Issues Presented by Emerging Technologies for New Zealand Electricity Sector Regulation – A High-Level Overview

Report for

Vector Limited

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Notice

Contents

Abbreviations

DER	Distributed energy resources – e.g. PVs, and electrical storage (including EVs)
EV	Electric vehicle (plug-in)
HEMS	Home energy management systems
HFCV	Hydrogen fuel cell (electric) vehicle
IoT	Internet of things
LFCT	Low fixed charge tariff
P2P	Peer-to-peer
PV	Photo-voltaic solar panel
V2G	Vehicle-to-grid
WTP	Willingness to pay

1. Introduction

1. This report provides a high-level discussion of how emerging technologies in the New Zealand electricity sector affects how that sector should be regulated. It summarises and extends the discussion of these issues provided in a separate and more wide-ranging report prepared by the author.[1] In this report, as in that report, it is assumed that regulation seeks to serve the long-term interest of electricity consumers. However, while the earlier report looked across all of the electricity sector, this report focuses particularly on electricity distribution.

2. The emerging technologies considered in this report include, but are not limited to:

    2.1. Specific electricity sector technologies – including photo-voltaic solar panels (PVs) and electrical storage (e.g. home-level batteries), home energy management systems (HEMS), and smart meters; and

    2.2. Other technologies potentially impacting on electricity sectors – e.g. plug-in electric vehicles (EVs), communications technologies (e.g. 5G mobile), or internet-of-things (IoT) technologies that produce or consume electricity.

3. Technologies that can produce electricity at a small-user level, or within local electricity distribution networks, are collectively referred to as distributed energy resources (DERs). As well as PVs, these include batteries, which "produce" electricity by discharging it, and hence also some types of EVs (i.e. those with vehicle-to-grid (V2G) capability, whose batteries can discharge electricity as well as store it for motive use).

4. The main themes addressed in this report include:

    4.1. Factors affecting the realisation of emerging technologies' benefits – social impacts of private choices, coordination issues and path dependencies, and the importance of ownership;

    4.2. The changing nature of electricity consumers – the rise of prosumerism, personalisation, and waterbed effects;

[1] Meade, R., 2018, *Preparing Electricity Regulation for Disruptive Technologies, Business Models and Players – In the Long-Term Interests of Consumers*, independent White Paper commissioned by the Electricity Retailers' Association of New Zealand, August.

4.3. The changing nature of electricity distribution networks – bi-directional flows, dynamism, and decentralisation/automation; and

4.4. The generally changing nature of electricity regulation – shared regulatory issues and pan-sectoralism, internationalisation, and forbearance.

5. These themes are discussed in turn in the following sections. The regulatory implications of each theme are summarised at the conclusion of each section, while the final section draws together some general regulatory implications.

2. Factors Affecting the Realisation of Emerging Technologies' Benefits

2.1 Social Impacts of Private Choices

6. Emerging DER technologies like PVs and storage/EVs will provide their users with direct private benefits, which will be taken into account when users make their uptake decisions. These private benefits include savings in terms of energy and electricity transportation costs, but also other possible benefits such as new types of services, and increased electricity consumption. They are also likely to have significant wider social impacts, including:

6.1. Likely positive impacts – such as household-level PVs and storage/EVs being able to offer energy supply and network support services that increase both electricity supply (renewably, at low marginal cost) and its reliability; and

6.2. Possible negative impacts – such as greater intermittency and volatile/unpredictable electricity demand and supply (which could reduce reliability), increased market power of peaking/shoulder generators when DERs are unable to supply, or shifting existing network cost recoveries that are tied to energy consumption. Such recoveries might shift from wealthier households that can afford DERs (which can reduce the power those households need to buy) onto a diminishing pool of less-wealthy households who can't afford DERs – a form of "waterbed effect".

7. If these wider social impacts are significant, then consumers' private choices may be privately beneficial, but either more or less desirable for consumers and society at large (depending on whether social impacts are net positive or net negative). In that case, measures may be needed to ensure private and social interests are better aligned,

including reform of pricing structures or regulated pricing models to ensure they reinforce desirable private incentives,[2] for the widest possible social benefits from the emerging technologies.

