ELECTRICITY NETWORK TRANSFORMATION ROADMAP

Interim Program Report

2015–25

energy networks association

A partnership between ENA and CSIRO

Contact details

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FOREWORD

The Electricity Network Transformation Roadmap is an ambitious program. It aims to develop pathways to navigate the critical change in Australia's electricity networks during 2015–25. The goal is to foster innovative electricity systems that focus on better serving the needs and aspirations of future customers.

While the Roadmap program is a partnership between CSIRO and the Energy Networks Association (ENA), it relies on broad stakeholder collaboration to 'co-design' optimal pathways for this transition. Stage 1 of the program has already benefited from the valuable participation of almost 200 customer representatives, supply chain stakeholders and discipline experts.

This Interim Program Report describes the progress of Stage 1 from July to October 2015. It is a foundation for the 2015–25 Network Transformation Roadmap and Industry Transformation Report, which will be developed throughout 2016.

Given the level of broad community and industry engagement so far, we would like to take this opportunity to acknowledge this contribution and extend our sincere thanks to all participants. We look forward to building on this collaboration in 2016.

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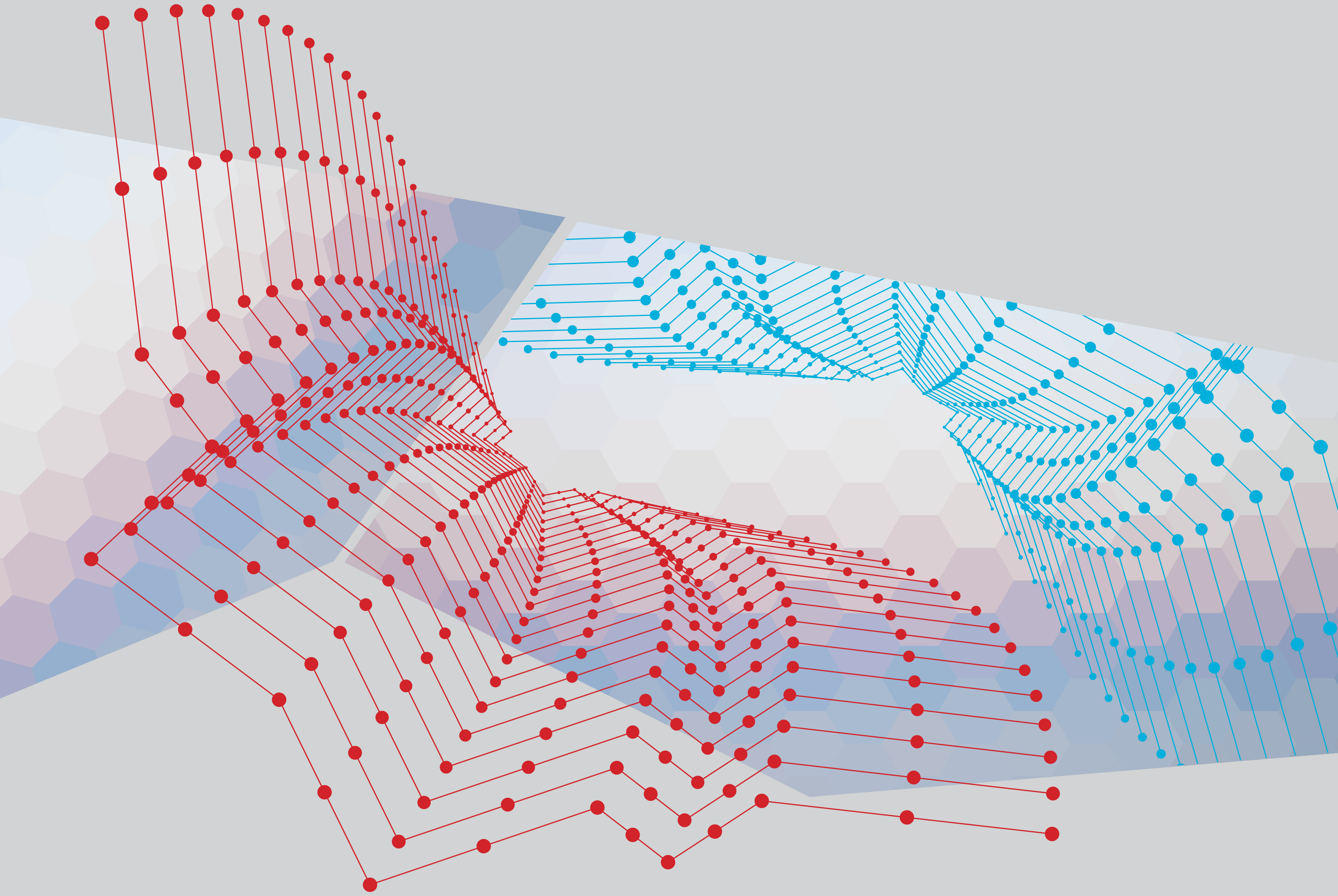


EXECUTIVE SUMMARY

Australians are embracing the future of electricity. We are engaging with new electricity services and technologies at record levels, such that Australia is recognised globally as being at the frontier of key aspects of energy transformation.

Until recently, almost all electricity in Australia was provided by a small number of generation plants and flowed in a single direction to passive consumers who used electricity in largely the same way. Now, in 2015, Australia has the highest penetration rates of rooftop solar photovoltaic (solar PV) systems on the planet; is a global 'test bed' for energy storage market entrants; with a wide range of customers who are diverse in their energy use and level of engagement.

Timely access to safe, efficient and reliable electricity services remains fundamental to modern life. Electricity is critical to our future economic growth and employment, and it enables almost every aspect of our modern lifestyle.

The transformation of Australia's future electricity system is critical to our contribution to mitigating dangerous climate change. We can reduce our emissions from electricity and expand electrification to achieve abatement outcomes in other sectors, including transport.

In other words, electricity systems around the world – and especially in Australia – are experiencing a scale of change perhaps not seen since the dawn of electrification. This transformation is ultimately an expression of changing customer aspirations and new levels of empowerment. It is energy 'transformation' in action, similar to what many other industries – from taxis and accommodation, to newspapers and telecommunications – have experienced over the past decade.

Purpose of the Electricity Network Transformation Roadmap

CSIRO and the Energy Networks Association (ENA) are partnering to develop an *Electricity Network Transformation Roadmap* – a blueprint for transitioning Australia's electricity system to enable better customer outcomes.

Based on long term scenario analysis to 2050, the Roadmap will identify an integrated program of actions and measures that provide the 'pathway' for Australia's energy transition over the 2015–25 decade. The Roadmap will be based on substantial evidence and quantitative analysis. Like the Future Grid Forum undertaken by the CSIRO in 2013, the Roadmap program emphasises broad stakeholder engagement to help 'co-design' and prioritise transition options. The Roadmap program has already benefited from the valuable participation and input of almost 200 customer representatives, supply chain stakeholders and discipline experts.

To ensure value for customers and society more generally, the Roadmap program places customers at the centre of our electricity future. The program adopts five key design principles related to:

- creating new customer value
- proactively informing the evolution of the electricity system, market frameworks and regulatory mechanisms
- providing network businesses with the capacity to change, innovate and lead by building organisational capabilities and collaborative relationships
- enhancing long term asset productivity for both traditional services and new value creating applications
- facilitating industry collaboration and focus on key knowledge gaps and barriers that impede timely and orderly system transformation.

The Roadmap program will be delivered in two stages over approximately 18 months:

- This *Interim Program Report*, released in December 2015, is the foundation for the next stage of detailed empirical analysis to develop the Roadmap.

» The 2015–25 Network Transformation Roadmap and Industry Transformation Report will be released at the end of 2016, synthesising key conclusions and recommended actions, developed after extensive engagement with diverse stakeholders.

Focusing on societal benefits and customer choice for all Australians

The Roadmap is important because some of the alternative future outcomes will be better than others, not only for Australian customers, but the nation as a whole.

To guide the development of the Roadmap, a 'balanced scorecard' has been developed, against which the many possible options will be compared (Figure 1). The perspectives of customer groups and other external stakeholders will continue to play a key role throughout the Roadmap program.

Quantitative analysis of these dimensions of customer outcomes will support the final report. Australia's electricity systems are likely to require up to $1,140 billion in capital and operating expenditure between now and 2050, from 'prosumers', customers who install their own on-site generation, and their service providers.[1] Australia's electricity system must be positioned to achieve optimal outcomes for its customers and society as a whole.

How the Chapters work together

This document is an early reporting point of the Roadmap program, and the different areas of work are at different levels of maturity. The report is therefore broken into major and supporting Chapters. The major Chapters cover the work activities that were the main focus of Stage 1 and made significant progress in 2015. The supporting Chapters cover work activities that also progressed in 2015 but mainly summarise what is known about the topic and provide a sense of direction for Stage 2 of the Roadmap program.

The major Chapters are:

» Chapter 1: Customers at the centre of Australia's future grid

» Chapter 2: What's driving Australia's electricity sector transformation

» Chapter 3: Technical challenges and opportunities of distributed energy resources.

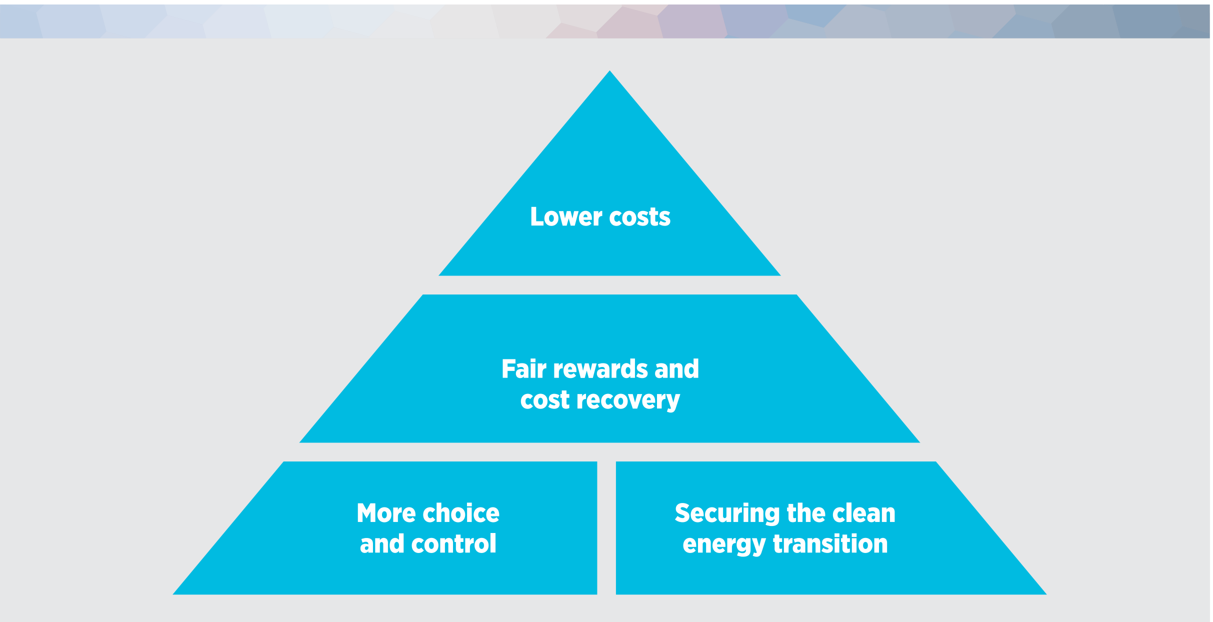
The supporting Chapters are:

» Chapter 4: Business models for an evolving electricity future

» Chapter 5: Price and incentives for a transformed electricity system

» Chapter 6: Priority directions for electricity policy and regulation.

