Final Report

Prepared For:

Economic Regulation Authority - Western Australia

Anticipating the Changes Ahead

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1. INTRODUCTION

In this report, we look forward at key changes either underway in the Western Australia (WA) electricity sector or that can be anticipated to affect the sector over the next few years. We then consider whether current electricity market arrangements can or cannot effectively accommodate these changes and deliver efficient outcomes.

1.1. FOCUS AREAS AND OVERALL APPROACH

The Economic Regulation Authority ("ERA") identified several key factors driving or likely to drive material change in the WA energy landscape, and that may trigger issues that merit further review:

- New technologies – such as battery storage and electric vehicles;
- Renewables – increased penetration supported by expansion in financing options;
- Energy efficiency – such as adoption of various measures to reduce and manage energy consumption;
- Prosumers – such as aggregation of distributed producers and consumers and potential for increasing utilization of peer-to-peer trading amongst them;
- Capacity – such as reduction of excess capacity and changes to the reserve capacity mechanism (RCM);
- Network – such as penetration of behind-the-meter technologies, locational constraints and grid fragmentation; and
- Tariff reform – such as announcement of more cost reflective pricing and changes to the cost structure.

There are inter-relationships amongst these areas, which we consider as part of a discussion of overarching themes in this section. Most of the changes or consequences for these areas are amplified by the potential for adoption of energy storage. Consequently, we address storage-related issues separately in Section 2.

In Section 3, we then consider, for each area, three questions:

- What is the issue?
- Why is it an issue?
- What might be the consequences?

In some areas, regulatory, market, or policy responses have already started to address these issues.[1] Our take on these areas is deliberately kept at a higher level – intended to keep attention focussed on the key identified themes of aligning costs, benefits, and risks using a combination of market, regulatory, and policy settings so that the consequences of all of these developments will produce, over time, positive overall value for WA.

1.2. Key Themes: Alignment vs Disruption

Pressures for change arise because someone (or many) perceive benefits worthy of applying pressure, taking specific actions, making investments, or altering behaviours somewhere in the overall energy value chain. These benefits can be financial in nature, or may involve other types of benefits, such as emerging preferences for sustainability. To the extent that perceived net benefits align with broader societal net benefits, then resulting outcomes can usually be said to be economically efficient (or self-correcting over time), though there may also be associated equity issues (typified by an assessment of winners and losers). The key concept is "alignment" – meaning alignment between the decision that an individual stakeholder makes and the impact that decision has on WA overall.

Not all misalignments are equally bad. Some are effectively self-regulating or self-correcting because they trigger responses that limit the extent of any potential problem. These can often be ignored so long as a sufficiently self-regulating response occurs within a reasonable time frame or the overall response is not material. Other changes, however, auto-catalyse new problems or expand problems and further increase distortions or costs. These merit more urgent attention, especially if the rate of catalysis is likely to be quite high.[2] The extraordinarily complex way the growing range of issues and options interrelate makes it more important to understand the fundamental drivers of value and the ways in which regulation, market design and policy contribute to self-correcting or auto-catalysing responses.

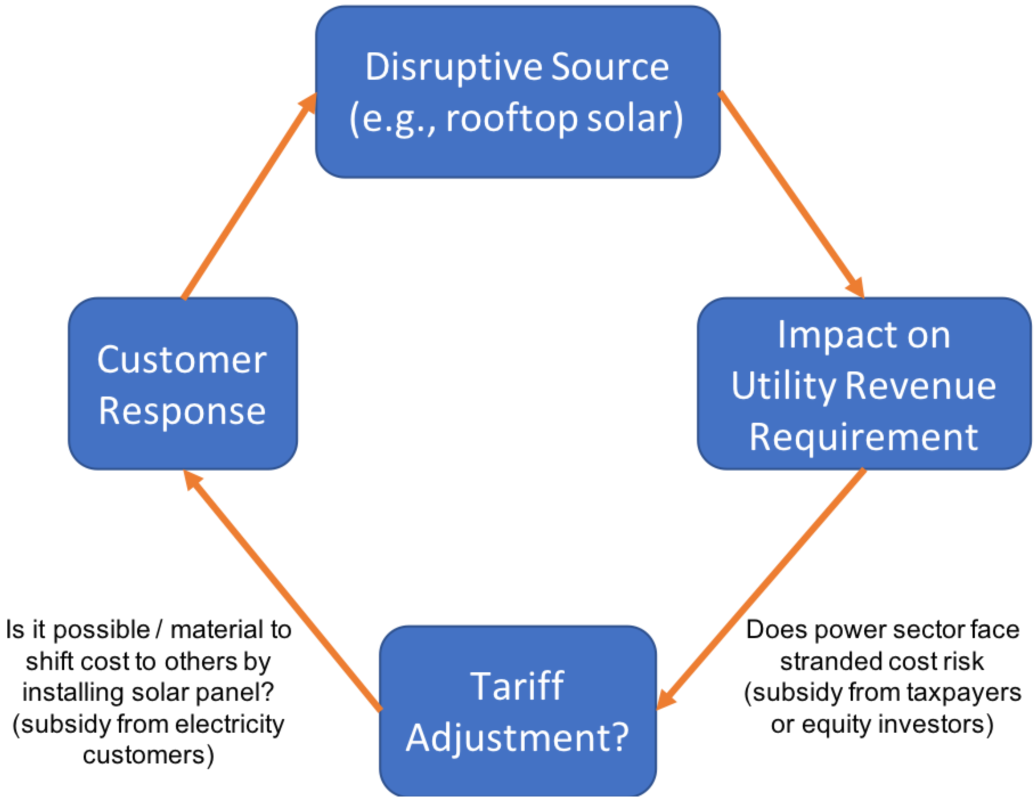
1.2.1. A Simple Feedback Loop

A simplified example of an auto-catalysing response involves the impact of a single disruptive source, such as the installation of rooftop solar by consumers seeking to avoid high electricity prices. Because of the way tariffs are structured, the result can increase the incentive for the remaining non-solar customers to also install rooftop solar.

1 http://www.treasury.wa.gov.au/Public-Utilities-Office/Industry-reform/Electricity-Market-Review/ or https://www.treasury.wa.gov.au/Public-Utilities-Office/Household-energy-pricing/Electricity-pricing/

2 Life was so simple when it took years to build power stations. Now even six months can be more than enough time for many new technologies to materially shift future costs and how those costs affect various stakeholders.

Figure 1: Conventional (Simple) Feedback Loop



In this simplified example, adding the rooftop solar to the system results in potentially reduced cost recovery for the utility, which in turn triggers the need to increase prices to compensate for lost revenue.[3] Yet, because the incentive to invest in solar is partly related to the end users' ability to avoid paying tariffs, shifting costs can increase the number of customers who perceive value in investing in rooftop solar systems.

The above feedback loop depends on four key factors:

3 The associated feedback loop is not limited to rooftop solar – any disruptive technology or behavioural change that results in a loss of utility revenue can trigger the feedback loop *if* the associated loss of revenues does not align with an associated comparable reduction in utility costs. Put differently, if the resulting loss in revenues were to align reasonably with actual reductions in utility costs, then there *would be no need for a tariff (price) adjustment*. The problems arise when the revenue loss materially exceeds any realised cost savings, triggering the need for a tariff increase, which if then applied to non-solar customers naturally increases their potential savings from adoption of their own solar rooftop panels. In the limit, the loop ends when there are no more opportunities for cost shifting-based avoidance. Unfortunately, the final end point of such a loop is by no means assured to be least cost overall (not Pareto optimal). At any point along the way, those who are exposed to the risk of costs being shifted to them in the future would have preferred the grid to have made deals to provide the same savings to the potentially defecting customer, calculated on the basis that the customer would then not need to invest in the solar panels, a point we make in Section **Error! Reference source not found.**.

- the extent that the cost of installing rooftop solar has fallen to the point where some combination of tariff avoidance and other customer preferences makes installation a feasible value proposition;
- the extent that cost avoidance involves cost-shifting rather than cost reduction;
- the materiality of cost shifting and how that alters the value proposition of solar panel installations by customers previously not considering doing so; and
- the speed with which solar panel installation costs are falling for a given level of generation, as this accelerates all of the factors above, and may in fact reflect a separate feedback loop related to emerging economies of scale in panel development, marketing, and installation.

When stakeholders can take actions that shift costs to others, the impact and potential need for a regulatory or policy response depend on: why the shift is possible, who the shift affects, how material the shift can be, and whether the shift is sufficient to trigger an auto-catalysing reaction. For example, if occurring entirely within a market, the development of new technologies or changing consumer preferences can be seen as normal business risks. If people stop wanting to drink coffee, then coffee shops must find other ways to stay in business. But if electricity normally provided through the grid is suddenly able to be provided from rooftop panels due to policy support (which is a change factor originating outside of the market), the effect can be tantamount to that of a subsidy. At that point, even simple feedback loops such as that shown above can amplify the effect (auto-catalysis) because the policy support interacts with tariff policies that may not result in accurate or fully responsive tariff outcomes.