2.2 Coordination Issues and Path Dependencies

8. It is not a given that the competitive process will, by itself, lead to emerging technologies delivering the best outcome for consumers. The victory of VHS over Betamax in video recorder technologies is a classic example where the competitive process delivered an arguably inferior outcome. In addition to the reasons just mentioned, this is also the case where emerging technologies involve significant “network effects” – i.e. when they deliver greater benefits the more users they have.[3] It is also the case when significant scale economies are involved, so having fewer, larger providers can be more efficient than multiple, smaller providers. This gives rise to a different set of coordination issues – getting consumers and suppliers to coordinate on outcomes leading to the greatest social benefits.

9. With consumer devices becoming increasingly interconnected and managed via “cloud” services – the internet of things (IoT) – it is likely that emerging technologies in electricity will not operate independently either within or across households. New digital “platforms” and services will likely emerge to “aggregate” or otherwise coordinate uses, either responding to existing market signals, or creating entirely new markets. Examples include peer-to-peer (P2P) trading of energy produced by PVs between individual households, or wholesale market trading of energy stored in household batteries or EVs (using V2G technologies) through larger-scale aggregation services. Depending on how they are structured, such platforms and services could either resolve or exacerbate the coordination issues discussed in Section 2.1,[4] adding to the importance of coordinating on the most socially-desirable platforms.

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[2] Examples include the low fixed charge tariff (LFCT), and current splits between fixed and variable lines charges. They also include rules about how much electricity lines companies can provide competitive services, and how costs of competitive activities are treated when determining allowable revenues from regulated activities.

[3] For example, ride-sharing services provide greater consumer benefits when there are many drivers on one side of the “platform” (attracting rides) and many rides on the other (attracting drivers).

[4] For example, algorithmic trading of DER energy could potentially exacerbate existing network unreliability issues.

10. These platforms and other aggregation/coordination services will likely involve significant network effects or scale economies. Local providers, with solutions tailored to New Zealand conditions, may struggle to be viable relative to much larger overseas platforms having more established expertise, larger markets, and hence larger datasets to learn from.

11. An important example is New Zealand's choice about whether or not to commit to plug-in EVs to decarbonise the transport sector. That would likely require investments in renewable generation, and also in distribution networks to cope with increasing peak demands and to provide recharging infrastructures.[5] An alternative forward pathway could be to commit to hydrogen fuel cell (electric) vehicles (HFCVs). That would instead require investments in clean hydrogen creation (e.g. using renewable electricity), and in distribution (e.g. through conversion of existing petrol station networks). Committing to neither leaves the risk of competitive entry that deters or at least delays investments in either. It also leaves consumers unsure about which technology will prove the long-term "winner", deterring or delaying their switch to either EVs or HFCVs.[6] Together these factors could result in only a fraction being realised of the potentially considerable network effects associated with consumers and suppliers coordinating on any one approach.

12. Consumer benefits from DERs are likely to be substantial, but it is not assured that the first offerings will remain the best in even just a few years' time. This can additionally lead to "path dependencies", with switching costs and other "lock-in" effects – or network effects – that could delay or impede entry by better providers. Earlier providers could also benefit from achieving scale, and by accumulating consumer datasets to learn from that are hard for rivals to replicate.[7]

2.3 Importance of Ownership

13. Whether emerging technologies substitute for, or complement, the activities of existing industry players affects those players' incentives to encourage (or impede) such

[5] Such investments may not be needed if there is a mass shift towards mobility as a service and/or improved public transport, away from private vehicle ownership.

[6] Another important choice is whether or not New Zealand commits to greater public transport and less private transport infrastructure, or vice versa. This affects the investment case – for both providers and users – in either private vehicle technology.

[7] Delays or entry barriers are not assured, since pioneering providers might simply "create the market", with later providers able to "leap-frog" their offerings if later offerings are sufficiently attractive. It is also possible that early providers over-invest in consumer-benefitting infrastructures, not anticipating how later technologies might lead to more intense competition that reduces the value of their initial investments.

technologies. By analogy, automobile manufacturers may have an incentive to persist with internal combustion engines given their existing investments in such technologies, unless and until they see it in their own interest to promote alternatives like hybrid or fully-electric vehicles. The same issues will arise in electricity sectors.