Figure 1: The 'balanced scorecard' of customer outcomes



1 This level of electricity sector expenditure appears large, but amounts to expenditure of approximately $1,000 per capita per annum between now and 2050. This amount is not an unaffordable level of expenditure – indeed household electricity bills are projected to maintain their current share of household income (approximately 2–3 per cent). Rather it demonstrates that even small improvements in electricity sector efficiency can deliver substantial, multi-billion dollar dividends to the economy.

Customers at the centre of Australia's future grid (Chapter 1)

The starting point for the Roadmap program is an exploration of the diverse human needs and aspirations that future electricity systems must serve. The Roadmap deliberately has 'human-centred design' at its heart, rather than a technological or organisational view.

This Chapter describes why customer orientation will be critical for the viability of future energy enterprises. This orientation is particularly critical in a context where business models continue to transform, competitive landscapes keep expanding and new coalitions of market actors are evolving.

The Stage 1 work program explored a range of customer segments in 2025, to provide a plausible basis for analysing electricity solutions that different residential, commercial and industrial customer types are likely to value. This work enables a genuinely customer-oriented exploration in Stage 2 of the diverse functions that network businesses and other market actors will need to perform in 2025 to deliver that value. It also allows an examination of the new levels of collaboration and inter-operability that will be required.

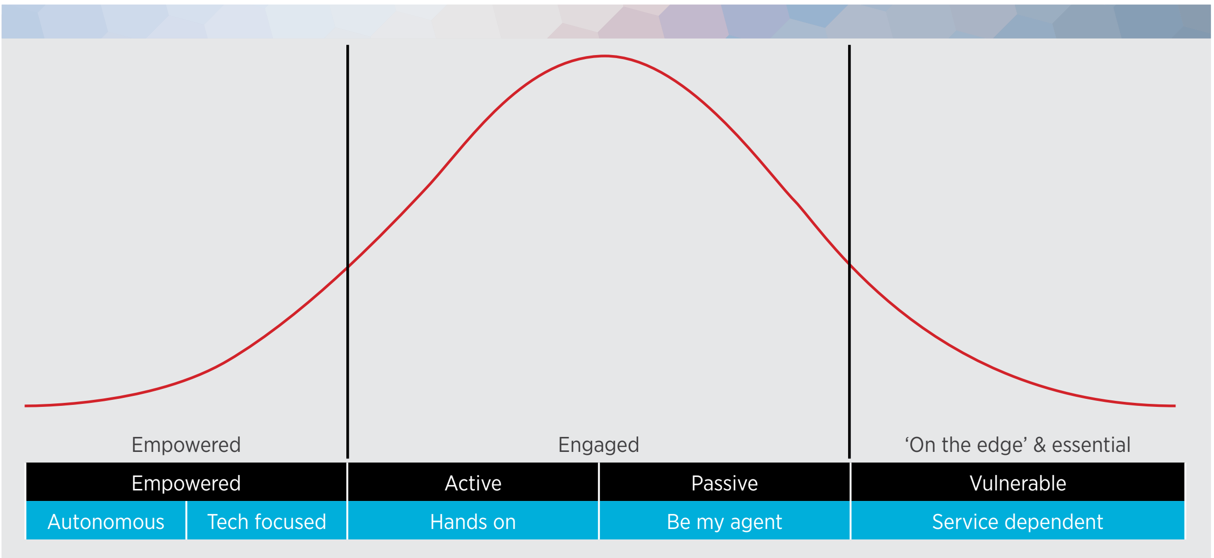
The resulting customer-oriented perspectives will inform all other parts of the Roadmap program.

In several industries, from taxis and accommodation, to newspapers and telecommunications, conventional approaches to service delivery are being upended. This 'disruption' phenomenon is also causing a major shift in how many Australians interact with electricity. The mass adoption of rooftop solar PV and an increasing range of other energy technologies is shifting decision-making power towards residential, commericial and industrial end-users. At the same time, customers value highly traditional service features, including timely access, safety, reliability and quality of supply.

Ultimately, customers exercising their growing energy choice – and not the technologies themselves – are driving this transformation.

The Roadmap therefore gives a high priority to collaborating with a wide range of customer representatives, non-network stakeholders and futures thinkers to explore the services and outcomes that electricity customers may value in 2025. Using global literature reviews, expert reports and structured workshops, a range of plausible 2025 representative groupings (or customer segments) has been developed (Figure 2). These groupings include both residential and non-residential customers, and provide the basis for further analysis.

Figure 2: Example market segmentation curve for residential customers in 2025



Source: Plausible 2025 customer segments were informed by an international literature review, commissioned expert papers and structured stakeholder workshops. In particular, Rosemary Sinclair of Energy Consumers Australia is acknowledged for employing the market curve device to graphically represent customer segments (adapted with permission). For more detail on the process undertaken, see Appendix C: Customer-oriented segmentation.

Table 1 summarises the analysis of future residential customer segments and the types of service that they value most. This report also provides similar assessments for commercial and industrial end-users.

Supported by extensive stakeholder contributions, this analysis provides valuable insights. In summary, Australian electricity customers in 2025 are expected:

- to have different expectations and priorities, and this diversity will not necessarily correlate with income levels, especially as new business models and financing tools evolve
- to continue to value electricity solutions that provide secure and reliable electricity, given Australia's increasingly automated and digitised economy and lifestyle
- in some cases, to value options allowing them to trade off electricity service features that have traditionally been standardised, in exchange for a financial benefit, such as being more responsible for their own reliability of supply (by choosing to install on-site energy storage, for example)
- to compare and contrast competing electricity solutions based on each option's ability to perform the combination of 'jobs' that they uniquely want done (including functional and financial 'jobs' as well as social and emotional 'jobs')
- to want simple, accessible choices, and may prefer bundled products and services that conveniently combine technologies, data access and/or entertainment
- to seek energy solutions that are highly customised and delivered in the emotionally and socially engaging ways that customers already expect from service providers outside the energy sector in 2015.

Given the seminal nature of this analysis, the findings are likely to be tested, reviewed and refined throughout the Roadmap program. Using the new information developed from this work, Stage 2 can examine the following matters from a customer-oriented perspective:

- Which market actors individually and/or in combination will be well-positioned to create and deliver the value that future end-users will expect? How might network businesses and other market actors work together to deliver this future value?
- How can network businesses continually identify competitive opportunities and evolve as organisations to successfully commercialise those opportunities?
- How will network businesses engage and help empower end-users and other market actors to make informed choices?

Table 1: Summary of future residential customer segments based on what they value most

	Autonomous	Tech focused	Hands on	Be my agent	Service dependent
Distinctive features	**Independent**: Wants full control, granular cost management and the ability to configure the operation of the electricity solution. Will often involve disconnecting from the grid entirely, and may be motivated by locational cost or reliability issues.	**Empowered**: Has a strong affinity with technology and desires control. Wants to influence directly the design and operation of the customised solution. System cost is important but maximising returns on investment from trading energy services with the grid is critical.	**Active**: Wants to understand what each available option has to offer and to be involved fully in the selection process. Willing to maintain a moderate to high involvement in the ongoing operation. System cost and return on investment from interacting with the grid to trade energy services are both important.	**Passive**: Prefers electricity solutions that provide ease and convenience at a reasonable cost. Desires an agent to provide a shortlist of options that make sense, are easy to deliver and require a minimum of ongoing involvement. May invest in additional cost saving measures if simple and convenient.	**Dependent**: Needs affordable network services and help to identify the most suitable options. Includes vulnerable customers experiencing energy hardship. Also includes households that cannot adopt new electricity solutions, given rental property constraints or a lack of access to capital.
Common features	All customer segments will value solutions that provide secure and reliable electricity for Australia's modern lifestyle. Some customers may want to trade off some aspects that have been standardised traditionally, in return for a financial benefit. Participation in a given segment is fluid and bi-directional. Households are likely to transition between segments at different stages of the life cycle, either towards greater autonomy or increased dependence. Customer segments are likely to be less affected by income level, as evolving business models and financing mechanisms make complex solutions available to larger proportions of customers.				

What's driving Australia's electricity sector transformation (Chapter 2)

The Future Grid Forum assumptions and modelling of 2013 were updated in 2015 to provide a current view of the complex transformational forces affecting Australia's electricity sector.

Distributed energy resources of many types and combinations will continue to expand customer choice over 2015–25. This expansion will include customers traditionally less able to access distributed energy resources.

Recognising the potential for distributed energy resources to deliver system benefits, updated residential customer bill projections for 2030 and 2050 are lower than 2013 estimates. This fall reflects greater confidence in the ability of demand management technologies and energy storage to moderate peak demand and enhance grid use.

However, the modelling identified that continued growth of distributed energy resources without substantial structural change is likely to undermine the efficiency and equity of Australia's electricity systems.

The Stage 1 work program confirmed that the key drivers of Australia's electricity system transformation – as identified in the 2013 Future Grid Forum report – remain current. It recognised that this transformation was initially driven by the mass adoption of distributed energy resources (in the form of rooftop solar panels), together with broad community acceptance of energy efficiency initiatives. The next decade has potential for subsequent waves of technological and business model transformation, driven by further, widespread adoption of energy storage, electric vehicles and community energy solutions.

Recognising the potential of distributed energy resources to deliver system benefits, the updated residential customer bill projections for 2030 and 2050 are lower than 2013 estimates (Figure 3). This change reflects greater confidence in the ability of demand management technologies and energy storage to moderate peak demand and enhance grid use. In particular, the data for and modelling of the cost, performance and potential adoption of battery storage have improved.

