integration. Energy Networks Australia (ENA) – who represent electricity transmission and distribution companies – foresees a growing role for DER

[54] Authors calculation based on : 228,898 households with solar and 7,210,000 households in New York State. See https://www.seia.org/state-solar-policy/new-york-solar; https://renewablesnow.com/news/coalition-calls-for-1-million-solar-households-in-ny-by-2023-615489/; https://datausa.io/profile/geo/new-york/#housing
[55] Chatham House analysis of data from Australian Photovoltaic Institute (2017), 'Australian PV market since April 2001', http://pv-map.apvi.org.au/analyses (accessed 9 Nov. 2017).
[56] https://reneweconomy.com.au/battery-storage-australian-households-charge-market-16562/
[57] Climate Council of Australia (2018), *Fully Charged: Renewables and Storage Powering Australia*.
[58] Lambert, F. (2018), Tesla is installing Powerwalls and solar power on 50,000 homes to create biggest virtual power plant in the world, Electrek, https://electrek.co/2018/02/04/tesla-powerwall-solar-virtual-power-plant/ (accessed 16 Mar. 2018).
[59] Spector, J. (2018), The Best News Yet for Energy Storage in New York, Greentech Media, https://www.greentechmedia.com/articles/read/new-york-storage-industry-cash-target#gs.iVGxQRI (accessed 29 May. 2018).
[60] Maloney, P. (2017), Fire safety issues dog battery storage growth in New York City, slowing deployment, Utility Dive, https://www.utilitydive.com/news/fire-safety-issues-dog-battery-storage-growth-in-new-york-city-slowing-dep/438290/# (accessed 17 Jun. 2018).

owning prosumers in providing network support.[61] The ENA anticipate that between now and 2050, customers rather than traditional utilities will likely represent a quarter of all system investment.

The Australian Energy Council (AEC) and ENA have recently published reports that describe a transition towards a combined DNO/SO with responsibilities for dispatch and coordination of DERs, in a similar manner to the DSPs of REV,[62,63] but termed distribution network service providers (DNSP). Also in a similar manner to REV, the AEC and ENA foresee a growing role of market platforms, termed network optimisation markets (NOM). Initially it is expected that these market platforms, or NOM, will be relatively simple, providing a limited range of Network Support Services (NSS) to the DNSP, procured from DERs.

The ENA Roadmap is light on detail regarding the changing value of DERs. However the NSS (both at transmission and distribution level) are seen as important complimentary sources of the DER value stack in the future. The Roadmap also recognizes that unlocking such NSS value is more challenging than the value of DERs within wholesale and retail markets. Importantly, whilst REV is attempting to stimulate increased deployment of DERs via new forms of value attribution, Australia’s penetrations level of DERs (particularly solar PV) is significantly higher. As such, incentivizing deployment is not such an imperative.

The Roadmap anticipates that the NOM will become increasingly sophisticated over time, and anticipating that digital NOM (dNOM) will “procure and automate real time network optimisation services” by the end of the 2020’s.[64] As these market platforms become increasingly sophisticated, they will need to be supported by Advanced Network Optimisation (ANO) function, undertaken by the DNSP, with the ANO effectively acting as a DSO.

Due to the high penetration levels of DERs within the Australian electricity system, DNOs are beginning to respond. Ausgrid are already developing the basic functional elements of the ANO; replacing their Distribution Network Management System with an Advanced Distribution Management System (ADMS).[65] By 2021, this system is expected to be operational, giving rise to the operational services that DERs can then supply via market platforms (or NOM) which communicate with the ANO. These market

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[61] Energy Networks Australia (2017), *Electricity Network transformation Roadmap: Final Report*.
[62] KPMG (2017), *Distribution Market Models: Preliminary Aseesement of Supporting Frameworks. Report for the Australian Energy Council*.
[63] Energy Networks Australia (2017), *Electricity Network transformation Roadmap: Final Report*.
[64] Ibid.
[65] Ausgrid (2018), *Modernising Ausgrid’s Operational Control System*.

platforms will need to be operated in an independent manner in order for cost effective, competitive services to be procured.[66]

The ENA Roadmap and an independent review by KPMG acknowledge that the development of the three critical functions of DNO, DSO and market platforms will undergo various phases of development. Further, that if DERs are to provide cost effective alternatives to expensive network CAPEX, conflicts of interest of the DNSP will need to be addressed,[67] as they do under the DSPs of REV. Without which, competitive markets for low cost DER alternatives for NSS are unlikely to develop.

Both ENA and KPMG anticipate that the market platforms will be simplistic to begin with, gradually developing greater sophistication, initially focusing on peer-to-peer trading. Until a threshold is reached, it is anticipated that this type of market platform is unlikely to impact on the functioning of the DNSP. As such, coordination and optimization between the DSO arm of the DNSP and market platform may not be necessary in the initial phases. However, once sufficient volumes of electricity are traded in this peer-to-peer manner, a threshold may be reached, at which point the DSO arm is likely to require increasing control. This is the point at which financial separation or legal unbundling is likely to be required.