14. It is currently unclear whether emerging technologies such as DERs are necessarily substitutes or complements for existing activities of incumbent electricity industry players. Storage, for example, might be viewed as a complement to lines services (such as by providing network support services). Alternatively, it might be a substitute, by enabling households with the necessary capacity to invest in DERs to smooth their use of lines services (and thereby reduce their peak demand for network capacity – possibly to zero if they have sufficient onsite generation and storage).[8]

15. It is possible that DERs are substitutes for lines services in some circumstances and complements in others, meaning lines companies might inherently prefer or dislike DERs, and take actions accordingly. Alternatively, it might be possible for providers to limit the types of services offered by emerging DER technologies, to those they prefer and not those they dislike. Either way, the consumer benefits realised from such technologies could depend very much on who owns them, and whether different classes of provider are able to limit or impede the use of these technologies even when owned and operated by others.

16. The total benefits that consumers receive from emerging technologies in electricity will depend on:

    16.1. The net benefits of those technologies being owned or controlled by any given party; and

    16.2. How the incentives of different owners or controllers of the technologies interact in the overall industry “ecosystem”.

17. Taken in isolation, these net benefits will reflect differing trade-offs depending on whether the owning or controlling party is a distribution company, retailer, generator, household, or

[8] Households’ ability to invest in DERs will depend on a myriad of factors, such as home ownership status, access to finance, type and availability of roof space, etc. Also, even households with substantial PVs and storage might choose to remain “on-grid”, if only because this preserves a potentially-profitable option to sell energy or DER services across existing networks. This is less the case if such energy or services can instead be transported using EVs with V2G capability to physically relocate energy in their batteries to points of demand, especially if such vehicles can do so autonomously.

third-party (e.g. "tech giants", or other possible aggregators).[9] If owned or controlled by distributors, the trade-offs will also be affected by whether those firms are customer- or investor-owned, and also whether they are subject to price-quality regulation or exempt from such regulation. If owned or controlled by retailers or generators, the trade-offs will differ depending on whether these firms are integrated into the other activity (i.e. are gentailers), or stand-alone firms. They could also differ to the extent any such firms are involved in other activities (e.g. broadband, entertainment or sports content, etc).

18. For example, it is not clear which of the following is most likely to best serve the long-term interests of consumers:

    18.1. If households own DERs, pros include those households enjoying low-marginal cost renewable electricity, substituting for potentially more costly network upgrade costs, and providing new energy sources for EVs. Cons include possibly excessive fixed costs when compared to larger-scale DER investments, uncoordinated use resulting in worsened supply reliability, and waterbed effects for non-uptaking households; and

    18.2. If regulated lines companies own DERs, pros include improved coordination of DERs and lines activities, resulting in improved supply reliability and at potentially lower cost, and – perhaps inadvertently – earlier uptake of DERs through socialisation of DER costs through regulated pricing (overcoming potential behavioural barriers to uptake). Cons include possible deterrence of superior alternatives, locking in solutions that favour lines companies but not households or rival suppliers, and network charges being shifted from households uptaking DERs to those that don't (or can't).

2.4 Implications for Electricity Sector Regulation

19. Based on this discussion of factors affecting the realisation of benefits from emerging technologies' in electricity, some high-level regulatory implications include:

[9] For an elaboration on these trade-offs, and possible responses, see Sections 4.3.3 and 7.6 of Meade, R., 2018, *Preparing Electricity Regulation for Disruptive Technologies, Business Models and Players – In the Long-Term Interests of Consumers*, independent White Paper commissioned by the Electricity Retailers' Association of New Zealand, August.