The scenario analysis identifies total system expenditure (including capital and operating expenditure) of $950 to $1,140 billion over the next 35 years. Between $220 and $470 billion is required in on-site or off-grid expenditure by customers and their agents. Significant network expenditure of $280 to $340 billion is also required, which represents about one third of total system expenditure in all scenarios.[2]

Such capital intensive, long-life infrastructure spending highlights the need for policy and regulatory frameworks that ensure infrastructure will be financed and the investment environment is efficient (see Chapter 6).

As they did in 2013, the scenarios show diverse outcomes for total system cost, asset utilisation and customer electricity bills, depending on the complementary investments in centralised services, distributed energy resources, emissions reduction policies and assumed cost and growth trends. Generally, the potential for significant differences in customer outcomes is evident both across and within scenarios, depending on customer preferences, technology adoption and carbon abatement trade-offs (Figure 4).

Scenario 2 ('Rise of the prosumer') may pose significant risks to the efficiency and equity of Australia's electricity systems, for example, as distorted incentives deliver suboptimal distributed energy resource deployment. In this case, residential bills are relatively higher on average in the long run, with stronger disparity between the bills of customers with and without technology (particularly those with and without solar PV).

By contrast, Scenario 4 ('Renewables thrive') illustrates the potential for a near zero emission electricity sector, although at a higher cost than the other scenarios that lessen abatement.

2 While the total system expenditure is a very large number, across the economy this level of electricity sector expenditure equates to approximately $1,000 per capita per annum to 2050. This is commensurate with the current level of expenditure and does not represent an unaffordable quantum. Indeed, as with the previous Future Grid Forum modelling, household electricity bills are projected to remain the same share of household income as they are now, approximately 2-3 percent. Rather it identifies that even small improvements in the efficiency with which the electricity sector operates can deliver substantial, multi-billion dollar dividends to the economy.

Figure 3: Projected average annual residential electricity bills under volume tariffs, by technology ownership and comparison with the 2013 Future Grid Forum projections

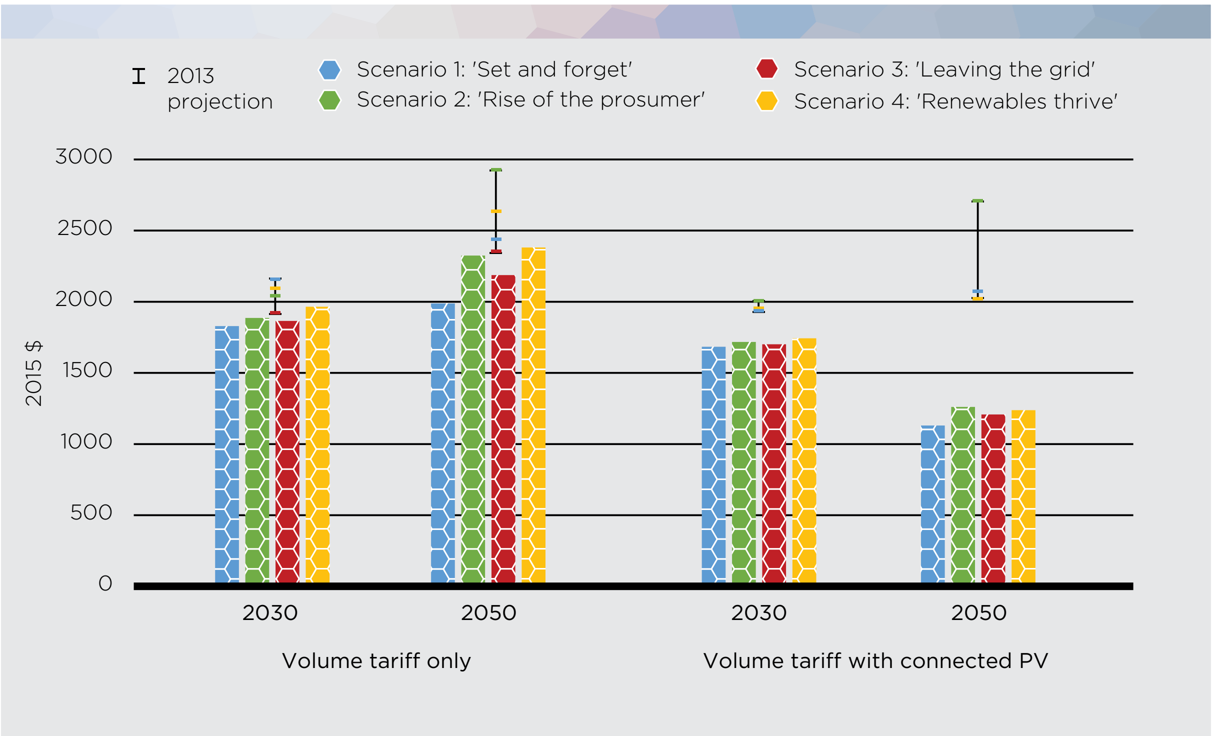
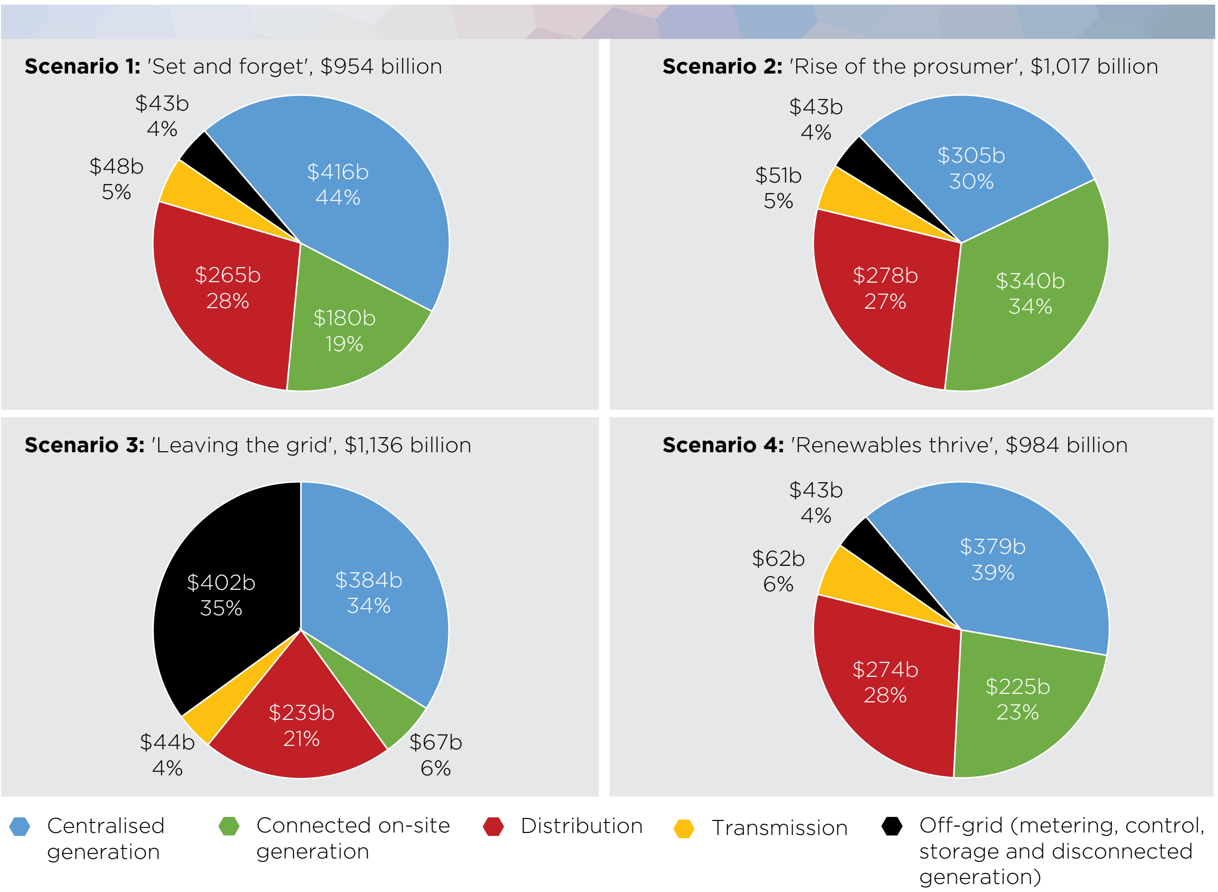


Figure 4: Projected cumulative electricity sector investment and operating expenditure to 2050 (including percentage contribution of each supply chain component), by scenario



Technical challenges and opportunities of distributed energy resources (Chapter 3)

Distributed energy resources can both impose technical challenges on traditional electricity systems and deliver benefits to those systems.

This Chapter assesses how continued growth in distributed energy resources can both negatively and positively impact electricity networks. Effective integration of distributed energy resources can deliver benefits for both customers and the efficient operation of electricity networks. Stage 1 identified integration options capable of providing benefits both now and in the future, along with critical gaps in the current suite of Australian Standards that must be addressed to leverage the full value of distributed energy resources.

Historically, the electricity system was highly centralised in both design and management. However, by definition, distributed energy resources are decentralised in their geographic location, ownership status and operational profiles. The important role of grid-connected distributed energy resources means, therefore, Australia needs to rethink electricity system design and operation.

Distributed energy resources include various forms of distributed generation, both renewable and non-renewable, energy storage systems, demand response systems, electric vehicles etc. This Chapter summarises the challenges and benefits that such resources present to electricity systems. And, recognising the increasingly important role of well-integrated distributed energy resources, it catalogues the negative technical impacts that can arise, and investigates how better integration can deliver positive benefits for both individual customers adopting distributed energy resources and all customers with an interest in the efficient operation of electricity networks.

Stage 1 identified options to facilitate integration, along with critical gaps in the current suite of Australian Standards that must be addressed to leverage the full value of distributed energy resources. Stage 2 of this work program will identify options and pathways that realise fully the customer and societal benefits of better integrating both centralised and distributed resources to dynamically match supply with demand.

Business models for an evolving electricity future (Chapter 4)

Key insights are provided from the recent Accenture review of how transformational forces are impacting network business model evolution. The review, which focused on distribution networks, also considered international case studies and examined future roles and business model options relevant to Australian electricity networks. It noted four broad business model approaches: Platform Enabled, Intelligent Grid, Beyond-the-Meter Services and Information Services.

The most progressive utilities globally are planning multiple evolutions of their business models. Australian electricity networks will need to respond to their own unique circumstances. In other words, there is no 'one size fits all' approach to future business models for electricity networks, and no 'optimal final state' business model suitable for all networks.