Ideally (at least from an economic efficiency perspective) supply costs should be recovered with more accurate regard as to system conditions at the time of usage. The increasing complexity of these dynamic interactions suggests rising value to smart metering technology and any other approach that facilitates more refined pricing based on time, location, observed behaviours, or other potentially material customer-system interactions.

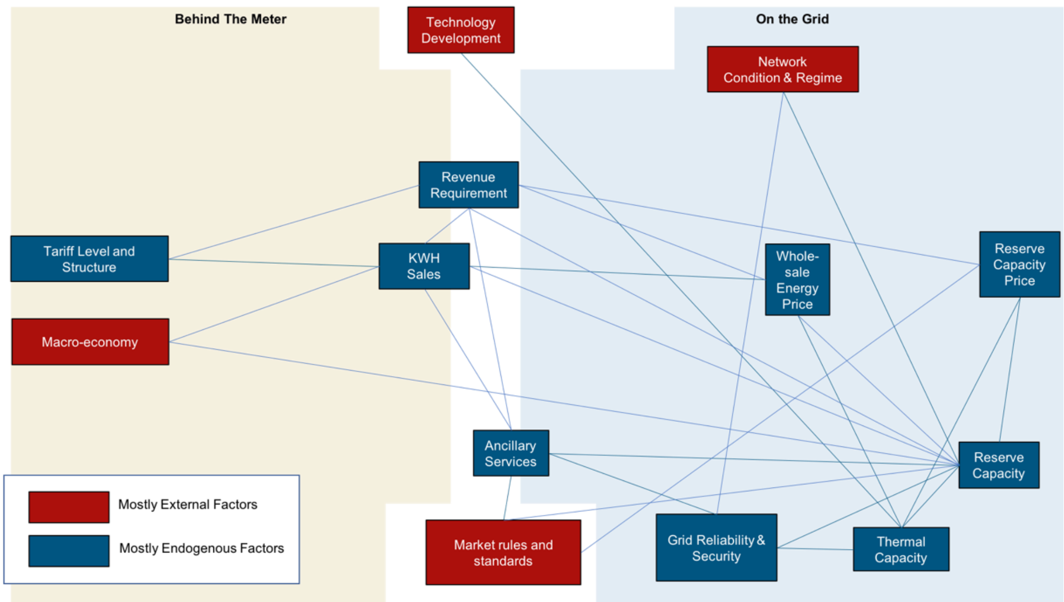
Notably, we understand that already, around 20 percent of residential premises with solar panels have some form of smart meters installed. It is likely to be sensible to utilise the capabilities of existing technologies already in place, as well as to consider how to expand the use of smart meters cost-effectively. Given developments in smart metering technology and reduction in associated costs, the case for greater/more use of smart metering is increasing.

Ultimately, decisions taken behind the meter are mainly influenced by avoidable tariffs, as that is the primary value signal that consumers see from the energy market. It is useful to bear in mind that Australia in general and Western Australia, in particular, have had amongst the highest such avoidable (volumetrically based) electricity tariffs, depending on customer class and usage profile. Only recently have network tariff structures in WA changed to incorporate a fixed portion related to capacity. The availability of an abundant solar resource amplifies this impact.

1.2.2. Escalating Complexity

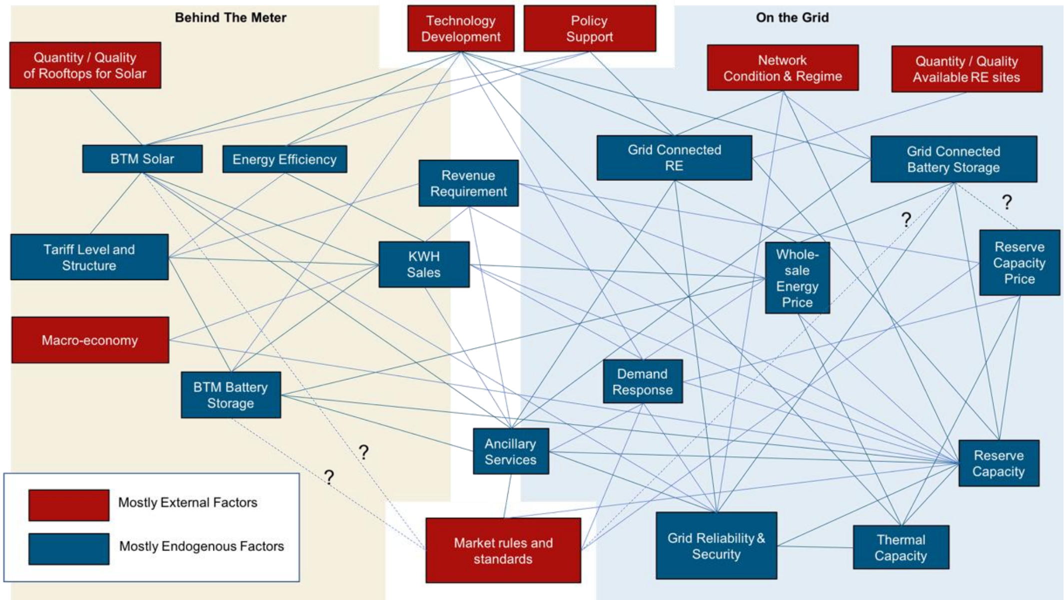
Historically, the factors and interactions in the electricity sector were relatively simple, with few feedback loops to worry about. Tariffs reflected the interaction of demand and supply forces, with no material decisions to be made behind the meter other than whether to use or not use electricity (and how much and at what point in time). The essential factors are highlighted in Figure 2, in which the feedback between what happens behind the meter and what happens on the grid is limited to price elasticity of demand and the need for on-the-grid generation to meet total kilowatt-hour sales and kilowatt peak demand. Similarly, the wholesale market is simply a least cost dispatch of capacity (determined by a limited array of mostly thermal generation technologies) and mechanisms to assure adequacy of supply.

Figure 2: A Simpler World



Such a simple world no longer exists. The introduction of demand response was an initial complication, as that established a stronger linkage between demand and capacity and between demand and prices. But system complexity increased dramatically mainly because of the emergence of renewable energy and battery storage technologies on both sides of the meter. The result is a much more complex set of interactions as shown in Figure 3.

Figure 3: More Complex, Dynamic Interactions in the "Real" World



In Figure 3, a variety of factors reflect situational characteristics or external forces that influence the workings of the electricity sector. Factors such as macroeconomic growth, technology development, market rules, the quality and number of available rooftops for solar panel development, and the age and condition of the existing network all have implications for the complex interactive dynamics that influence the various choices available to each stakeholder. In particular, the left-side feedback created between avoided cost (tariffs) and behind-the-meter choices and between the left-side and right-side feed-back loops are both major, complicating phenomena.

In some cases, the best way for some factors to interact with the overall system has not been fully defined, including the relevant rules and standards pertaining to integration of behind-the-meter solar and battery storage and, also, grid connected battery storage given their complex interactions with the rest of the system.[4] These are shown in Figure 3 as dashed lines with a question mark denoting their likely evolving nature.

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4 Many of these interactive pathways have always existed, but they were not relevant or material for decades as the choices actually available were limited in the practical sense of being one-sided. It is not until the value gap across multiple choices narrows sufficiently and can pivot depending on other factors, that it makes sense to consider all of those choices and their implications more rigorously. Consider for example, that many of the complexities highlighted in Figure 3 were identified in the 1970s in response to rising oil prices and a subsequent, albeit comparatively temporary and collectively modest, focus on energy conservation and alternative energy developments in many countries. United States President Jimmy Carter, during the late 1970s, famously installed solar-thermal panels on the White House roof. In fact, various forms of solar technology have been around for decades, but they have been so much more expensive and so much less technically effective as to not constitute viable pathways outside of the scope of demonstration projects or specialised applications. What is happening now is that these historically latent pathways – and undoubtedly others that we have not considered or fully identified – are quickly becoming viable choices for stakeholders on both sides of the electricity meter.

1.2.3. Implications

The world ‘behind the meter’ and the world ‘on the grid’ interact mainly through the total costs that must subsequently be recovered through tariffs as well as through any impacts on total energy sales over time and through impacts on resource adequacy, system security, and overall reliability. As a consequence:

- Behind-the-meter decisions largely key off tariff design and level, as this is what the behind-the-meter stakeholder sees as a key decision variable driving consumption decisions and investment in behind-the-meter energy technologies.
- On-the-grid decisions key off separate signals, largely related to wholesale energy prices, policy support for renewable energy, the reserve capacity mechanism, and ancillary services arrangements.