19.1. Ensuring current and future regulatory settings support private uptake decisions where those decisions generate positive net social benefits, and ensure private parties bear the full costs of their uptake choices otherwise;

19.2. Making conscious choices about how regulation encourages or impedes the uptake of emerging technologies, recognising that even status quo regulation is a choice that affects the nature and pace of uptake (for better or for worse). Regulation can play a role in helping to set standards where these encourage innovation, coordinating the creation of new markets, and in shaping the overall direction of competitive travel to maximise consumer benefits if network effects or other coordination issues mean competition might not do so by itself;[10] and

19.3. Being mindful of how ownership and control of emerging technologies affects the nature, extent and pace to which their consumer benefits are realised, including how parties with market power or regulatory advantages may seek to leverage their position into new areas (affecting the associated consumer benefits, either positively or negatively).

3. The Changing Nature of Electricity Consumers

3.1 Prosumerism

20. Emerging technologies like DERs could facilitate a sea-change in electricity systems. One key way is by shifting generation and energy trading from being the preserve of traditional large-scale generators selling energy via retailers (i.e. uni-directionally), to being an activity undertaken by a host of small-scale self-generators who compete with traditional suppliers – whether for their own supply, or to meet the electricity demand of others (i.e. bi-directionally).

21. For example, households with PVs can generate in real-time. Conversely, those with batteries/EVs can become small-scale "power stations" at times of their choosing. Either way, such households are no longer simply "consumers" of electricity supplied by third

[10] Examples include specifying product characteristics (e.g. voltage and frequency) or setting technology standards, clarifying data ownership, or even mandating the cessation of certain technologies (e.g. analogue television broadcasts). Either way, hardware and software providers, electricity firms, and consumers can then coordinate on certain outcomes, rather than take technologically-divergent paths in strategically uncertain situations where benefits to individual consumers hinge on choices made by all other parties.

parties. Instead, they are "prosumers", variously consuming or producing electricity depending on circumstances (e.g. real-time electricity prices, or network support services prices if lines companies offer them).

22. This necessarily affects how users of these emerging technologies should be viewed for regulatory purposes. They might prefer less energy market competition to more, or higher distribution support services prices not lower, since this means they can make more money by selling energy or support services. This sets their interests apart from those of non-uptaking, traditional consumers, who would typically prefer more competition and lower prices so they can buy electricity, and have it delivered to them, more cheaply. This means regulators will need to distinguish and cater for such diverging interests, while ensuring that regulatory rules do not inappropriately favour certain consumers over others.

3.2 Personalisation

23. Even if all electricity consumers adopt emerging technologies in electricity, it should still be anticipated that regulators' jobs will become more complicated. A host of emerging technologies enable electricity consumers (or prosumers) to be increasingly differentiated in terms of their preferences and behaviours, and their ability to buy or sell in energy markets.

24. These include smart meters (particularly those that look beyond mere household-level electricity consumption), and home energy management systems (HEMS). They particularly include technology platforms that facilitate the realisation of the IoT, such as digital assistants and smartphones, and the associated "smart" devices such platforms interconnect. Such technologies enable real-time monitoring, prediction and influencing/control of consumption, at the level of individuals and even appliances.

25. These technologies enable the increasing personalisation of service offerings and pricing. This enables providers to charge consumers different prices – for either the same or more tailored services – that better reflect individual willingness to pay (WTP), or ability to pay. It could also involve providers serving otherwise under-/un-served market segments at lower prices or more appropriate price/quality bundles.

26. Just as regulators will need to distinguish the interests of traditional consumers from those of prosumers, they will also need to take a more nuanced view of the regulatory interests of many other different types of household.

3.3 Waterbed Effects

27. Technologies that enable greater personalisation might prove highly advantageous to some households, possibly relieving regulatory concerns for them. However, they might raise regulatory concerns – both new and old – for other households. For example, such technologies might enable providers to better identify the least profitable market segments, and abandon them altogether (raising possible issues about equity of access). Greater personalisation can also mean that some households obtain improved offerings, but others (by default or by intent) receive worse offerings – a form of "waterbed effect".

28. From a regulatory perspective there may be equity or other reasons to be concerned at firms being able to charge customers more, even if they have higher WTP. This might include, for example, more vulnerable customers whose higher WTP stems from disadvantages in being able to compare or access better product or service offerings (rather than inherently valuing those offerings more highly and/or having greater means to pay for them).