Traditional electricity network business models were based on networks (both transmission and distribution) providing a one-way flow of electricity from distant centralised generators to largely passive customers. Electricity was considered an essential service and provided by a regulated monopoly business. However, just as technological systems are transforming, so are the business models, revenue streams and cost structures that underpin them. For this reason, network business models must be able to similarly transform to both deliver the new value desired by future customers and ensure the economic and technical efficiency of networks as enabling platforms.

ENA commissioned Accenture to examine future business model options relevant to Australian electricity networks. At a high level, this work found:

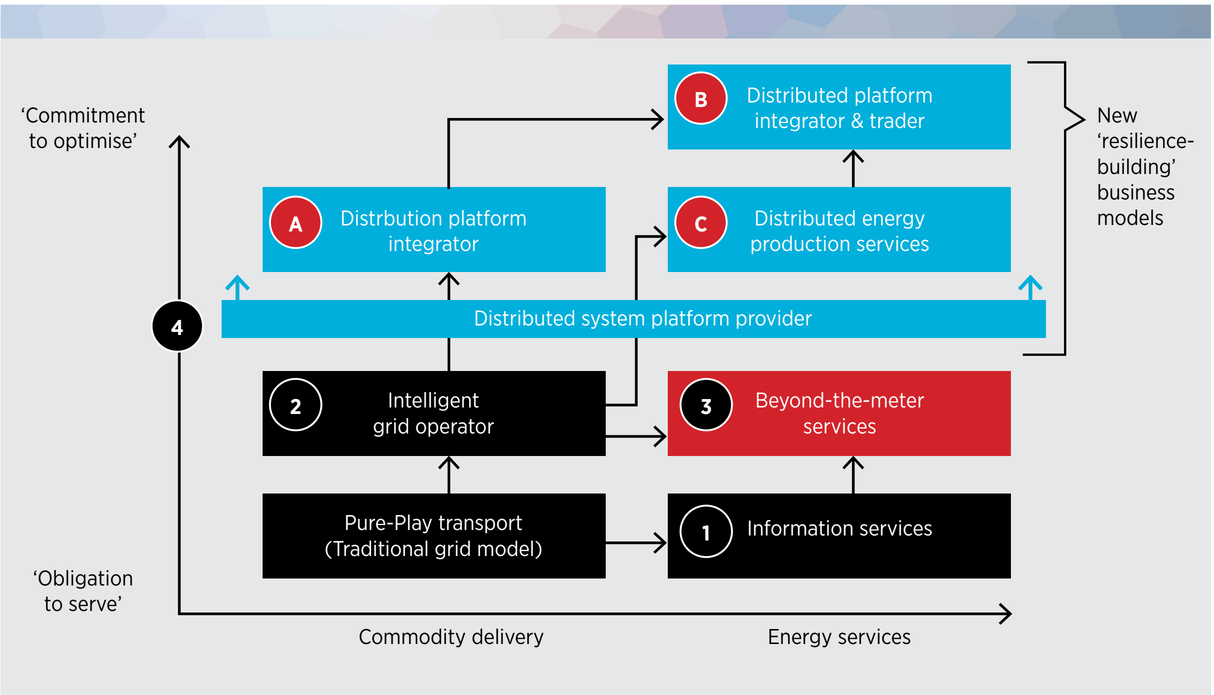
- four broad business model approaches are emerging: Platform Enabled, Intelligent Grid, Beyond-the-Meter Services, and Information Services (Figure 5)
- the most progressive utilities are those planning multiple evolutions of their business model
- there is no 'one size fits all' approach to future electricity network business models, and no 'optimal final state' business model for all networks.

Australian electricity networks will need to respond appropriately to their changing circumstances. Their choice of responses will be influenced by, for example, their location, climatic conditions, geographic spread, customer characteristics and density, demand profile and growth factors, and company structure and skill base.

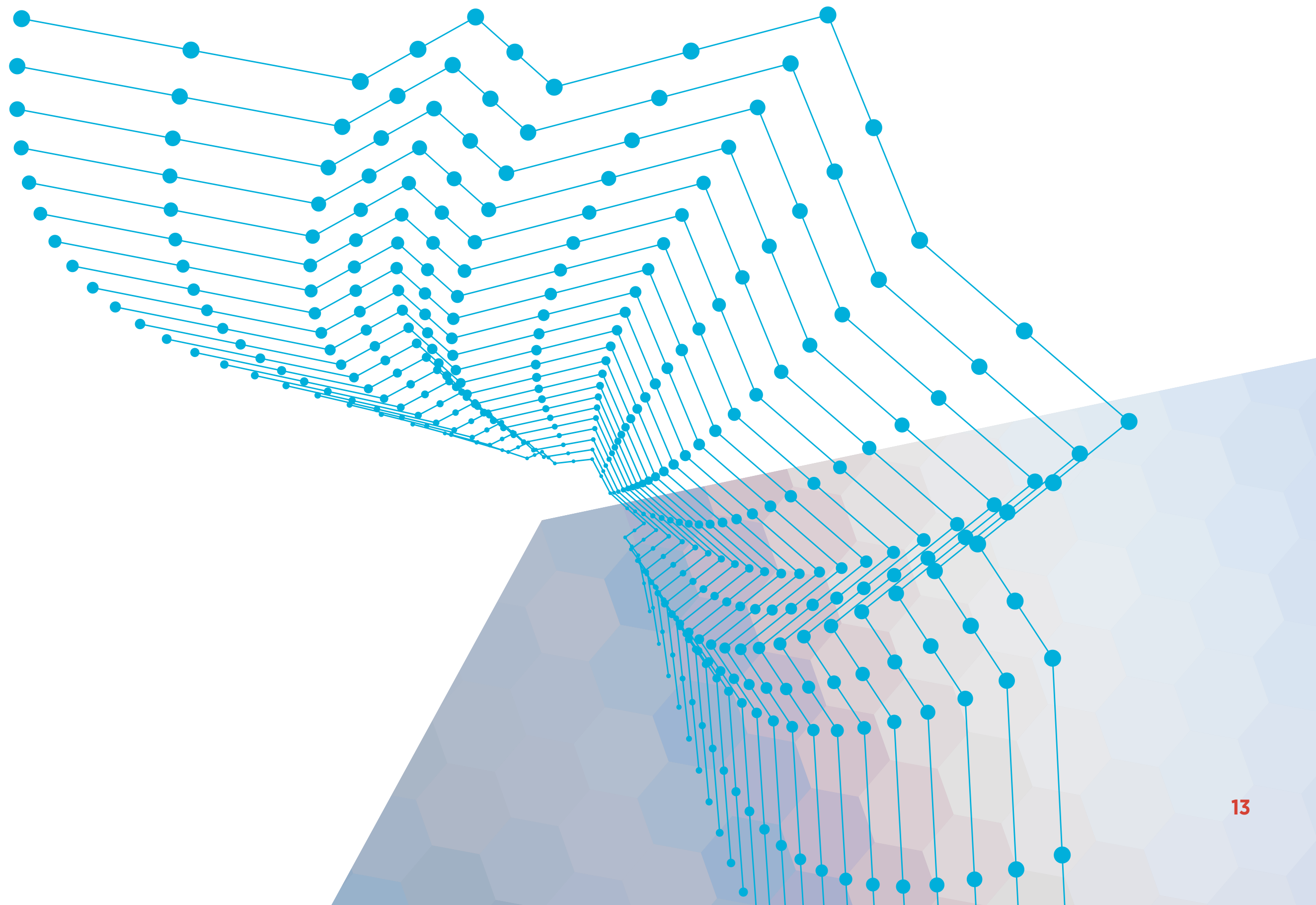
Further business model analysis in Stage 2 will consider:

- what operational flexibility may be available to networks within their current regulatory frameworks
- how to ensure the flexibility of regulatory frameworks is recognised and used to allow timely innovation in network service delivery and customer outcomes
- what, if any, major changes might be needed to allow Australian networks to operate most flexibly in delivering long term value to customers.

Figure 5: Accenture's progressive electricity distribution network business model approaches



Source: Accenture 2015, *Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution*, Accenture, Melbourne, p. 12.



Price and incentives for a transformed electricity system (Chapter 5)

Future electricity systems that empower customer choice in a manner that is both equitable and highly efficient will require new approaches to electricity pricing. That is, electricity pricing and incentives will be critical to delivering a balanced scorecard of societal benefits, not least because they will help customers optimise their own energy production and consumption for shared benefit.

For Australia's network businesses, network tariff reforms are **revenue neutral** – that is, they will govern how network costs are shared among customers, not alter the amount of regulated revenue.

The initial program of tariff reforms planned from 2017 can be thought of as a 'First Wave'. Under these reforms, network service providers will meet their *universal responsibility* to all customers to price network services and share cost recovery in a fair and efficient manner. These reforms will provide improved signals for new service providers, and the full optimisation of distributed energy resources is likely to require a 'Second Wave' of price and incentive reforms through to 2025. This 'Second Wave' will likely offer customers the opportunity to participate in new pricing options or markets, which are likely to be location specific and dynamic in real time.

Stage 1 of this work program has focused on the options for network pricing reform to help transform the electricity network industry. It has also considered how electricity pricing could evolve over the next decade to more fully reflect a two-way exchange of value and services between electricity networks and customers. Further, it has considered the overall structure of future price signals and how more effective network price signals can be reliably transmitted to customers.

The following are among the key findings so far:

» Fairer, more efficient electricity network prices could provide significant benefits by avoiding cross-subsidies (in the short term and the long term) and lowering electricity bills (in the long term). They will also function to incentivise efficient investment in both network infrastructure and distributed energy resources.

» Recent studies estimated that tariff reform could save Australian customers up to $17.7 billion by 2034, from more efficient investment in networks and distributed generation capacity.

» Tariff reform can enable the integration of distributed energy resources without the unintended growth of widespread cross-subsidies of up to $655 per year by 2034. Customers could save up to $250 per year on average residential electricity bills by 2034.

» For Australia's network businesses, network tariff reforms are **revenue neutral**.

In the 'First Wave' of tariff reforms from 2017 (Figure 6), network businesses will meet their *universal responsibility* to all customers to price network services and share cost recovery in a fair and efficient manner. (The First Wave of tariff reforms focuses on recent changes in the rules that require distribution network businesses to develop prices that better reflect the costs of providing services to individual customers. These changes help individuals make more informed decisions about how they use electricity. However, it is also important to recognise the need to improve the signals and incentives that larger customers receive directly through transmission pricing structures). Stage 2 of the Roadmap program will further assess how a 'Second Wave' of medium term price signal reforms can evolve over the next decade to deliver efficient outcomes for customers and the electricity system as a whole.