If these interactions are not aligned for any reason, then the efforts of stakeholders on one side of the meter or the other to optimise the value they see from their private perspective may not (and indeed is unlikely to) optimise outcomes for WA as a whole.

Consequently, we recommend ongoing focus on developments occurring along three crucial dimensions:

- **Increasingly complex inter-relationships** – It has become much more important and relevant to recognise, explicitly, how these manifold and complex interrelationships impact when planning, developing policies, evaluating options for pricing and regulation, and in enhancing the market design.
- **Risk of Amplification / Catalysis** – Of the many interactions, the most important are those that can amplify or constrain outcomes in ways that may not be desirable.
- **Pacing** – The speed of change is increasingly a factor. Consequently, institutional and market capabilities need to stay “in front” of these changes through timely development and responsive evolution of appropriate regulatory, policy, and market approaches.

When analysing these risks, some elements clearly originate from the outside of the “market” yet they have major implications for virtually everything. Renewable energy policy clearly fits this category. Such multitudinous interactions make it more difficult to assess, robustly, the overall costs and benefits of these policies on the WA economy. It is also important to consider carefully those elements featuring ‘two-way’ connections (i.e. first-order feedback loops). The relationship between avoided cost and behind-the-meter investment decisions fits this category. And finally, it is essential to consider those elements that have many interactions with other elements as the possibility of unintended consequences that ripple through the entire system can be quite significant and more difficult to diagnose from an assessment of outcomes alone. The workings of the reserve capacity mechanism and ancillary services arrangements are clearly two elements that fit into this category.

1.3. SUMMARY

As an introduction to this paper we have restated the focus areas for consideration and highlighted the inter-related nature of all elements of the electricity supply chain. We have framed changes in the elements as being either disruptive or aligned with efficient outcomes.

A key observation is that price signals can easily be misaligned with underlying economic forces, resulting in incentives for stakeholders to take actions that appear to them as beneficial, but which may not reduce cost to the system (WA) overall. A myriad of emerging feedback loops complicates the process of determining the impact of new policies and technology choices. Perhaps the most significant challenge arises when stakeholders face vastly different incentives merely because they focus on one side of a meter versus the other.

We introduced the concepts of alignment and disruption. Alignment exists when the benefits and costs of a change as perceived by a stakeholder broadly derive from the impacts experienced across the entire system. In other words, there are no unintended consequences or ignored externalities that have the effect of shifting costs to others. In contrast, disruption occurs when a new policy or new technology choice exploits an imperfection, rigidity, or missing feature in the regulatory arrangements or market design so as to shift costs from one group of stakeholders to another. This amplifies the apparent benefits (as seen by the adopting stakeholders at the expense of others) and accelerates the change, but risks increasing the overall costs to WA.

From these considerations, we can make several broad observations, or starting propositions, that we consider to be pro-alignment and thus pro-efficiency and pro-equity with less risk of unintended consequences:

- Tariff structure redesign. WA has recently undertaken to institute fixed charges into the electricity tariff as a step towards better aligning the avoidable cost portion of tariffs with the costs that are actually avoided when customers alter their energy usage behaviours. The challenges of tariff design require balancing the risk of cost-shifting and the risk of inefficient signals for energy usage at peak times that can increase fixed network costs. This challenge may best be met through greater integration over time of smart meters, many of which already exist as part of rooftop solar panel installations.

- Energy market reforms. More accurate price signals are signals that better reflect system conditions at the time energy is produced or consumed. Signals that are more accurate and closer to real time provide more granularity and responsive dynamics to pricing and can reduce the risk and cost of potential disruptions. These include the current energy market reforms related to the wholesale market enhancements.

- Enhancement of locational signals. These include the move to the constrained access model, efforts to increase locational signalling of capacity requirements, and efforts to reduce the reliance on the Tariff Equalisation Contribution.[5]

- Enhancement of ancillary services pricing, service definitions, and cost allocation, as needed. This ensures that new technologies with valuable response features are able to monetise these sources of value (and thus be more likely to be commercially viable at a time of need), and to ensure that technologies that impose cost on the network bear that cost.

- Enhancements to the RCM to ensure that it is sufficiently dynamic and responsive to market conditions. As with real-time and locational pricing, this includes adjustments to the RCM that reduce technology, location or other biases in the provision, pricing and cost allocation of the reliability objective.

Given the imperfections and rigidities embedded in the current and planned policy settings, the choice to leave policy settings unchanged will almost certainly lead to different outcomes than many expect, with costly consequences for some, if not all, stakeholders.

5 State-wide averaging of prices.

2. THE ASCENDENCE OF STORAGE

2.1. OVERVIEW

Storage technologies vary in terms of their responsiveness, scale, flexibility, and energy density. Consequently, different storage technologies have features that may be more valuable in some situations than in others, or for some applications rather than others.

Storage is unusual in the degree to which commercial viability can depend on multiple, and often changing, value propositions. For example:

- Storage can be either a generator or a load depending on market conditions, though over time it is a net load due to conversion losses;
- Storage may be a least cost source of certain types of ancillary services under some conditions, but other forms under different conditions;
- Storage in some locations may provide ancillary services support to the energy market under some conditions, but may be valuable as network capacity under other conditions; and
- Depending on the amount of storage, storage may also have value, perhaps in conjunction with firming up certain types of DSM, in the provision of capacity under a variety of conditions as well.

To the storage investor, these optional or flexible applications represent potential de-risking of an investment in storage technologies that can be valuable in the event that sufficient long-term contracts in any single attribute are not available.

In WA, guidelines are still evolving as to how, precisely, storage technologies could be commercially compensated for many of the services they may be able to provide. The current iteration of the Wholesale Electricity Market Rules (1 September 2017) does not make specific provisions for inclusion of electricity storage as a market participant, though possibly related elements exist.[6] Going forward, more detailed consideration and clarity will be needed.

The issues at stake are not that particular storage technologies need to be specifically or individually defined for inclusion in the market rules. Rather, all the sources of value that matter to the electricity sector in WA should be available to all of the potential technologies that can provide that value, on an appropriately competitive basis, without artificial or definitional limitations or constraints.

In the case of storage, several complicating questions often arise such as:

6 For example, provisions for interruptible load exist.

- Can or should networks participate in ownership and control of storage technologies used for network support, but which might also have value in the energy, ancillary services, and capacity markets? And, if not, then how can such technologies access value streams that originate from network cost optimisation rather than only from energy market opportunities? Such questions are particularly challenging in the context of uniform pricing, which reduces the accuracy of available pricing information?

- Should storage be registered as a separate service, should it be registered as a load, or as a retailer and generator?

- How can storage located behind the meter best create value for WA as a whole, given that decisions taken behind the meter do not necessarily fully consider the impact of cost shifting on other customers?

- Can storage provide capacity in the RCM, either if designed specifically to do so, or in conjunction with other resources?

- Are there any other wholesale market improvements that would allow greater benefits to be realised from the operational and locational flexibility and scalability of storage technologies?

Ultimately, technology neutrality depends on a technology agnostic value or output based assessment: if a technology can do something valuable (or can do something that imposes costs somewhere else in the system), then an investor in that technology should be able to access that value (and be exposed to that cost).[7]

2.2. Related Emerging Issues

The emergence of new technologies and new patterns of consumer behaviour have introduced factors that most probably make forecasting (even) less accurate, both in the short and long term.[8] In particular, as new storage technologies emerge and are adopted – particularly behind the meter – the effect on the rest of the system becomes harder to predict as the drivers of storage use behind the meter are not the same as the drivers of energy market outcomes on the grid. Consequently, the AEMO may need to utilise more conservative forecasts or apply larger safety margins, which can increase costs to the system overall (if experience observed in other jurisdictions, such as California or parts of Europe is any guide).

7 A taxonomic assessment does not achieve technology neutrality in the face of technologies that were not previously anticipated (e.g., technology A is allowed because it is a defined technology, but technology B is not allowed because no one thought of it before).

8 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf

The most significant challenge concerns gaining visibility by the system operator of what is going on “behind the meter”. Many behind-the-meter technologies being adopted have, or could readily be designed/installed to have, sophisticated energy measurement and communications capabilities. Yet such information is often lost or invisible to the system as a whole where it would be valuable.[9]

A reconsideration of how already-available metering technologies and associated information can best be used to the benefit of WA has merit. So too does a consideration of the different pathways by which such technologies can be expanded (or should be expanded) as more customers opt to exercise greater control and choice over how much power they use, how much power they generate for themselves, and what relationship they have with the grid.