29. Conversely, regulation itself can give rise to waterbed effects. Examples include the low fixed charge tariff (LFCT), and lack of regulatory focus on socially-optimal fixed and variable lines charges. The LFCT provides an incentive for households that are able to invest in DERs to do so in order to reduce net energy consumed from suppliers. That way they qualify for low fixed lines charges, and can avoid paying higher variable charges. Similarly, current fixed and variable lines charges have not been set with a view to maximising consumer benefits in a world of DERs. In either case this can induce households with resources to invest in DERs so as to reduce their contribution towards fixed network charges. To the extent regulatory arrangements allow lines companies to recover such charges from remaining customers, this could imply an increasing burden on households that have less ability to invest in DERs.

3.4 Implications for Electricity Sector Regulation

30. Based on this discussion of the changing nature of electricity consumers, electricity sector regulation needs to become far more nuanced. For example, it needs to:

    30.1. Recognise that some traditional consumers are now effectively small-scale suppliers (or possibly part of large-scale suppliers if their DERs are aggregated);

30.2. Pay greater regard to consumers (or prosumers) receiving increasingly personalised offerings, which may benefit some households and relieve traditional regulatory concerns; and

30.3. Look out for waterbed effects (i.e. any socially-undesirable consequences of greater personalisation), including those which are an artefact of regulation itself.

4. The Changing Nature of Electricity Distribution Networks

4.1 Bi-Directional Flows

31. Distribution-connected parties – as opposed to large, grid-connected parties – have traditionally only been net users of electricity, and of transportation services ending at their (usually fixed) point of demand. With the likely rise of DERs and prosumerism, such parties might also inject electricity into distribution networks, creating counter-flows affecting net network capacity.

32. This means local electricity distribution networks could become highly granular low-voltage versions of high-voltage national transmission grids. They could feature considerably many more points of possible offtake or injection, requiring much closer attention to changing network requirements/constraints and effective capacity as emerging technologies are increasingly adopted.

4.2 Dynamism

33. Relatedly, the increasing uptake of EVs and/or PVs means that net demands and associated distribution requirements will not only change with uptake. They will also change in real-time, as:

33.1. EVs relocate on networks – possibly autonomously and algorithmically, in response to changing network requirements and real-time electricity prices; and

33.2. PVs generate intermittently in response to changing sunlight levels, and connected electric appliances turn on or off, also possibly autonomously and algorithmically in response to changing network requirements and real-time electricity prices.

34. This means distribution network conditions and requirements will become increasingly dynamic. They may ultimately resume predictable patterns, or be induced to do so through

supplier or regulatory measures (e.g. improved pricing signals for both energy, and network services). However, they might also become more unpredictable and volatile, especially in response to exceptional circumstances (e.g. sudden correlated increases in demand, or sudden changes in supply such as through outages or major weather events), or hard-to-predict algorithms.

4.3 Decentralisation and Algorithmisation

35. The national grid involves relatively few large generators and retailers, and is amenable to centralised monitoring and management to ensure ongoing real-time supply and demand balance. As emerging technologies make distribution networks more dynamic and bi-directional, there will be increasing need to ensure real-time balance can be preserved (subject to increasing storage providing short-term buffers against imbalances). However, the far greater granularity and dynamism of such evolving distribution networks could make centralised monitoring and management intractable.

36. This raises the possible need for distribution network monitoring and control to become much more decentralised, dynamic, and probably algorithmic – unless DERs are sufficiently aggregated that lines companies need only interact with a manageable universe of DER operators. Absent formal aggregation, it is likely that many DERs will be operated and self-dispatched algorithmically (e.g. through P2P trading platforms, providing a low-cost means to maximise DER benefits). Such algorithms could constitute "virtual aggregators", albeit requiring lines companies to engage with "code" that causes aggregate behaviours that are harder to predict than those of other aggregators.

37. Absent either form of aggregation, lines companies will need much improved network monitoring and control technologies to accommodate increasing dynamism and changing energy flows as emerging technologies like DERs are adopted. Other parties such as retailers will also need to better understand network conditions, just as generators need to understand grid conditions. This means distribution networks may need to become much more transparent than now, highlighting where constraints and opportunities arise at more granular and real-time levels.