This 'Second Wave' of tariff reform will be critical to ensure the fair and efficient operation of electricity networks as integrated enabling platforms, as Australian customers either acquire distributed energy resources or access them through community schemes. The more effective the integration of distributed energy resources into the network, the greater is the opportunity to reduce future network costs while ensuring grid resilience and reliability for the ultimate benefit of customers.

To explore this further tariff reform, Stage 2 is expected to:

- assess opportunities and challenges in distribution and transmission network pricing over the medium to longer term
- further evaluate innovative pricing and incentive measures such as locational tariffs; nodal pricing; critical peak pricing or peak time rebates; distributed generation incentives, credits or feed-in tariffs; and transactive energy markets for services (for example, ancillary services)
- look for further applied opportunities to use behavioural economics techniques to enhance network tariff reform implementation, and to practically help consumers understand and respond to network tariffs that reflect the drivers of network costs.

Without prejudging future network considerations, these 'Second Wave' pricing and incentive reforms may most likely occur through consumers' *voluntary participation* and *experimentation* by networks and other service providers.

Figure 6: Two 'Waves' of tariff reform to 2025

First Wave			**Second Wave**
Highly volumetric tariffs	Improved fixed cost recovery	Demand based tariffs	First Wave reform PLUS
FIXED | USAGE (c/kWh)	FIXED | USAGE (c/kWh)	FIXED | USAGE | DEMAND (c/kW)	Voluntary, localised pricing options » Demand management storage tariff » Back-up supply charges » Critical peak pricing » Peak time rebates Voluntary incentive (payment) options » Embedded generation incentives, credits or feed-in tariffs » Ancillary services payments
− Significant cross-subsidies between consumers − Technology adoption (airconditioning, solar, storage) driven partly by cost shifting − No reward to shift consumption off-peak − No 'locational' reward to customers to reduce network costs (through demand management or embedded generation) − No incentive for new energy markets and services	+ Reduced cross-subsidies between consumers + Reduced incentive for technology adoption (airconditioning, solar, storage) to be driven by cost shifting − No reward to shift consumption off-peak − No 'locational' reward to customers to reduce network costs (through demand management or embedded generation) − No incentive for new energy markets and services	+ Minimised cross-subsidies based on customer use of the network + Economic incentives for technology adoption based on contribution to avoided network costs + Reward to shift consumption off-peak − No 'locational' reward to customers to reduce network costs (through demand management or embedded generation) ■ Some incentive for new energy markets and services	+ Minimised cross-subsidies based on customer use of the network + Economic incentives for technology adoption based on contribution to avoided network costs + Reward to shift consumption off-peak + 'Locational' reward to customers to reduce network costs (through demand management or embedded generation) + Incentives for new energy markets and services

Priority directions for electricity policy and regulation (Chapter 6)

Electricity markets, consumer technologies, network business models and energy resources are changing, so it is necessary to think differently about Australia's traditional regulatory framework for electricity networks. For this reason, Stage 1 has developed guiding principles for regulatory evolution over 2015–25 and identified important issues that need further consideration, rather than setting out prescriptive 'answers'.

This Chapter identifies that some elements of the current regulatory framework are robust and will remain relevant, while others are not 'fit for purpose' in the range of expected future scenarios, and they risk delivering poor customer and societal outcomes. It also notes that a regulatory regime that is outpaced by technology and market developments cannot protect consumers or deliver a balanced scorecard of societal outcomes.

Given the pace and scale of change occurring across electricity systems in the developed world, many jurisdictions are reconsidering historical approaches to economic regulation. As a leader in aspects of this global transformation, Australia needs a clear conversation about the purpose and expectations of regulation. It must achieve a coherent framework for defining what is regulated and why, and providing well-defined options for regulating services at different stages of contestability.

In this context, it is also necessary to consider how network transformation could fundamentally change possible risk allocations. To minimise the cost of delivering energy services, for example, the current regulatory framework provides a predictable cost recovery framework. Investors have sufficient confidence to make ongoing investments in long-lived capital-intensive network assets, such as poles and wire. Given the significant expenditure requirements even in decentralised future energy scenarios, changes to the regulatory framework must be assessed carefully against the long term interests of customers. Regulatory frameworks for future network services must foster investor confidence to efficiently finance long-lived infrastructure.

Finally, the Chapter notes that different transition pathways and destinations for regulatory frameworks are viable but expectations and processes need to be agreed upfront. To contribute to this national conversation, Stage 1 has focused on developing and testing a range of guiding principles (see following box) for regulatory evolution over 2015–25.

Stage 2 will examine specific actions that would:

» continue to protect the interests of customers by minimising the cost to finance significant network infrastructure investments in the grid, given its continuing role in delivering essential services, and its emerging role as an active platform for market participation and exchange

» ensure adequate consumer protection measures throughout the energy market transformation

» ensure economic regulation evolves, promoting efficient market participation and service delivery for the benefit of customers.

Proposed design principles for regulatory framework

An appropriate future-ready economic regulatory framework should be:

» **Focused on the long term interests of customers** – Regulatory decisions on remaining regulated services should account for the perspectives and priorities of both current and future customers. They should focus on providing a stable framework for investments that deliver the connectivity and access to bi-directional electricity services that customers value.

» **Flexible and enabling for emerging technology, technology diffusion, new competition and marketplaces** – Efficient competition should be allowed to emerge, with flexible and dedicated processes to recalibrate or remove regulation where appropriate. Rules should be nimble and facilitative, enabling prompt market action.

» **Able to align network incentives with long term customer value** – The regulatory framework should provide clear revenue and profit opportunities for delivering services that create value for customers and market actors.

» **Proportional and bounded** – In an environment of increasing contestability and competition, regulatory intervention needs to be well justified and proportional to the risks of a clearly identified problem. Further, its application should account for the costs and benefits of intervention. Robust independent processes are needed for regularly evaluating the boundaries of competition, considering the full range of costs and benefits.

» **Non-discriminatory** – Network service providers should be free to deliver valued, efficient energy service solutions to each customer. The framework should not be reactive or ‘permission’ based. It should provide a competitively neutral platform that does not pre-define a single ‘ideal’ network business model.

» **Consistent, coherent and knowable for all participants** – Regulatory rules should continue to be consistent across Australia, and they should be predictable, simple, precise and knowable in advance, to facilitate least cost market participation and efficient investment. Regulatory decisions that share risks across networks, debt and equity providers, and customers need to be conscious, consistent with the risk compensation provided in the framework and predictably implemented. Similarly, cost recovery should align with those customers that initiate the system cost.

» **Independent and accountable** – Regulatory rules should be applied and enforced independently, commonly, transparently and accountably (including the rights to reasons and appeal for consumers and businesses whose interests are materially affected).

Key findings of Stage 1

CSIRO's updated Future Grid Forum scenario analysis remains a plausible basis for the Roadmap to identify potential 'no regrets' actions. It indicates the following context:

- Australia faces a broad spectrum of potential energy futures that vary greatly in the adoption of new technology, the mode of customer engagement, and the role of the electricity network.
- Customer bills outcomes are slightly lower than forecast in 2013, reflecting the role of storage in facilitating economic integration of solar PV and other distributed generation.
- Solar PV take-up is dominating embedded generation and tracking to the high end of the 2013 projected share, while battery storage cost trends have further improved.
- The updated scenarios continue to reflect electricity networks performing an evolving range of critical roles by 2050 that support diverse energy use and services for customers.

Potential electricity customers in 2025 are likely to evaluate an expanding range of electricity solutions based on their different needs and desires. Based on anticipated preferences, the following customer segments are plausible in 2025:

Five residential end-user segments across a *vulnerable—engaged—empowered* spectrum. These are Service dependent, Be my agent, Hands on, Tech focused and Autonomous.

Four commercial and industrial end-user segments across an *essential—engaged—empowered* spectrum. These are Vulnerable, Passive, Active and Autonomous.

These segments enable exploration of strategic options and are not meant to be perfect 'predictions' of customers in 2025. It is expected that participation in a specific customer segment will not necessarily be directly coupled to household income or enterprise financial status, as new business models and financing options evolve.

Integration of distributed energy resources will require a careful operational response to challenges such as voltage management, frequency regulation and network stability. However, such resources could also provide the solutions to support network challenges and improve network efficiency. To do so, Australia will likely need regulatory frameworks, enhanced standards and commercial responses that unlock the potential of storage, demand response services and power electronics solutions.

Advanced business model responses by energy networks may focus on 'Platform Enabled' services, supported by *key operating principles* – namely, being able to integrate all types of generation; enabling consumers to provide services back to the grid; offering enhanced or optional services; being agnostic about supply; and facilitating retail markets.

Effective tariffs and incentives will play a critical role in achieving efficient investment, lower average bills and minimising unfair cross-subsidies. A 'First Wave' of reforms will include fixed cost recovery and demand based tariffs. Then, a 'Second Wave' may help customers participate in new pricing options or markets, which are likely to be location-specific and dynamic in real time.

Key elements of **Australia's energy regulatory framework** are robust. However, a managed – rather than ad hoc – approach to regulatory reform is required to support flexibility and innovation, the introduction of contestability, new approaches to risk allocation, and the transition to more fit-for-purpose regulation. Seven guiding principles are proposed.

INTRODUCTION

Australian households and enterprises are integrating old and new ways of engaging with electricity at record levels. Increasingly, the world sees Australia as shaping future electricity systems.

Not so long ago, almost all electricity flowed in a single direction – from relatively few centralised generators to largely passive consumers. A world where millions of micro-generators produced electricity – mostly fuelled by intermittent renewable sources – was inconceivable. Few imagined that millions of future customers – both consuming and selling electricity – would need to be interconnected in a way that continues to ensure reliable '24/7' energy supply at a fair price for all.

Fast forward to 2015, and Australia has the highest penetration of grid-connected, rooftop solar photovoltaic (PV) systems anywhere in the world. In some states, one quarter of all customers now generate electricity. Further, there is reason to believe large numbers of Australians will also adopt energy storage and electric vehicle technologies.

Electricity systems around the world – and especially in Australia – are experiencing a scale of change perhaps not seen since the days of Thomas Edison and Nikola Tesla in the 1880s.

Electricity in transition

New technologies enable this transition, but ultimately it is an expression of changing customer goals, aspirations and new levels of empowerment. It is energy transformation in action, and is similar to the experiences of many other industries over the past decade – from taxis and accommodation, to newspapers and telecommunications.

Powerful trends and technological megashifts are driving this unprecedented electricity system transformation, including:

- increasingly engaged customers
- falling solar PV and energy storage costs
- the impact of energy efficiency initiatives
- renewables policy and carbon abatement schemes
- the transition from one-directional to multi-directional flows of electricity
- issues arising from universal energy access, cross-subsidies and social inequity
- the growing potential for vehicle electrification and microgrids.