Looking ahead, decentralised, behind-the-meter storage and other energy production and consumption management technologies offer opportunities to provide valuable network support, capacity resources, load-shaping capability, and various other ancillary services depending on location and other system conditions. However, to monetize these will require some combination of new communications protocols, standards, or mechanisms and perhaps most importantly consumer behavioural change[10] to allow the system operator to see and potentially control resources behind the meter. It may also require or benefit from the enablement of a Transactive Energy (TE) marketplace through a prosumer-oriented market mechanism.

We note that there have been Australian standards for air conditioning load control for years. The question now is how to induce manufacturers/suppliers to include the communications at the design/installation stage so as to avoid the typically much higher costs associated with retrofitting. Given the effectiveness of codes and standards as a mechanism for enhancing energy efficiency, some role for regulation and policy seems appropriate here, and perhaps essential, though care is invariably required to avoid overly constraining potential solutions.

9 https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/the-digital-utility-new-opportunities-and-challenges

10 Be it from response to new information or shifting preferences, or through new incentives or nudging, or in response to requirements or obligations.

2.2.1. Storage and the Rise of the Prosumer

Current regulations do not explicitly spell out any specific provisions to guide the emergence of a prosumer market. Even so, entrepreneurs in WA are actively working in this area. As the behind-the-meter production and consumption market increases, the "rest of system" must accommodate the associated impacts at a cost that is not necessarily covered by value created by prosumer activities on the other side of the meter (or even seen by those participating prosumers). These interactions between markets on both sides of the meter are becoming much more important, and ideally can be brought into alignment (and kept aligned over time) to reduce distortions that increase inequity or cost (or both).

The most effective way to achieve this is likely to increase the dynamism and economic accuracy of pricing within the traditional power system. Tying behind the meter behaviours more robustly to short and longer-term wholesale energy market outcomes will require further reliance on (and likely greater adoption of) smart meters to support more dynamic pricing to the customer and possibly support introduction of other features as well.[11]

Storage is a significant enabler and accelerant of prosumer markets, as it vastly increases the overall level of behind-the-meter renewable energy that customers can adopt. What is particularly difficult, however, is to ensure the right incentives exist to put storage on one side of a meter versus another (and when to do so and how much is required). In economics, the intrinsic value of a battery or a solar panel or any source of embedded generation should not depend on whether it is placed a few centimetres to one side of meter or the other, though it often does.[12] That said, the availability of an increasing array of storage and other options assures that customers will take whatever actions appear to them to reduce their costs and enhance their flexibility. If, as a result, they push costs to others, that is not necessarily their concern (nor would they necessarily have any idea that they are doing that).

It is clearly a difficult challenge to ensure that system level resources are not exploited for the benefit of a fortunate subset of WA's population or commercial enterprises at a cost to all others. It is also a challenge to ensure that the overall system as we have come to know it is not closed to (or *unreasonably* protected from) new value propositions.

11 Controllability is at least one category of such features that can have value from a system security perspective.

12 http://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=1636808

2.2.2. Ancillary Services

The increased penetration of renewable energy and the potential reduction in inertia available per MWh has triggered greater awareness of, and ultimately, the need for refinement of ancillary services. Ancillary services are likely to play an increasingly evident and tangible role in ensuring the electricity system, on both sides of the meter, meets customer needs in terms of quality and system needs for security. Consequently, the associated value of ancillary service provision must be available to the resources able to provide it.

By optimising the sizing of the storage resource, one can customise the storage solution to the ancillary service requirement in ways that are quite parsimonious and flexible over time.[13] A 20 MW battery array that sits at an opportune state of charge can be designed to provide +20 or -20 MW (a 40 MW range) of Frequency Control Ancillary Services (FCAS) for a period of time tailored to meet specific ancillary services requirements.

As battery performance decays over time, the array can be topped up as needed – it does not need to be replaced *en masse*. Other resources that may previously have been providing FCAS may then be free to operate more efficiently and extract more value as energy or capacity resources. With battery storage costs falling these are becoming ever more compelling solutions, particularly when multiple value propositions exist.

2.2.3. The Challenges of Electric Vehicles

Many electric vehicles are technically capable of providing the same service as battery storage (so-called Vehicle-2-Grid, or V2G). It is less well known that the battery capacity of a modern EV is sufficient to supply a small household with at least a day of electricity autonomy, making V2G a very interesting technology with respect to impacts on longer-term customer grid pricing options. EV owners with V2G capability are in a position to provide their own "reliability", which becomes interesting at the point where their distribution connections require upgrade or maintenance. Is it cost-effective to upgrade or maintain the distribution system in that location or to offer a constrained service at a lower cost to that customer at that time? Parallels can be drawn to the decisions taken by telecoms providers to switch high-cost-to-service landline customers to mobile.

13 Unlike many traditional generation technologies, storage can often be designed and maintained to be precisely what is required, and adjusted over time to "fit" circumstances required with limited waste and a virtually "just in time" installation approach.

In the longer term, the emergence of EVs or specialised mobile storage applications can have a profound impact on locational demand and supply conditions within the electricity grid. This impact may be value-enhancing, or it may be value diminishing – all depending on what signals and incentives exist. Early adopters of EVs (not just in WA) currently have few signals with which to judge what costs they may impose on the system by virtue of when or where they choose to charge. Most systems do not yet provide signals to influence when or whether EVs can create value through bidirectional connectivity. It is early days, but nevertheless, these are issues well worth watching.

2.3. CONCLUSIONS

These common trends are all accelerated and augmented by the ascendance of storage technologies and complicated by gaps in the availability of smart metering technology. They present some of the biggest challenges to long-accepted pricing and investment approaches that socialise certain costs through the use of default assumptions of community-wide reliability standards and simple class-based and locationally undifferentiated and time-of-use-agnostic tariffs.

Electricity storage can make a power system more reliable and secure and it can make a market work more efficiently, reducing cost and even risk. However, there is no guarantee that storage will be integrated and used in value-increasing ways just because it is storage. If storage is in the wrong location or used in ways that are not evident to the system operator, then storage can also raise costs. The key challenge is to adopt policies, regulations, and market structures and mechanisms that best align the various value propositions associated with what storage technologies can do with what actual value is required in the power system at a point in time.

Unfortunately, the complex cross talk between behind-the-meter and grid-side activities makes it more difficult to identify the best regulatory approaches especially if regulation evolves as a series of one-off changes. A more coherent approach to pricing and planning reforms is likely to be needed.

Given the complexity of identifying the best way forward given so many different choices and competing “voices”, different regulators have begun, accordingly, to experiment with sandboxing approaches.[14] A regulatory sandbox is no panacea, but may provide a way to deal holistically with at least some types of changes that have the potential to out race the slower, traditional, processes of regulatory and policy adaptation.

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14 Ofgem from the UK initiated a regulatory sandbox for electricity and gas businesses and “awarded” it to the peer-to-peer energy trading companies. https://www.ofgem.gov.uk/system/files/docs/2017/02/open_letter_regulatory_sandbox_6_february_2017.pdf

Another example is the fintech sandbox from Singapore http://www.mas.gov.sg/Singapore-Financial-Centre/Smart-Financial-Centre/FinTech-Regulatory-Sandbox.aspx or from Australia http://asic.gov.au/for-business/your-business/innovation-hub/regulatory-sandbox/

3. KEY CHANGE AREAS

In this section, we draw on the themes discussed above, while also discussing some of the key change areas and how they are affecting WA now or might affect WA in the future.

3.1. Renewable Energy Technologies

3.1.1. What is the Issue?

Currently, Western Australia, like most of Australia, is experiencing a growing number of rooftop solar PVs and this is projected to continue.

Two factors may accelerate these trends further – in ways that are particularly difficult to predict. First, evolving financing options may increase the uptake rate beyond even what has been forecasted to date.[15] New financing options have the potential to enable tranches of customers to adopt solar systems who might otherwise not have been expected to do so. Second, even though ownership (principal/agent barrier), orientation, or design may have, to date, discouraged some on-site installations, new business models such as rooftop rental models, as well as community or cooperative ownership models may provide alternative pathways that support or trigger development of these otherwise difficult-to-develop or previously less commercially attractive rooftop resources.[16]

Increasing diversity of business models, new financing options, continuing falling costs, and rising tariffs for grid-connected electricity all favour adoption of solar panels on *more and more* roofs, suggesting that forecasts-to-date of solar uptake – particularly if based on simple trend analysis -- could plausibly be too low. This is despite a growing body of experience from which to form projections.

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15 For example, "solar leasing" and "solar power purchase agreement" approaches that have been evident and impactful in other markets from around 2011 but which are just starting to emerge in WA.