4.4 Implications for Electricity Sector Regulation

38. The discussion in Section 3 implied that electricity regulation will need to be much more nuanced in terms of reflecting differing consumer interests. Based on this discussion of the changing nature of distribution networks, electricity regulation will also need to be more

nuanced in terms of how such networks and their associated regulatory issues are understood. In particular:

38.1. Lines companies' ability to meet reliability requirements will become much more affected by third-party (possibly algorithmic) decisions, especially households' or aggregators' decisions about self-consuming or trading energy from DERs. It also includes decisions about when and where to charge or discharge energy from EVs (also possibly algorithmically, and at arbitrary locations – especially as EVs become autonomous). The nature and location of regulatory reliability obligations and penalties will need to be re-examined as DER and EV uptakes grow;

38.2. Distribution networks will need to be subject to regulatory arrangements more akin to those currently applied to the high-voltage transmission grid, although the possible intractability of centralised monitoring and control of much more granular distribution networks will need to be considered; and

38.3. Since parties other than lines companies will likely play increasingly important roles in affecting distribution network conditions and performance, or will be affected by such conditions and performance, there will likely be greater need for real-time and granular information (e.g. network "heat maps") to be made available more widely about network conditions and resulting investment and business requirements/ opportunities.

5. The Generally Changing Nature of Electricity Regulation

5.1 Shared Regulatory Issues and Pan-Sectoralism

39. As electricity sectors become more reliant on communications technologies, and transport sectors become more electrified, it is easy to see how the electricity, telecommunications and transport sectors will become increasingly inter-dependent. This means sector-specific regulation will have increasingly pan-sectoral impacts – though sector-specific regulatory remits, objectives and skills will likely mean this will involve increasingly unintended consequences.

40. Instead, it can be expected that certain regulatory concerns will become increasingly shared across traditional sectors, and more naturally addressed at a pan-sectoral level. These include:

40.1. Privacy regulation – or rather “unprivacy” regulation, meaning how data from individuals and households can be used to improve product and service offerings, and even be used to “pay” for such offerings;

40.2. Reliability and security of supply – with outages or other supply issues in the electricity sector increasingly affecting the performance of other sectors such as telecommunications and transport, and vice versa;[11] and

40.3. Cyber-security – vulnerabilities in any one of an increasingly number of inter-connected sectors could result in cascading vulnerabilities in others.

5.2 Internationalisation

41. Many of the emerging technologies in electricity, and associated service offerings, will be developed in larger jurisdictions. Especially in those where the imperative to decarbonise electricity supply is more pronounced than in New Zealand (which has an unusually-high level of renewables-based generation compared with other developed economies). And also where larger customer bases present larger datasets and markets for developing and perfecting platforms and algorithms that complement these emerging electricity sector technologies.

42. It is decreasingly likely that New Zealand will be able to take its own path for either technology standards or regulatory approaches. Global technology standards, or at least standards tailored by major producers to major markets, will become increasingly dominant, requiring New Zealand to decide which global standards it wishes to adopt, rather than attempt to dictate idiosyncratic standards.

43. Likewise, globally dominant “tech giants” can be expected to play an increasingly important role in defining both technologies and the products and services supported by them. Regulators in smaller countries like New Zealand risk facing a “tech-lash” if they are unilaterally assertive in defining new regulations. This suggests the formation of regulatory “blocs”, in which smaller countries Like New Zealand cooperate with similar countries, or align themselves with individually-powerful regulators (e.g. the European Commission), in order to influence the design of global regulatory rules.

[11] For example, breakdowns or crashes on transport networks affecting relocations of EVs, and hence of mobile electricity demand and/or supply.

5.3 Forbearance

44. With a quickening pace of technological change, and the disruption caused by the business models they spawn, new regulatory challenges will arise, but traditional regulatory concerns could abate. Among these are concerns about market power abuse in sectors like electricity transmission and distribution, which traditionally have been characterised by large scale economies, few producers, and little prospect of these features changing.