These shifts present opportunities and challenges for electricity systems around the world, especially for nations with well-established systems. In Australia, the change involves transforming nationwide integrated electricity networks of almost one million kilometres while they continue to serve 10 million customers. Importantly, change of this magnitude does not impact only physical poles and wires infrastructure. That is, the regulatory frameworks, commercial systems, pricing structures, and supporting control and technological systems that keep Australia switched on 24/7 add complexity to this generational challenge.

Partnering to navigate transition

Australia's electricity systems underpin the nation's modern economy, lifestyle and future prosperity. However, as the CSIRO Future Grid Forum noted in 2012-13, Australia's established electricity systems face complex and unprecedented challenges that have:

> *... the power to affect all links in the electricity supply chain and to encourage new market structures, actors, and business models to emerge. The future is likely to look vastly different from today ...*[3]

The four 2050 scenarios developed by the Future Grid Forum all highlighted that Australia's electricity future is very different from current and historical norms. This set of long term perspectives that are refreshed in this report supports five propositions affirming the need for the Electricity Network Transformation Roadmap program:

1. **Disruptive change is upon us** – All future scenarios see electricity networks continuing to perform critical roles in supporting Australia's modern lifestyle and economy. This critical infrastructure, however, now faces significant and transformative challenges. Many of these challenges are unprecedented and were not anticipated by the architects of current industry systems and processes.
2. **The change is multidimensional** – The transformative forces impacting electricity networks are multidimensional and not solely technological. They represent a convergence of business model, regulatory and societal changes, together with technological shifts. Modern electricity systems function as complex 'ecosystems', so many of these effects must be addressed in a whole-of-system manner rather than a siloed or piecemeal one.
3. **The pace and scale of change may outstrip current change management** – Regulatory change processes are underway, but increasingly, they are at risk of being outpaced by disruptive threats. Regulatory mechanisms were not designed to facilitate the transformative change that may now be necessary. In addition, regulators increasingly expect network businesses to lead their own reinvention rather than wait for external guidance.
4. **A 'critical decade' of transition is ahead** – The implications of the 2050 scenarios for Australia's electricity systems are significant, not least because they diverge from the present. Change is occurring quicker than expected, and on a broader scale. The 2015–25 decade is expected to be a critical window for ensuring Australia's electricity networks are configured and enabled to provide the best outcomes for customers and the nation through to 2050 and beyond.
5. **Agility, collaboration and co-design are needed** – No single player or industry sector can 'engineer' the energy system transformation. To survive and prosper in this context, network businesses, energy institutions and diverse market actors alike need to learn, collaborate and innovate. Structured, whole-of-system collaboration and co-design by all participants is needed.

Recognising the critical nature of electricity for Australia's future, and the need to effectively navigate such generational change for shared societal benefit, CSIRO and the Energy Networks Association (ENA) are partnering to develop the Roadmap. CSIRO is Australia's national science agency, and one of world's most multidisciplinary applied research organisations. It focuses on global energy challenges and delivering evidence based solutions. ENA is the peak national body representing Australia's electricity distribution, electricity transmission and gas distribution businesses. (See Appendix A for more information about Australia's electricity network businesses.)

3 CSIRO 2013, *Change and choice: Future Grid Forum final report*, Canberra, December.

A ‘balanced scorecard’ of societal benefits and customer choice

In such a dynamic context, Australia’s energy future may unfold in many ways. No-one has perfect foresight on what may occur. The Roadmap program was initiated because some potential futures will produce demonstrably better customer and societal outcomes than others will. Many aspects of long term transition cannot be planned and will depend on the forces of innovation, disruption and competition. In this uncertain environment, the Roadmap seeks to foster an operating environment in which Australia’s energy system prioritises serving diverse and evolving customer needs.

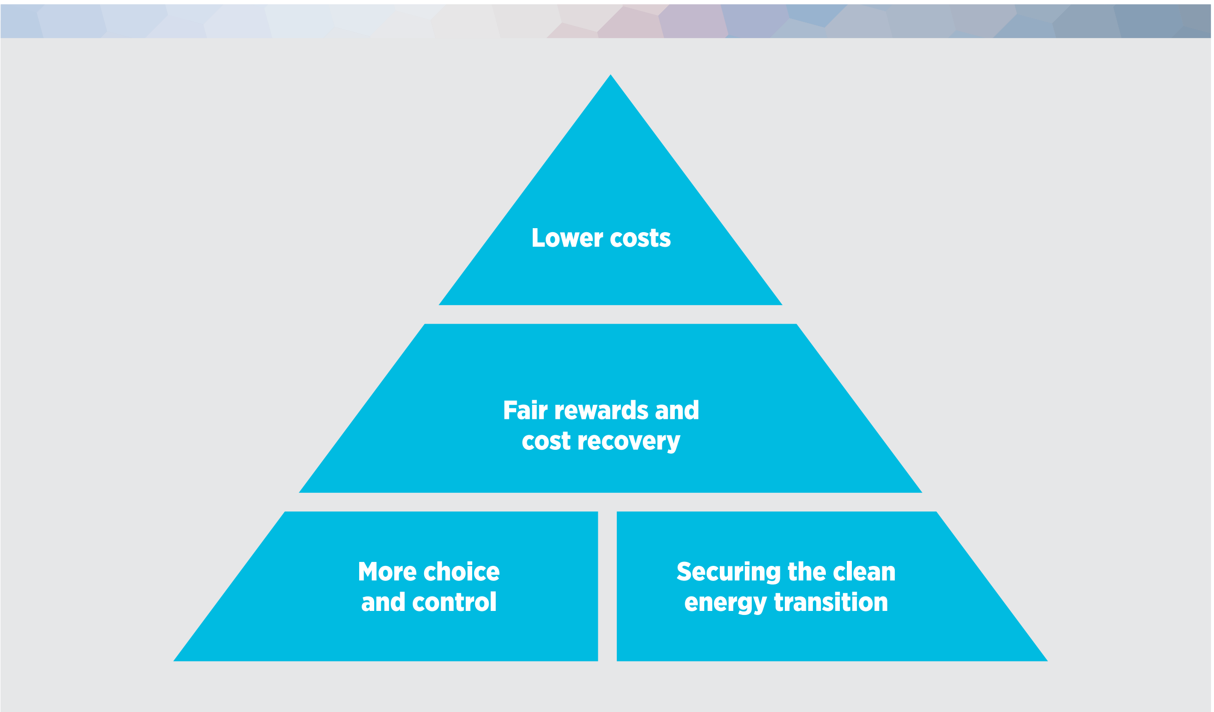
Regardless of their level of engagement, Australians will likely continue to favour electricity solutions that are safe, reliable, affordable and sustainable. Increasingly, future network customers are also likely to have a voice in a ‘negotiated service’ outcome, and reconsider some service features that traditionally were standardised, such as reliability of supply.

To provide a clear focus for developing a Roadmap, the Roadmap program identified a ‘balanced scorecard’ of success measures spanning societal benefits for all Australians (Figure 7). The 2015–25 Roadmap and supporting report are planned for delivery in late 2016. They will outline actionable steps and milestones required over the next decade to develop an operating environment that can deliver better long term customer outcomes into the future.

Together, navigating to a customer-oriented future

The balanced scorecard positions long term customer and societal benefits as the Roadmap program’s key goal. However, no single player or industry sector can engineer the whole-of-system transformation necessary to optimise these societal outcomes. For this reason, the Roadmap program prioritises broad collaboration with customer representatives, service and technology providers, policy makers, regulators and academics. It also seeks to engage industry incumbents and relatively new market actors and service providers.

Figure 7: Roadmap’s balanced scorecard outcomes



While hosted by ENA and CSIRO, the program is committed to participant co-design. Like the earlier Future Grid Forum, the process aims to maximise engagement across industry sectors and disciplines to reduce the silo effect that can hinder meaningful transformation. With the goal of developing a meaningful Roadmap, five design principles inform all activities:

» **Focus on creating new customer value** by empowering service innovation that anticipates and co-creates the solutions that future customers will value.

» **Proactively inform Australia's electricity system evolution** to unshackle Australia's electricity market framework and its associated regulatory mechanisms, and use fully all existing regulatory provisions.

» **Provide network businesses with the capacity to change, innovate and lead their own reinvention** by building organisational capabilities and collaborative relationships that underpin success in a complex and customer-oriented future.

» **Enhance long term asset productivity** by maximising the productive efficiency and resilience of Australia's current $82 billion asset base for both traditional services and new value creating applications for customers and market actors.

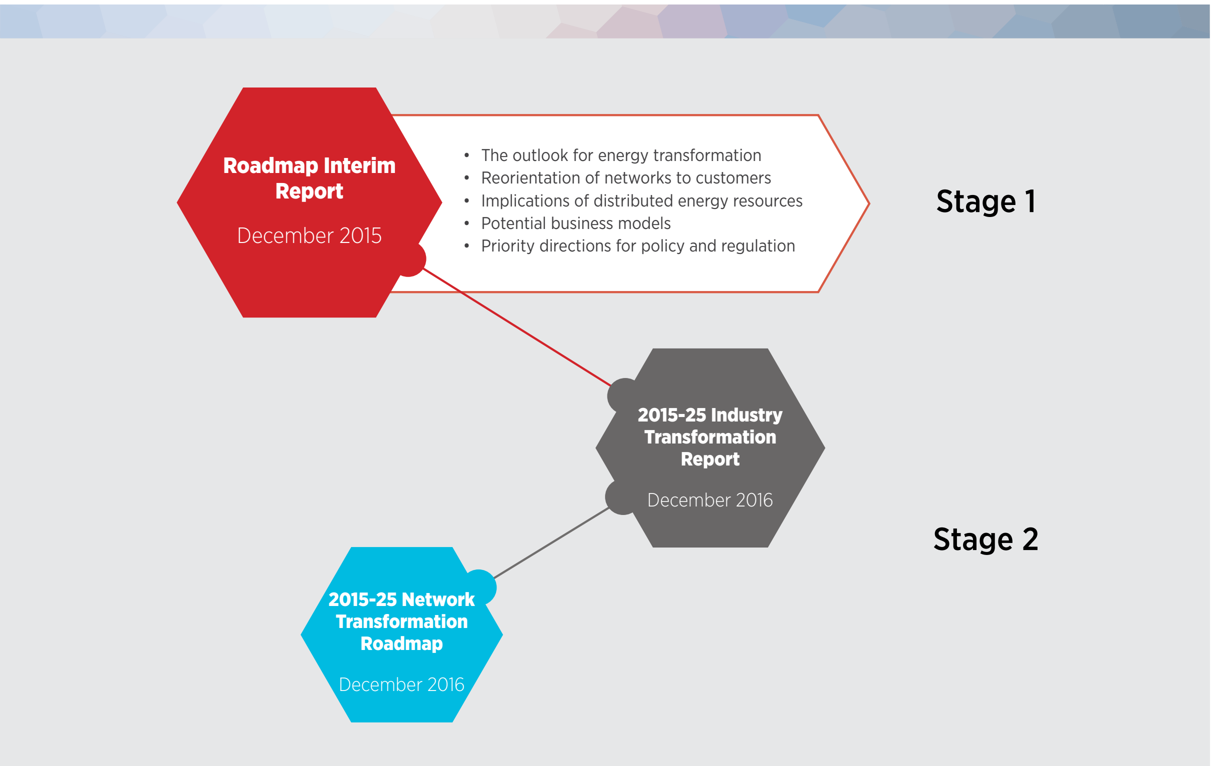
» **Facilitate industry collaboration** to integrate the parallel projects underway in the sector, foster innovation and strategically focus on the key knowledge gaps and barriers that impede timely and orderly system transformation.