16 For example, see Sun Electric (www.sunelectric.com.sg), which advertises "You don't need a roof to go solar. Sun Electric's platform connects rooftop owners that collect solar energy to consumers that want clean energy through our innovative SolarSpace technology." Also, as panel installation costs per kWh fall, and as avoided costs per kWh increase, there is a natural expansion of economically attractive rooftops.

Furthermore, Variable Renewable Energy (VRE) uptake increasingly appears to be robust to the presence or absence of subsidies in the future. For larger systems (those above 100kW), the quantity of Federal Government subsidies available through the Large Generation Certificates (LGCs) has been capped, and appears to be largely fulfilled by announced and under-construction projects. This has reduced the forward price for LGCs to near zero levels.[17]

Consequently, for larger roof-top VRE projects in Western Australia today, there is no longer any assurance of receiving any subsidy. Yet, we understand that these projects are continuing in record volumes, justified principally by avoided grid-based energy and network charges. For roof-top systems below the 100kW threshold for Small-Scale Technology Certificates, the upfront subsidy is being wound back annually until its expiry in 2030, and we would not be surprised to find that the 3 to 4 percent annual reduction in the subsidy will be matched by further reductions in cost and improvements in efficiency. The payback period for smaller systems appears to have stabilised over the last couple of years in the three- to six-year range for most installations.[18]

3.1.2. Why is it an Issue?

To date, the economics to the adoptees of rooftop panels have been attractive increasingly due to the volumetric nature of tariffs for grid-supplied electricity, even before considering possible personal preferences for energy independence or renewable energy. Behind-the-meter generation has reduced the demand for grid-connected electricity, slowing growth and leading to rising tariffs as new capital expenditures for transmission and distribution have to be recovered.[19]

Favourable policy support arguably launched this basic situation but, as tariffs have increased and panel costs per kWh have decreased, policy support has become less crucial to the continuation of high adoption rates.[20] Indeed, the high rate of adoption to date has fostered the development of a highly competitive installer and marketing base. All of these factors have supported scale, which has perhaps contributed to, but in any event certainly been able to take advantage of, falling costs of solar panels globally.

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17 For example, Goldwind recently entered a long-term power purchase agreement with Origin Energy for the output of a large wind farm. The publicly stated price of this arrangement was $65/MWh for energy and LGCs. http://www.goldwindaustralia.com/wp-content/uploads/Goldwinds-Press-Release-regarding-Stockyard-Hill-Project-07052017docx.pdf. In recent work for we have noted energy broker offers of $80 for LGCs in 2018, but only $20 per year for a 5-year contract. Notably, no offer for LGCs beyond 2023 was forthcoming,

18 Based on discussions with VRE developers and the broader VRE stakeholder community.

19 This assumes continuation of revenue cap regulation.

20 http://www.treasury.wa.gov.au/Public-Utilities-Office/Solar-PV/Renewable-Energy-Buyback-Scheme/

It is therefore more important to consider how electricity pricing impacts the prospect of future additional "cost-shifting" outcomes, as the process of adoption of panels appears to otherwise be self-sustaining, which means that absent any change, the degree of cost-shifting in the future is likely to increase, if not accelerate. Correspondingly, there will be an increased risk of stranded assets and increased energy poverty outcomes.

There is also increasing divergence of incentives between renewables on either side of the meter. The economics of grid-connected renewables depend more on policy support, as wholesale market prices are naturally subject to downward pricing pressure in periods when higher renewable energy output occurs. Consequently, grid-connected renewables face at least some naturally growing resistance due to the impact on wholesale market prices (before considering policy support that is available).

In contrast, behind-the-meter renewables avoid tariff charges, which can lead to cost shifting over time, actually *increasing* the incentive to undertake further investment to avoid the higher tariffs and so on.

The lack of appropriate consistency and coordination between the behind-the-meter and grid-connected "markets" mean that (without explicit policy support) a grid-connected solar farm would have almost no case for merchant or commercial development in any market that also sees massive adoption of behind-the-meter solar. Both types of projects compete for the same slice of underlying energy consumption, but participants in each "space" face very different commercial incentives.

A more generalised way to make this point is that there are clearly a number of factors altering consumption patterns that can result in a change in the distribution of costs, but we currently have pricing systems that enable costs to be reallocated inappropriately. The result is a set of price signals that do not both "encourage the good" *and* "discourage the bad". Such system would need to take a more holistic approach to ensuring consistency of price signals on both sides of the meter – and this is likely also to require more attention to metering and metering solutions as a key element to support more efficient pricing.

3.1.3. What Might Be the Consequences?

The risk is that new financing models, such as solar leasing, will open up the introduction of solar panels to an even larger range of households who heretofore may have been unwilling or unable to support the up-front capital or may have not had access to the rooftop space. In that sense, new financing and business model options just amplify the potential for both inequitable trends as well as pro-efficiency trends.

Another consequence is potentially higher costs for the same amount of renewable energy generation as compared to an alternative where renewable energy is provided from grid-connected resources. As a result of material inconsistencies in the pricing and economic signals to stakeholders on each side of the meter, it is not clear whether the dominant direction of development of renewable energy resources (on the rooftop versus connected to the grid) is least-cost.

That said, the distributed nature of rooftop solar has the benefits of diversity and potential reduction of network related costs – though these have certainly not been the fundamental economic drivers of rooftop solar adoption. Simple tariff avoidance is by far the best reason for a rooftop to gain a panel relative to development of a grid resource.

Unfortunately, the lack of any nuance means that both the pace of adoption has been astonishing, and the implications have been slow to be recognised. By now, it is a bit too late to change course dramatically, so the greater focus needs to be on thinking through what to do for the future. At minimum, continuing tariff structure reform is likely to be needed to mitigate the most egregious/entrenched auto-catalysing feedback loops between network costs and behind-the-meter behaviours.

3.2. ENERGY EFFICIENCY

3.2.1. What is the Issue?

As tariffs have increased, energy efficiency investments become relatively more attractive to the customer.[21] However, uptake of energy efficiency measures has rarely fully aligned with apparent economic benefits. Historically, in most countries, there has been a substantial gap between what appears to be the economically efficient level of investment in improving energy efficiency and the actual level of adoption. The energy efficiency literature is replete with discussions of market failures, information gaps, and seemingly inexplicable failures of consumers to make what appear to be obviously value-enhancing choices.

21 Demand response may also become more attractive depending on the nature of the price signals seen by the customer. Demand response may or may not result in fewer kWhs sold, but, at minimum results in a different time-of-use profile. The intersection of energy efficiency and demand response is a function of a combination of price levels (e.g., rising, falling, stable, above a threshold trigger point, or below) and pricing structures (e.g., what costs can be avoided and how), and pricing drivers (e.g., time or system conditions). Some of these factors rely relatively more on *active* behaviours (turning off a light, paying attention to a signal), and some rely relatively more on passive behaviours (setting and forgetting a thermostat or washing machine cycle, or buying more efficient appliances, motors, or lighting, or signing up to provide centralized interruptibility or allow centralized control over certain energy using equipment or processes).

Technologies may help accelerate adoption of energy efficiency to the extent that features are built into the technologies themselves and thus involve largely passive interactions with consumers. Alphabet's "Nest" learning thermostat is one example emerging from the technology sector,[22] as are a number of other smart home innovations, though most are still in early days and are by no means yet a mass market or tangibly material phenomenon.

More broadly, gains in energy efficiency in appliances and motors can propagate through economic systems over time through equipment upgrade and replacement cycles. Similarly, new buildings can be designed and built to be more energy efficient to begin with. Standards for appliances and buildings have been a major source of energy efficiency improvement, even if mainly by removing the worst-performing equipment from the market-place.[23] These factors are already present in most markets, including WA, and whereas adoption may nevertheless lag theoretical optimum levels, the effect over time seems generally to be cumulating.[24]

3.2.2. Why is it an Issue?

Unanticipated greater adoption of energy efficiency (and potentially demand response) can increase as tariffs increase, which can complicate long-term forecasting and may lead to higher costs of reserve capacity if targets are set too high and then not needed. Given that it is can be especially challenging to forecast uptake of energy efficiency and demand response in the first place – customers seldom appear to adopt all of the energy efficiency or demand response potential that appears economic on its face. It is clearly difficult to project whether or at what point rising prices might trigger material departures from historically observed energy efficiency or demand response behaviours.[25] Yet one can be equally sure that a market with relatively rising prices and an increase in available energy efficiency and demand response options will see a different trend in the uptake of energy efficiency and demand response than in the past.

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22 See: https://nest.com. Nest is owned by Alphabet, the parent company of Google.