45. Emerging technologies, and disruptive entry by non-traditional suppliers, mean that incumbent firms will increasingly face competition from new quarters. For example, distributors could face reduced demand for electricity transportation due to increasingly distributed and/or self-generation. This means that the trade-offs traditionally made between protecting against market power abuse on the one hand, and facilitating innovation on the other, should become more balanced in favour of the latter.

46. This implies greater reliance on responsive ex post competition regulation, applied as and when problems arise, and less on more prescriptive "set and forget" industry-specific regulation.[12] More generally, it implies greater "regulatory forbearance" – i.e. being less tolerant of regulation inadvertently impeding innovation, while being more tolerant of inadvertently allowing market power to persist. As long as innovation is sufficiently disruptive and consumer-benefitting, such a rebalancing of the risk of regulatory errors is warranted if consumer interests are to be best served.

47. Finally, and relatedly, as the fact of technological change becomes more likely while the nature of such change becomes increasingly hard to predict, this implies electricity regulation needs to look much more like that of other, historically more changeable sectors. Hence, as in telecommunications, regulation intended to combat market power abuse needs at least periodic reviews. Ideally, regulation for both sectors should become more "efficiently dynamic".

48. This means signalling in advance the triggers for future regulatory change, and the objectives to be pursued when implementing any such change. That way consumers, established and entrant producers, and regulators, all have clear shared understandings of how the "rules of the game" will be changed in the future as circumstances evolve, even if the precise rules cannot be predicted in advance. Doing so creates an efficient balance

[12] This is another reason why regulation is likely to become more pan-sectoral (see Section 5.1).

between regulatory predictability on the one hand, and responsiveness on the other, in an increasingly hard-to-predict regulatory and competitive environment.

5.4 Implications for Electricity Sector Regulation

49. Based on this discussion of the generally changing nature of electricity regulation, such regulation should become:

    49.1. More pan-sectoral rather than sector-specific, focusing on regulatory concerns that are increasingly shared across inter-connected sectors, and less confined to traditional "regulatory silos" that risk creating unintended regulatory consequences across sectors;

    49.2. Relatively more international than domestic, with an increasing focus on multilateral regulatory cooperation as an efficient approach for dealing with global regulatory issues being raised by increasingly globally-dominant providers; and

    49.3. More tolerant of inadvertently allowing market power to persist, and less tolerant of inadvertently impeding the innovations that can resolve such market power. It should also become more responsive and less prescriptive, and clearly signal in advance the rules for how regulation will change in the future, if not precisely what future regulation will be.

6. Overall Implications for Electricity Sector Regulation

50. New technologies like DERs will eventually transform the New Zealand electricity sector, particularly as their costs fall, and their consumer benefits become more and more compelling. The traditional "balance of power" in the sector could shift much more towards consumers, or at least towards the firms – disruptors or pro-active incumbents – that aggregate, own and/or control consumer-level technologies.

51. Just as firms and consumers will need to adapt to this changing landscape, so too will electricity sector regulators. The very premise of price-quality regulation of electricity distributors – that it is necessary due to a lack of competition, and little prospect of such competition emerging – needs to be revisited. So too do other legacy regulations that will likewise serve to either accelerate or impede the uptake of emerging technologies, though not necessarily by design. Choices about such regulation need to be made ahead of time,

since simply waiting and seeing amounts to a choice about uptake, just not necessarily the one that best serves consumers' long-term interests.

52. Finally, emerging technologies, business models and players might eliminate the need for existing electricity sector regulation. However they will likely create new rationales for regulation (e.g. data protection) – though such new rationales will increasingly be shared across sectors, and likely addressed at a more pan-sectoral level.

53. Even where existing regulation continues to have a role to play in an increasingly-disrupted electricity sector, it will need to become much more nuanced. This includes a more refined understanding of different consumers' (and prosumers') interests. It also includes regulatory rules that are more lenient than now where emerging technologies alleviate traditional regulatory concerns, but possibly even more stringent than now where they exacerbate those concerns.

54. This is particularly where existing or entrant industry players with market power participate in new, potentially-competitive activities. If that market power is likely on balance to limit consumer benefits, stricter limits should be considered. However, where it is likely to enhance consumer benefits, then greater regulatory forbearance is warranted.

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