By setting out pathways for navigating this transition over the 2015–25 decade, the Roadmap seeks to place Australian customers at the centre and position network businesses, diverse market actors and the entire energy supply chain for the future.

The purpose and structure of this Interim Program Report

The Roadmap program is a two stage process running over approximately 18 months. This Interim Program Report outlines the findings of Stage 1, which ran from July to October 2015 (Figure 8). These Stage 1 findings provide foundational content for the Stage 2 Roadmap development process in 2016. This report also highlights key factors that will be examined in the next phase of work that may be advanced before the Roadmap is delivered.

Figure 8: Key deliverables for Stage 1 and Stage 2



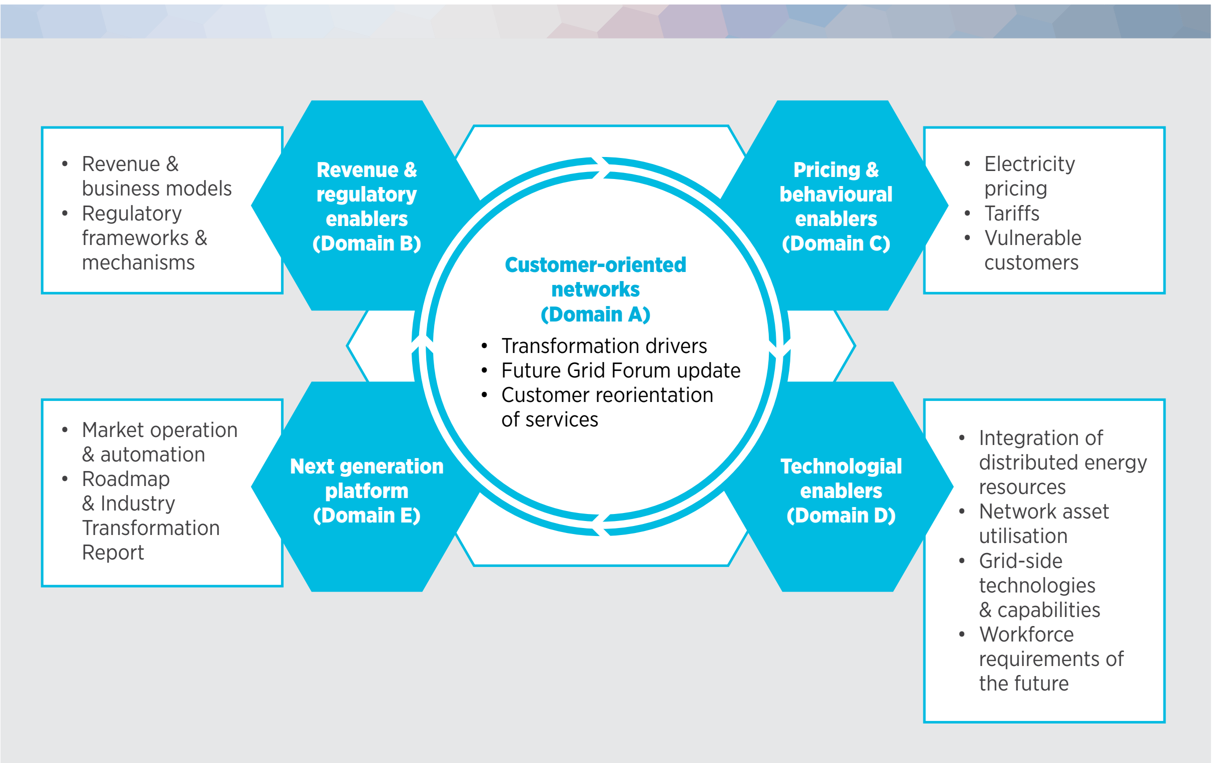
How the Chapters work together

Because this document is an early reporting point of the Roadmap program, and the different work programs are at different levels of maturity, it is broken into major and supporting Chapters. The major Chapters cover the work programs that were the main focus of Stage 1 and made significant progress in 2015. The supporting Chapters cover work programs that also progressed in 2015 but with a primary role of summarising what is known about the topic and providing a sense of direction for Stage 2.

Major Chapters

Chapter 1: Customers at the centre of Australia's future grid begins with the end in view. Rather than starting with a technological or organisational view, the Roadmap program focuses first on the diverse human needs and aspirations that must be the focal point of electricity solutions in a vibrant, free market economy (Figure 9). It summarises why customer-orientation will be critical for the viability of future energy enterprises as business models transform and the competitive landscape expands. It considers the range of likely customer segments in 2025 as the basis for analysing electricity solutions that different residential, commercial and industrial customer types are likely to value (including a focus on affordable and reliable service access for vulnerable customers). This structured view of plausible 2025 customer segments and their respective values and aspirations builds on materials available in the published literature. For Stage 2, it makes possible a customer-oriented exploration of the diverse functions and roles that network businesses and other market actors will need to perform to deliver that value, and the necessary new levels of collaboration and inter-operability.

Figure 9: Roadmap domain and work package architecture



Chapter 2: What's driving Australia's electricity sector transformation summarises the technological and economic forces that are transforming electricity systems both globally and in Australia. It updates the original Future Grid Forum assumptions to provide current quantitative modelling of four plausible scenarios for how these transformational forces may unfold over the period to 2050. This analysis considers electricity consumption, peak demand, network use, and adoption rates of various distributed energy resources across the various scenarios. Importantly, it provides up-to-date perspectives to compare and contrast the societal outcomes arising from the different scenarios. It also provides a quantitative baseline for evaluating the broad range of transition options, which the Roadmap program will consider in Stage 2, against the balanced scorecard of objectives described above.

Chapter 3: Technical challenges and opportunities of distributed energy resources examines both the challenges and benefits that distributed energy resources present to electricity systems. Distributed energy resources include various forms of distributed generation (both renewable and non-renewable), energy storage systems, demand response systems and electric vehicles. Australia's current electricity system was designed and operated as a highly centralised system. By contrast, distributed energy resources are, by definition, decentralised in their geographic location, ownership status and operational profiles. Recognising the increasingly important role of well-integrated distributed energy resources, the Chapter catalogues the technical impacts that can arise and investigates how well-integrated distributed energy resources can deliver benefits for both customers and the efficient operation of electricity networks. It identifies integration options capable of providing benefits both now and in the future, as well as critical gaps in the current suite of Australian Standards that must be addressed to leverage the full value of distributed energy resources.

Supporting Chapters

The transformative forces affecting electricity networks are multidimensional and not solely technological. They represent a convergence of business model, regulatory, pricing and other societal changes accelerated by technological enablers. For this reason, modern electricity systems function as complex ecosystems, so must be addressed in a whole-of-system manner. This approach is critical for supporting future customer preferences and trends (identified by Chapters 1 and 2) in a way that minimises the societal cost of providing energy services to all Australian households and enterprises.

Chapter 4: Business models for an evolving electricity future expands on this whole-of-system view by reporting key insights from a recent review of how current transformational forces affect network business model evolution. The Accenture report considered international case studies and investigated future roles and business model options relevant to Australian electricity networks.

Chapter 5: Price and incentives for a transformed electricity system looks at electricity pricing and incentives necessary to deliver the balanced scorecard of societal benefits. In an increasingly distributed electricity system, where many distributed energy resources are privately owned or function together in community schemes, pricing and incentives will be pivotal to help customers optimise their own energy production and consumption for shared benefit.

Chapter 6: Priority directions for electricity policy and regulation notes Australia needs a clear conversation about the purpose and expectations of economic regulation, given transformational change. The Chapter proposes a set of guiding principles for regulatory evolution over the 2015–25 decade, and sets out important issues for further consideration. A regulatory regime outpaced by technology and market developments cannot protect consumers or deliver a balanced scorecard of societal outcomes.

Appendix A describes Australia's electricity network businesses.

Appendix B contains a detailed overview of the Roadmap program architecture.

Appendix C explains the tools used to develop customer segments.

CHAPTER 1
CUSTOMERS AT THE CENTRE OF AUSTRALIA'S FUTURE GRID

Quick look

- Australia's electricity systems have worked well for many decades. Australians continue to expand their dependence on electricity in an increasingly digitised world.
- How customers use, produce and value electricity services is changing. Increasingly, customers have more choices in how they access electricity, which in turn is driving significant change in how Australia's electricity systems operate.
- To reliably and efficiently serve the nation in the coming decades, electricity networks must understand what future customers are likely to value. Customer-oriented organisations will be most likely to thrive in an increasingly competitive future.
- Using best practice tools, the Roadmap program explored possible future customer types (or segments) in 2025, as well as what different future customer types might value. These segments and value propositions can help network businesses and other market actors transition and identify where change is needed most.
- Any consideration of future customers and what they may value will never be 'perfect'. This work will mature throughout the Roadmap project and beyond. Stage 2 will explore the diverse functions and roles that customer-oriented energy network businesses and other market actors must perform to deliver that value by 2025. It also considers the new levels of collaboration and inter-operability that may be necessary.

What we know

In developed countries, our modern lifestyle would not exist without electricity. Individuals depend on it for clean and reliable water, sanitation, heating and cooling, as well as communication and recreation. People experience and use more and more digital services in almost every aspect of life, increasing their dependence on electricity.

Australians have enjoyed reliable and widespread access to electricity for many decades. In the past, a centralised system supplied almost all electricity, with limited customer involvement. However, more recently, the way customers use, produce and value electricity and energy services has been changing. This transition is still in its infancy, but on many measures, Australia is a global leader of this transformation.