23 https://www.eex.gov.au/programs e.g. CitySwitch, Commercial Building Disclosure, Building Energy Efficiency Certificate, E3 program, Energy Efficiency in Government Operations, National Australian Built Environment Rating System and Nationwide Home Energy Rating Scheme, and Sustainable Cities Investment Program

24 Notably, residential energy consumption per dwelling has been on a downward trajectory since about 2005, with the main cause being attributable to passive energy efficiency improvements across a range of residential energy use technologies. See: Residential Energy Baseline Study: Australia, http://www.energyrating.gov.au/document/report-residential-baseline-study-australia-2000-2030

25 Invariably, some form of structured conjecture about the impact of future prices, new programmes, and customer preferences is necessary, as reliance solely on past trends is assured to miss any otherwise ascertainable future shift factor. See also: National Electricity Forecasting Report, AEMO 2016

So, one issue is simply that any investment plan or policy reliant on medium to longer-term forecasting therefore can plausibly be considered less robust than perhaps even such forecasts were considered before. Projections of reserve capacity and the nature and approach to assuring adequate reserve capacity in the future (as well as the parameters that translate into commercial risk to market participants) are all affected by these considerations. Looking forward, more flexible and dynamic approaches to respond to evolving market conditions – and different ways for stakeholders to manage their exposure to risk – merit more consideration.

Another complicating issue is that various energy efficiency and demand response options may exacerbate cost shifting to the extent that tariffs are avoidable, even if corresponding underlying system costs are not actually avoided. In that way, these are part of the same feedback loop that characterises rooftop solar, and they all contribute to the same underlying risk of cost-shifting. To some extent, consumers also face a choice of how much to invest in behind-the-meter VRE or storage solutions versus how much to invest in energy efficiency or behavioural change. After all, an investment in energy efficiency might no longer be economically attractive after solar panels are installed, as the value of savings from more efficient use of electricity may be materially reduced. Or vice versa.

3.2.3. What Might Be the Consequences?

Clearly, the emergence of behind the meter VRE and storage options together with broader trends of increased energy efficiency, at least in some areas or applications, combine to *reduce* total kWh electricity sales (as well as alter the time of electricity use). As previously discussed, a reduction in kWh sales may cause a reduction in revenues that exceeds any associated reduction in costs. The resulting feedback loop can then require a tariff *increase*. On one hand, such increase may incentivise further rounds of energy efficiency or behind-the-meter renewable energy adoption. On the other hand, those customers without such choices (or without the means to afford the up-front investment associated with such choices) face a rising *total electricity bill*.

Some energy efficiency initiatives may therefore have merit in connection with helping poorer customers manage or reduce their exposure to rising tariffs. In particular, rising tariffs will naturally *widen* the gap between higher consuming but lower income households (those without access to other means to reduce consumption beyond, say, sacrificing comfort in the summer and winter, respectively) and lower consuming but higher income households, who can avoid paying for substantial portions of network infrastructure.

Currently, there are few energy efficiency initiatives that specifically aim to address this problem, but it is equally clear that the changes to tariff structures (such as introducing fixed charges) and the potential implications for tariff levels of many of the disruptive challenges ahead will likely exacerbate these issues.

3.3. Prosumer

3.3.1. What is the Issue?

The emergence of prosumer aggregation and peer-to-peer business models that utilise technologies like blockchain[26] are a clear signal that the electricity markets of the near and longer-term future will be moving to accommodate increasing amounts of decentralised distributed energy. The core need for a robust wholesale market does not yet appear to face any material threat – indeed some argue that the wholesale markets are needed in the prosumer energy regime too.[27] The greater threat is to the conventional concept of a retail market. The most likely outcome is the co-existence of both centralised and distributed market models, in which case it becomes imperative to determine how best to achieve effective coordination between them.

3.3.2. Why is it the Issue?

The changes identified under the theme Prosumer are enabling owners of distributed assets to take more active part in the electricity market. The business models allow for more effective utilization of their assets and for mitigation of locational constraints inherently imposed by grid congestion (or ageing) and weather patterns.

3.3.3. What Might Be the Consequences?

The investment case for distributed energy resources keys off consumer perceived avoided costs, often with little visibility of potential system-wide impacts or constraints.[28] Centralised market models key off avoided costs perceived at the point of dispatch (taking into account security constraints throughout the system). Perfect alignment may not be easy or possible, but reducing the scope for material misalignment – especially if such misalignment has the potential to increase the costs associated with providing a reliable and secure system.

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26 We stress that blockchain technology or cryptocurrency is not a pre-requisite of a peer-to-peer trading platform. In fact, in most cases the implementations use a “simplified” blockchain without (all) the associated security features or propose to use cryptocurrency mainly as a way to secure early funding and drive market share.

27 GridWise Transactive Energy Framework, GridWise Architecture Council 2013 or Rahimi & Ipakchi, The Electricity Journal (2012) vol. 25, p.29.

28 We argue that some implementations of the prosumer markets will not always achieve system-wide least cost, due to their locational optimization focus.

Distributed market models could become future "participants" in an existing electricity market. Alternatively, batches of prosumers may remain independent (as, for example, in a microgrid). Blockchain-based technologies may enable more efficient handling of a large volume of minute scale transactions that are foreseen as an integral part of a TE framework allowing prosumers and consumers to trade energy among themselves. Both TE and aggregation are already piloted in Australia.[29] Obviously, if correspondingly aggregated consumers are allowed to participate in such a market they may affect electricity pricing in the larger WEM in ways that have not been fully considered.

The prosumer model and associated underpinning technologies pose a longer-term reconsideration of the concept of what is a "retail" service from an electricity provider. In the meantime, the key preparatory activities involve focus on how these models may be incentivised by rigidities and distortions present in regulated and market pricing, the associated technologies in use (metering), and the extent to which any or all of these create incentives for cost shifting to a potentially material degree.

3.4. Reserve Capacity

3.4.1. What is the Issue?

Changes to the reserve capacity mechanism have sought to address the fact that the previous RCM settings were barely responsive to changes in market conditions and did not adjust sufficiently to a multi-year situation of increasing excess capacity. The RCM involves administrative parameters and thus involves a degree of out-of-market judgement. On the other hand, the proposed auction also requires out-of-market judgement to establish an appropriate demand curve.

For now, with the auction set aside until 2021, there is an opportunity to reflect further on the RCM as an administrative mechanism and determine how it can be used most effectively. The principal weak spot is that the current RCM uses an administrative formula keyed to the cost of the benchmark reserve capacity technology, which is defined as an OCGT. If "capacity" can be developed for materially less than the cost of a new OCGT then the RCM will tend to institutionalise some amount of excess capacity. Thus, appreciating the relevance of reviewing the benchmark technology and ensuring that it is appropriate for its purpose becomes important. The precise amount will be driven by the slope as well as all the other risks and uncertainties associated with markets and behaviours.[30]

29 https://powerledger.io/ and http://www.sunverge.com/sunverge-customer-agl-brings-online-worlds-largest-residential-virtual-power-plant/

30 We discuss these factors in section **Error! Reference source not found.**.

The second aspect is the formula term that is often colloquially called the “slope” factor. The original slope factor in the “Lantau Curve” developed through the Reserve Capacity Working Group, was in the order of -3.5, which largely balanced the need for a more responsive relationship between the Reserve Capacity Price and the amount of Reserve Capacity, with the perceived value of managing financial risk in a market where forecasting error had been quite high. A steeper slope factor in the RCM formula reduces the risk associated with getting the benchmark technology wrong (see above), as the cost to consumers of excess capacity is greatly reduced. A steeper slope factor, however, also injects greater risk to investors. With the pending auction, a steeper slope represents a rather simple way to facilitate a transition over a relatively short and defined time period. If the auction does not proceed, then it is probable that the proposed slope and any transition should be reviewed to incorporate the latest information about supply and demand projections, among other things.

3.4.2. Why is it an Issue?

The purpose of the RCM – working in conjunction with the energy spot market, contracting, and ancillary service arrangements is to ensure timely capacity at the right location. An RCM that is insufficiently responsive to market conditions can lead to higher costs and persistent excess capacity or unresponsive capacity deficiency. A large part of the work undertaken through the RCM Working Group was to develop a sharper set of incentives that would discourage adding capacity when there is already too much and would more responsively signal the need for capacity in the event of need.

Changes to the RCM have been proposed and transitional measures adopted. However longer-term policy clarity does not yet exist. AEMO projects that excess capacity will reduce through 2020 or 2021, assuming the retirement of 384 MW from Synergy and no material additional capacity entry.[31] The lumpiness of these decisions remains a challenge for the small WEM, as a shift of a couple of hundred MWs can make a significant difference in the value of a capacity credit under the RCM – if the slope factor is increased.