An example of the first, basic form of market platform for peer-to-peer trading of electricity in Australia is the Decentralized Energy Exchange (deX). The deX is still very much in the piloting stages of development, but offers insights as to how an energy service model enabled by platforms and DSOs might function.[68] Sponsored by the Australian Renewable Energy Agency (ARENA), deX brings together DERs in a competitive market structure. DSO-type functionality is provided by GreenSync software in collaboration with network operators United Energy and ActewAGL. Bids and offers from multiple DERs are aggregated from solar PV, batteries and flexible demand within individual deX households, to provide the DNO with the least-cost balancing mechanisms it requires.

The deX has the potential to go further than simple peer-to-peer trading, allowing for the first time, prosumers to trade in DER grid services. In essence, the GreenSync software provides the DNO with the same software functionality that a DSO would provide. As such, the pilot project is a step along the path

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[66] Pérez Arriaga, I. and Knittel et al, C. (2016), *'Utility of the Future. An MIT Energy Initiative response, to an industry in transition'.*

[67] KPMG (2017), *Distribution Market Models: Preliminary Aseesement of Supporting Frameworks. Report for the Australian Energy Council*.

[68] deX (2017), 'deX: Decentralised Energy Exchange', https://dex.energy/ (accessed 13 Jan. 2018); Vorrath, S. (2017), 'Greensync launches world-first exchange to trade stored household solar power', RenewEconomy, 23 February 2017, http://reneweconomy.com.au/greensync-launches-world-first-exchange-trade-stored-household-solar-power-49889/ (accessed 13 Jan. 2018).

towards a DSO model that enables a platform marketplace of services.[69] The GreenSync system also allows transactions to be effected via digital wallets, an arrangement one step away from blockchain peer-to-peer payments.

Conclusions

The integration of variable renewables, combined with traditional drivers of network maintenance, are creating the opportunity for new forms of value from the energy services DERs could provide. The potential prosumer is partially locked out of the market, due to a lack of mechanisms to discover these new forms of value, particularly in relation to locationally specific services within the distribution network.

DNOs are key to unlocking this value and they will need to adopt new functions, principally the coordination and dispatch of DER services. As such a new actor is emerging, the DSO. Competitive market platforms for DER services are also crucial. These market platforms, or energy service platforms, will need to directly communicate with the DSO.

Market platforms, such as deX in Australia, are likely to emerge from innovative startups rather than the utilities' themselves. Whilst deX shows promise in connecting various DERs and their prosumers, market platforms under REV have struggled. As these market platforms grow in size a threshold will be reached, at which point operational impacts on the network will likely require greater separation – financial or legal – between DSO, DNO and the market platforms. In relation to New York and REV, this would result in the DSP creating financial independence between its DNO and DSO arms, or legal division between the two. Separation may be required sooner, to ensure an even playing field between prosumers owning DERs and traditional DNO network assets. Unbundling may prove more difficult for distribution utilities, as the distribution network is orders of magnitude more complex than the transmission network.

The significantly higher penetration level of DERs in Australia, relative to New York state, is arguably stimulating a greater rate of development of these types of market platforms. This is particularly true given markets for network services are likely to initially suffer a lack of liquidity due to the highly

[69] Vorrath, S. (2017), 'Big energy players back major power shift, as GreenSync unveils deX', RenewEconomy, 1 September 2017, http://reneweconomy.com.au/big-energy-players-back-major-power-shift-as-greensync-unveils-dex-91413/ (accessed 14 Jan. 2018).

locationally specific natural of these services. The deX has the advantage that the penetration level of DERs is already sufficiently high enough that platforms can initially offer highly liquid peer-to-peer trading services, moving towards greater focus on network support services over time. The deX is anticipated to provide insights as to how regulations and platform design will need to adapt as the system evolves.

Experience of operationalizing the complimentary stack of new DER values under REV illustrates the importance of distribution utilities in enabling the calculation of this value. LMPs could be key to progressively offering more locationally specific services, and unlocking greater DER value. These locationally specific services will require gradually increasing the granularity of LMPs, down to the distribution level. This will be extremely challenging considering the complexity of the distribution network and will likely require the distribution utilities running the DSOs to increase their technical expertise; monitoring and processing a great deal more real-time data from a wider range of network and DER assets, and overhauling IT systems such as Ausgrid is currently undertaking.

Connecting millions of DERs to platforms of interacting prosumers will undoubtedly shift the balance of power within the electricity sector. The traditional distribution network utilities clearly have an important role in this new landscape, but they will likely need to accept a greater diversity of revenues as those from their traditional cost of service model decline.

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Appendix

Figure 3: Sources

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