One of the more commonly raised questions arising from an evaluation of the RCM, is whether there should be a separate form of capacity mechanism for different types of capacity or whether there should be a defined or targeted mix of technologies. In fact, it is the way that the RCM interacts with the energy market (and contracting) and ancillary services value streams that ultimately determine the type of capacity that makes sense at any given time (if any). If these interactions are not aligned, then the result can be a different mix of technologies or higher costs than could otherwise have been achieved.

31 https://www.mediastatements.wa.gov.au/Pages/McGowan/2017/05/Synergy-to-reduce-electricity-generation-cap-by-2018.aspx

For example, the RCM targets the least cost, unconstrained, form of capacity, typically seen to be an OCGT (on liquid fuel if necessary). Such technology is comparatively less efficient, in terms of the amount of fuel used, when generating electricity. To increase thermal efficiency above the level of an OCGT generally requires higher capital investment cost. Such costs only make sense if sufficient energy market revenue (margins) cover the capital cost. Similarly, all else being equal, it can cost more to increase the speed of responsiveness of generating capacity as compared to adopting a variation of the technology that responds less quickly, precisely, or reliably. The value of incurring such higher costs depends on expected compensation from ancillary services offerings. Thus, it is the combination of trade-offs between capital cost and the benefits of efficiency and fuel choice, as well as the trade-off between capital costs and different degrees of responsiveness, as rewarded through ancillary services arrangements, that drive the long-term investment mix. These must all be reconciled within the energy market design.

3.4.3. What Might Be the Consequences?

A more dynamic short-term capacity price (whether produced by a modified RCM slope factor or by an auction with an associated demand curve) injects greater risk to investors. A sharper (more accurate) signal implies sharper (more volatile) risks. As risk increases, all else equal, new investment will naturally face pressure for deferral, or may become more expensive. Similarly, if the investment is driven in part by commercial market interactions and in part by policies or government support (such as renewable energy or specific decisions to invest or retire capacity in the market), then the capacity price can be influenced materially by “out-of-market” activity. Currently, a risk to any investor in thermal capacity is the inconsistency of market signals and behaviours on both sides of the meter, as the different investment dynamic behind the meter has direct negative implications for future demand growth for grid-supplied electricity, which greatly increases the risk of persistent excess capacity.

Over time, the RCM may also need to consider not just capacity *sufficiency* but also capacity *capability*. Intermittent resources may require additional response capability from other resources which may not align strictly with the definition of “capacity” or the measurement of precisely when “capacity” is available. These issues suggest greater attention to ancillary service requirements, but they may have implications for the definition of capacity or for the measurement of what amount of capacity is required.

Another issue is that it is much faster for capacity to exit than for it to be built, which introduces a greater level of uncertainty as to what mitigating options can address the gap between lumpy exit and optimally responsive entry. The nature of long lead time of traditional infrastructure development would mean the necessary investments may be made too late and the power system could be left sub-optimally unbalanced or at risk for an unacceptable period of time.

Finally, a potential concern is whether the RCM provides sufficient geographical value differentiation to ensure that capacity is located where it is most valuable, rather than behind a constraint where it captures an RCM payment but does not contribute actual equivalent capacity. This concern, which can arise for both an RCM arrangement and an auction arrangement, depends on either greater revenue from energy dispatch (and thus an incentive to be located where dispatch is most likely), or another mechanism to direct capacity to less constrained and thus more valuable parts of the network. Over time, with increasing renewables and some of the other disruptive trends, it is possible – perhaps even likely – that such considerations will become more important.

3.5. NETWORK

3.5.1. What is the Issue?

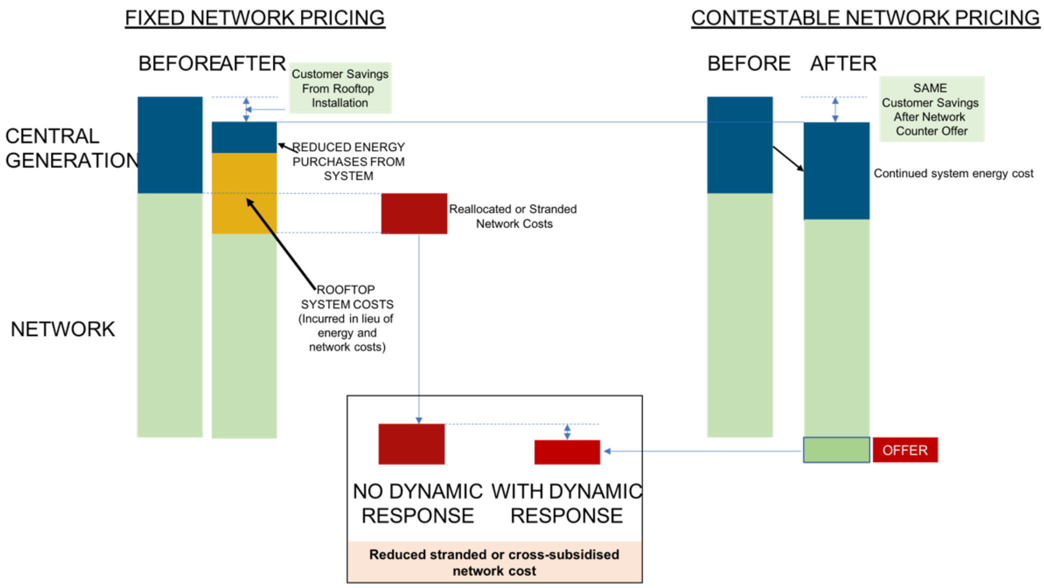
Three phenomena have been identified by ERA as material changes to the networks. First, the unprecedented rates of behind-the-meter installations of technologies, like variable distributed generation (rooftop solar or battery storage). Second, the potential for grid fragmentation. Third, the emergence of more, material, locational grid constraints.

3.5.2. Why is it an Issue?

Network pricing and cost recovery is an increasingly complex area which influences whether the costs and benefits of specific technology choices as they appear to adopters aligns with the way the costs and benefits align with WA as a whole. Customers who are able (through new technologies) to avoid regulated costs – especially those costs that were not intended to be avoidable -- necessarily shift the burden of recovering them to other customers with resulting unintended consequences that can be amplified by the various feedback loops we have discussed previously. Currently cost recovery to end users is limited by overall tariff structures and policies concerning the acceptability of locational pricing differentials. Such limitations can result in higher costs in the future.

In Figure 4, a customer has an option to install a behind-the-meter solar solution (rooftop solar). The customer considers the potential savings, which, because of the tariff structure and cost allocation, would result in a reduction in revenue paid to the network. If network pricing cannot respond, then the network stranded cost (costs that must be shifted to others if they are to be recovered at all) is the larger red box on the left side just above “NO DYNAMIC RESPONSE”. However, if the network could reduce (customise) its charges to that particular customer, it could “meet” the solar offer and the customer might stay (not adopt the rooftop solar solution). In such a case, more flexible location-based network pricing reduces overall stranded cost risk (the red box is smaller), which means less cost to be recovered from other customers or stranded entirely.

Figure 4: Effect of rooftop solar on cost recovery, stranded network costs, and utility bill savings.



Clearly, the choice of dynamic network pricing can reduce the risk of stranded cost, but it would also reduce the rate of uptake of behind-the-meter generation options, in part because it would favour more efficient use of the existing (already paid-for) network. However, network pricing is generally static or constrained by policies to equalise prices across a region or by customer class.

3.5.3. What Might Be the Consequences?

Behind-the-meter additions to the grid can complicate load forecasting (short to long-term) and grid planning and operation. A reduction in the accuracy of long-term forecasting creates risks of stranded assets and incorrect investment signals, whereas the short-term forecasting error creates risks of more volatile prices. This is exacerbated by developments in utility-scale VRE that contribute to the increased variability of the supply. Despite system operators having experience in forecasting variability, the methods used require a sufficient amount of historical data and low variance in observable characteristics. These requirements are not satisfied in the case of emerging technologies.

Locational issues further add to the risks. In the current regulatory design, there is no clear incentive to invest in distributed grid support (this could be rooftop solar or battery that sits behind the meter) where it would lower the costs to all stakeholders.[32] Further, grid fragmentation may complicate network operations and impair security (for instance due to localized over-generation or increased ramping rate requirements) as well as add an extra layer of uncertainty to system forecasting.

Two options seem to be presenting a way to minimize the risks of inefficient market operations – command and control and market-based instruments. For example, a rule could be designed to enable the system operator to control more of the energy assets connected to the grid (as tested under various new business models, i.e. V2G, etc.). Alternatively, a pricing mechanism could be developed to send signals to the assets / owners to adjust their output or bear the consequences commercially. The advent of energy management systems hints towards the latter as the more optimal solution – and it is more likely to avoid or minimise the need for any compensatory mechanism for "fair" treatment of existing system owners.

In summary, the changes occurring in the network clearly pose a risk to the security and reliability of the system. Behind-the-meter installations make it difficult to maintain the required level of stability and security of supply. Contrarily, to traditional generators, these technologies may enter or exit the market at short notice or no notice at all. Furthermore, network fragmentation increases the effort required to manage the clusters that may be quite diverse and may have a low local load factor (potentially raising cost allocation challenges as well).

3.6. Tariff Reform

3.6.1. What is the Issue?

WA's electricity tariffs for many customers are not cost-reflective in terms of both level and structure, though the introduction of a fixed charge is implicitly a move towards a more cost-reflective structure given that the tariffs were previously entirely volumetric (variable).[33]

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32 We note that Network Control Service creates an opportunity for distributed grid support, however the Market Rules are not explicit about any associated benefits.

33 https://www.mediastatements.wa.gov.au/Pages/McGowan/2017/06/Tariffs-fees-and-charges-to-assist-in-budget-repair.aspx

Tariffs for non-contestable customers and vulnerable households (who get various rebates and assistance) have been lower than the underlying cost of supply and the Western Australian government has been covering the shortfall. The new tariff announcements “introduce an increase of $169 to the fixed charge component of electricity bills, or 10.9 percent for the ‘representative household’.”

3.6.2. Why is it an Issue?

Ultimately, there are two main reasons for more comprehensive tariff reforms:

- The first is to align revenues and costs and thus reduce the absolute need for a subsidy payment. The economic argument is that subsidised electricity payments tend to benefit a far wider range of end users than would otherwise qualify as being “in need”. Therefore, cost-reflective electricity pricing combined with better targeted income and social support expenditures can be a less expensive way to achieve the same overall objective.

- The second is that overly simplistic tariff structures may (and currently do) incentivise cost-shifting from customers who have options available with which to avoid buying electricity from the grid. If the lost revenue to the grid exceeds the cost savings from not needing to supply as much electricity from the grid, then the result is a shifting of costs to other customers or to equity holders or tax payers.

To some extent these are both related so long as the efforts to decrease overall subsidies are done in ways that minimise the risk of cost shifting. Notably, tariff increases to alleviate an industry budget deficit achieve the desired result over time if the increase is done in a way that incentivises even greater cost-shifting behaviours in the future. Hence, the second reason for tariff reform – getting the structure right – is increasingly the more challenging and important longer-term objective.

Among other things, there remains room to consider further tariff changes, including further increases in the proportion of fixed, non-bypassable tariff components; introducing greater time-of-use differentiation or, indeed, introducing locationally differentiated tariff structures. The point of tariff reforms is not to stop some specific activity or start another, but rather to promote any activity that predominately involves value creation or value conservation while discouraging activities that involve expenditures that are largely rewarded by cost-shifting. Getting the balance right is not easy and may require greater use of smart meters in the future.

3.6.3. What Might Be the Consequences?

The move to cost reflective pricing is essential to close the budget gap. A reduction in subsidy frees up financial resources to devote to other objectives. A corollary effect is the need for an increase in budgeted expenditures on a variety of related support initiatives, including the annual energy assistance payment and the hardship utility grand scheme.

In the absence of tariff reforms – meaning that tariffs remain substantially volumetric and avoidable – it is reasonable to expect a continuation and potentially an acceleration of adoption of behind-the-meter solar panels and battery storage options. The result of this would be continuing upward pressure on the portion of tariffs designed to recover grid-related costs. Whereas some customers would be able to mitigate their exposure to higher prices by using less grid-supplied electricity, some customers would not. Consequently, the need for energy poverty assistance in various forms can be expected to increase, potentially dramatically.

A change to a less "avoidable" tariff structure – through, say, greater fixed charges – will tend to present greater *immediate* disruption for low-income households who use relatively less electricity. But the longer-term impact may well be moderated if the impact of cost-shifting is materially reduced. Either way, an emerging challenge is to utilise external programmes and/or to very carefully structure tariffs (including eligibility rules for any concessionary tariff) to deal more effectively with energy poverty, while not simultaneously increasing the incentives for cost-avoidance that can worsen the energy poverty problem (and raise the cost of dealing with it).

4. SUMMARY

The WA power system is – like all power systems – complex, dynamic, and inter-active. Virtually all major changes are triggering or will trigger either self-regulating or auto-catalysing responses. As the overall system necessarily becomes more complex (because of the increasing and unavoidable way all elements interact), these feedback effects become more difficult to forecast. This makes it more important to focus on fundamental factors, such as ensuring appropriate price signals, frequent adjustments to fixed settings such as tariff structures or use of averaging or other simplifications, and effective monitoring.

In this report, we highlight how electricity storage is one of the key factors to prepare for in the Western Australian WEM. A market and regulatory regime able to *efficiently* signal and accommodate use of storage is a market that is best positioned to create value from the adoption of various new technologies. A key current issue, however, is that the economics of storage are largely being driven by factors that favour an imbalance in the amount of VRE resources that are being introduced to the system. The incentives to add distributed VRE create value propositions both for additional storage behind the meter and for potential storage on the grid. Yet, in *neither* case is the amount of potential storage economically optimal (except in the narrow sense of being a least cost solution to the imbalance that is being exacerbated by other out-of-balance forces).

Assuming pricing reforms that allow VRE adoption to be more efficiently integrated, the next issue concerns how storage assists in the propagation of prosumer networks. Given the locational nature of such networks and high degree of correlation between consumption and production mismatches, storage is likely to be needed if grid independence is to be a valid and efficient possible option in some instances (and not just a cost-shifting or cost-escaping option).

Besides aiding the adoption of VRE and propagation of the prosumer networks, storage can also render useful services to the overall electricity network, both as a potential Ancillary Services provider and a source of distributed grid support. However, enabling these value streams will almost certainly necessitate changes in network pricing regimes and ancillary services definitions. The opportunities in this domain are not only within the reach of dedicated batteries but also are possible additional benefits of EVs and state-of-the-art energy management systems.

At least one dimension concerns the implications for smart metering technologies and how they can be used, and the extent to which ubiquity is required within each relevant customer class. Without time-based metering capability, as a minimum, dynamic pricing is a non-starter.

Another dimension concerns an increased focus on energy poverty mitigation. Historically, the use of simple mechanisms such as state-wide averaging; intended or unintended cross subsidies across customer classes; industry financial deficits supported by taxpayers; and the use of volumetric tariffs that protect low volume users (whether poor or wealthy), have all played a role, whether specifically designed to or not, in managing conflicting economic and social objectives. As each of these legacy "approaches" becomes unsustainable – largely because of new technology choices available to customers that allow material cost shifting – the reality is that electricity prices have increased and will likely increase further. That said, tariffs will need to increase *even more,* all else equal, if opportunities for *cost-shifting* continue to drive stakeholder behaviours, as someone will still have to pay for the electricity network.

The more tariffs are out of alignment with costs, and the more prospective cost shifting is likely to occur, the more future total electricity *bills* are likely to be higher for poorer customers (customers without the means or opportunity to invest in solar panels or energy efficiency improvements). Because of all the new choices available to energy stakeholders behind the meter, fewer and fewer, if any, satisfactory solutions to energy poverty can originate from within the electricity sector itself – beyond ensuring that markets and regulations align so as to promote least-cost pressures over time.[34] Instead, the solutions required depend on other mechanisms to identify disadvantaged customers and address the income gap separately. All that can be said is that if electricity *prices* increase for all, even as electricity *bills* reduce for some, the result must be a greater disparity of total bills within each customer class.

The emergence of storage and storage-like solutions hints towards an exciting future quite distinct from the past. Two ways forward are possible to manage the system. One way involves more command and control to reach – potentially in a manner that invades or reduces privacy or flexibility – beyond the traditional meter. Simplicity is one benefit of such an approach. The alternative is to develop a more interactive and dynamic incentive-based approach, but this would likely require a smart meter operating in a smart way, correspondingly smart pricing, and the necessary interactivity to support consumer sovereignty but limit arbitrary cost-shifting/escapism. To us, the latter is more appealing, though the journey to get there is still largely unmapped. The first steps – no matter which path forward is taken – concerns focussing on pricing, signalling, and aligning incentives as much as possible across the choices available on both sides of the meter.

34 In the sense of being driven entirely by observed usage levels without consideration of information that must come from other sources, such as income. Also, to the extent that income is used as a factor to develop a cross-subsidy scheme, the impact of that scheme raises tariffs for other customers, which can accelerate feedback loops.