Like other industry sectors – from newspapers to telecommunications and taxis – conventional approaches to service delivery are being upended. In the electricity sector, mass scale solar photovoltaic (PV) panels, energy storage and digitisation offer Australians new energy choices. These changes are shifting decision-making power towards residential, commericial and industrial end-users. This shift challenges traditional electricity business models, but it also presents opportunities for creating new services that future customers will value.

What we're doing

Customers are driving the transformation of the electricity system, so customers' needs and wants must guide efforts to develop a Roadmap of possible transition pathways. Given this, the Roadmap's central foundation has been to study the increasingly diverse uses of the electricity system and electricity services, who future electricity customers are likely to be, and what services and outcomes they will likely value. Specifically, Stage 1 of the program considered:

- What is customer-orientation and why is it important?
- Who are the electricity customers of the future and what are their aspirations?
- What are plausible electricity customer segments in 2025?
- What new value can we create for future electricity customers?
- What value are end-user customers likely to expect from future electricity solutions, and how will this differ between segments?

No single industry participant can 'engineer' the energy system transformation. Further, there is limited publicly available literature that systematically considers the solutions *future* electricity customers may need and value. So, a high priority has been given to collaborating with a range of stakeholders to explore the outcomes that electricity customers may be seeking in 2025.

Stage 1 of the Roadmap program established an understanding of what people and institutions might value from electricity in 2025 based on insights from overseas, expert reports and structured workshops. Over 100 participants – customer representatives, technology providers, industry experts, government and other energy value chain actors – collaborated on this work aided by the following six step process:

1. Stakeholder 2025 visions – At a full day workshop in August 2015, customer representatives and non-network leaders shared their visions for electricity solutions and relationships in 2025. Network representatives considered diverse perspectives on what end-users would value in the future.
2. Global literature review – CSIRO reviewed and synthesised a range of international literature and sources to develop a 'first cut' of plausible future customer segments, to test and refine at subsequent workshops.
3. Expert papers – CSIRO commissioned three expert discussion papers to provide North American, European and global perspectives and to help fill gaps in the literature.
4. Workshops and Best Practice Tools #1 – The 'first cut' of plausible future segments were workshopped by over 70 stakeholders using the 'Jobs to be Done' method, to anticipate future needs and aspirations across residential, commercial and industrial end-users.
5. Workshops and Best Practice Tools #2 – A second set of workshops considered the likely customer needs and aspirations, using the 'Value Proposition Design' method. Participants explored how individual electricity solutions and value bundles may evolve. Appendix C provides more information about this process.
6. Analysis, synthesis and review – CSIRO developed working papers, which participants reviewed and refined in iterative loops. This report is based on the final content from these working papers.

What we're learning

What is customer-orientation and why is it important?

Customer-orientation and customer-centricity are largely synonymous. Both terms pursue enduring value and competitive advantage by placing customer needs and aspirations at the heart of what an organisation does. It is an intentional way of thinking, being and acting corporately (Box 1.1).

Box 1.1: Google's approach to customer orientation

Google is changing the world by creating a pipeline of valuable new services and disrupting older ones. Customer-centricity is at the heart of its corporate values and culture. The first of Google's *Ten things we know to be true* begins:

1. Focus on the user and all else will follow:

   Since the beginning, ***we've focused on providing the best user experience possible***. Whether we're designing a new internet browser or a new tweak to the look of the homepage, ***we take great care to ensure that they will ultimately serve you***, rather than our own internal goal or bottom line…

While the practice of customer-orientation will differ between organisations, international analysis indicates customer-oriented organisations are likely to demonstrate five capabilities. Specifically, these organisations prioritise:

» **External focus** – Foster an external focus that is at least as equally important as the focus on internal organisational processes.
» **Customer knowledge** – Know who the organisation's customers and value chain participants are and continually listen to them.
» **Task appreciation** – Beyond listening, observe and comprehend the (evolving) tasks that customers and value chain participants want help with.
» **Solution pipeline** – Create a pipeline of solutions and experiences that fit with customers' evolving needs.
» **Organisational ambidexterity** – Integrate traditional core services (and service improvements) with the pipeline of new solutions and experiences that meet evolving customer needs.

Importantly, refocusing an organisation around serving customer needs and aspirations also underpins commercial vibrancy and longevity. Internationally, there is growing recognition of the strong linkage between an organisation's ability to create new customer value and the growth of shareholder value.

Kagermann (2011) notes:

» Customer satisfaction is correlated with increased 'share of wallet', improved customer retention and therefore cash flows, positive word of mouth, and other benefits. The research found a one point gain in customer satisfaction using standard metrics correlated with a 2.75 per cent gain in shareholder value.[4]
» More recently, customer satisfaction metrics have been used to guide portfolio creation. The customer-satisfying portfolio outperformed groups of companies with either low or decreasing customer satisfaction scores. In both cases, positive customer experiences affected the bottom line and stock market performance.[5]

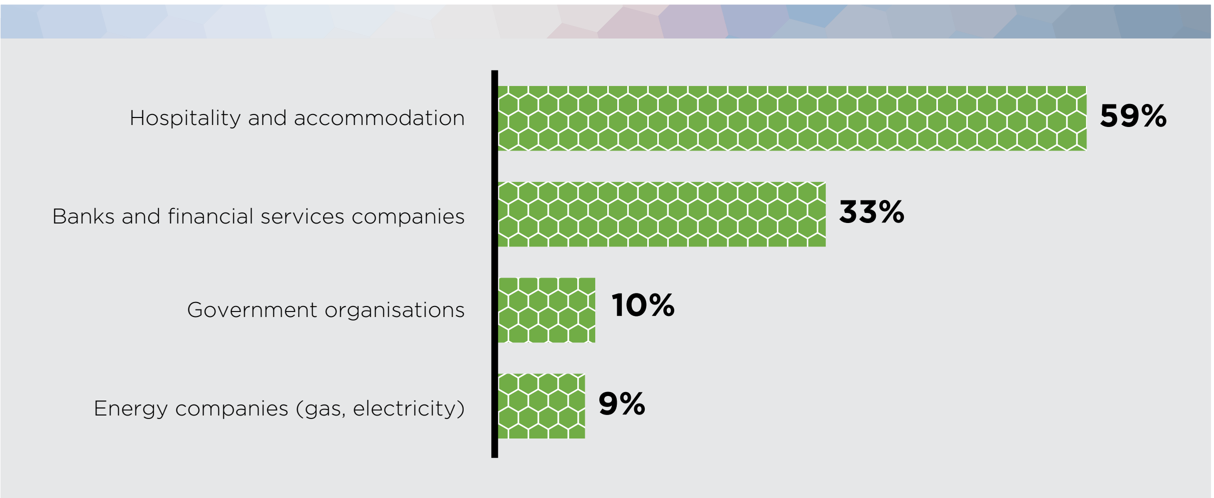
Other business strategists, operating in what is becoming known as the 'experience' or 'expectation' economy, support such findings.

Why is customer-orientation important in an increasingly competitive landscape?

The 21st century has been characterised as the 'disruption generation'[6] illustrating the many unprecedented competitive forces confronting traditional industries and supply chains.

Globally, energy companies do not rank highly in terms of customer service when compared with other industries (Figure 1.1). Further, the traditional roles the electricity system performed have remained largely unchallenged for decades.

Figure 1.1: Fairfax customer survey on industries providing best levels of customer service



Source: Financial Review Business Intelligence 2014, *Australian consumer study*, cited in Accenture 2014, *The balance of power; Why Australian utilities need to defend, delight and disrupt,* Accenture, Australia, p. 4.

4 Anderson, Fornell and Mazvancheryl 2004 in Kagermann, H *et al*. 2011, *IT driven business models: Global case studies in transformation*, John Wiley & Sons, New Jersey.
5 Asksoy 2008 in Kagermann, H *et al*. 2011, *IT driven business models: Global case studies in transformation*, John Wiley & Sons, New Jersey.
6 *The Australian*, 'Uber lessons in disruption', 5 January 2014.

However, disruptive forces motivate network businesses to focus on delivering what future customers will value. New energy technologies, business models and digitisation are driving what has evolved into a battle for the hearts and minds of electricity customers.

New energy solutions may complement or replace grid connection and are often promoted by agile new market entrants. These new products and players challenge incumbent organisations like traditional network businesses:

- Incumbents are organised to deliver functional efficiency whereas new entrants are organised to be close to their customers, which allows 'step-change' new innovations.
- Incumbent organisations incrementally improve existing processes and products whereas new entrants innovate services, solutions and experiences.
- Incumbent organisations operate within historically-defined boundaries whereas new entrants invent new boundaries, or find ways around existing boundaries.
- Incumbent organisations tend to be vertically integrated and/or provide most services internally whereas new entrants build open external networks and strategic partnerships.
- Incumbents improve existing touch points whereas new entrants create entirely new ones.[7]

To survive and thrive in an increasingly competitive landscape, organisations need to refocus on their customers' needs and aspirations (a demand-side focus) rather than their historical or existing products and services (a supply-side focus). That is, they focus on the *outcomes* customers seek to realise by interacting with their product or service.

It is difficult to predict the new energy innovations that customers will require. Some innovations may even seem surprising and counterintuitive. It is likely each network business will behave differently, depending on its operating environment and on the future business model it adopts (see Chapter 4).

It is also unlikely a single business will accommodate customers' needs on its own. Rather, the business will need strategic partnerships with other service providers and suppliers. Together, they may create an integrated 'value-network' that seamlessly delivers customised offerings to individual end-users.

How does customer-orientation relate to rebuilding social licence?

The social licence to operate of many energy system incumbents has eroded in the past 5–10 years. Social licence to operate is the level of acceptance or approval local community and other stakeholders continually grant to an organisation's operations.[8]

Some customers feel they cannot control electricity costs. Others may not understand what they represent. Both results foster a lack of 'permission'.[9] Some customers perceive energy networks are 'not on their side' and are not convinced they get value for money.[10] So more customer-oriented network businesses will better prioritise their operations and communications, to maximise community acceptance and build and sustain social licence to operate.

Social licence to operate consists of three levels of engagement:

1. legitimacy to operate
2. credibility to provide reliable information and honour commitments
3. trust created by building common or shared experiences (Figure 1.2). According to De Martini (2015), as well as fostering the ability to compete effectively, organisations establish social licence to operate by providing superior value options for customers.[11]

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7 Cashion, M (Palladium) 2015, *Strategy in the age of disruption*, CSIRO/ENA Network Transformation Roadmap Customer-Orientation workshop, Melbourne, 3 September (adapted).

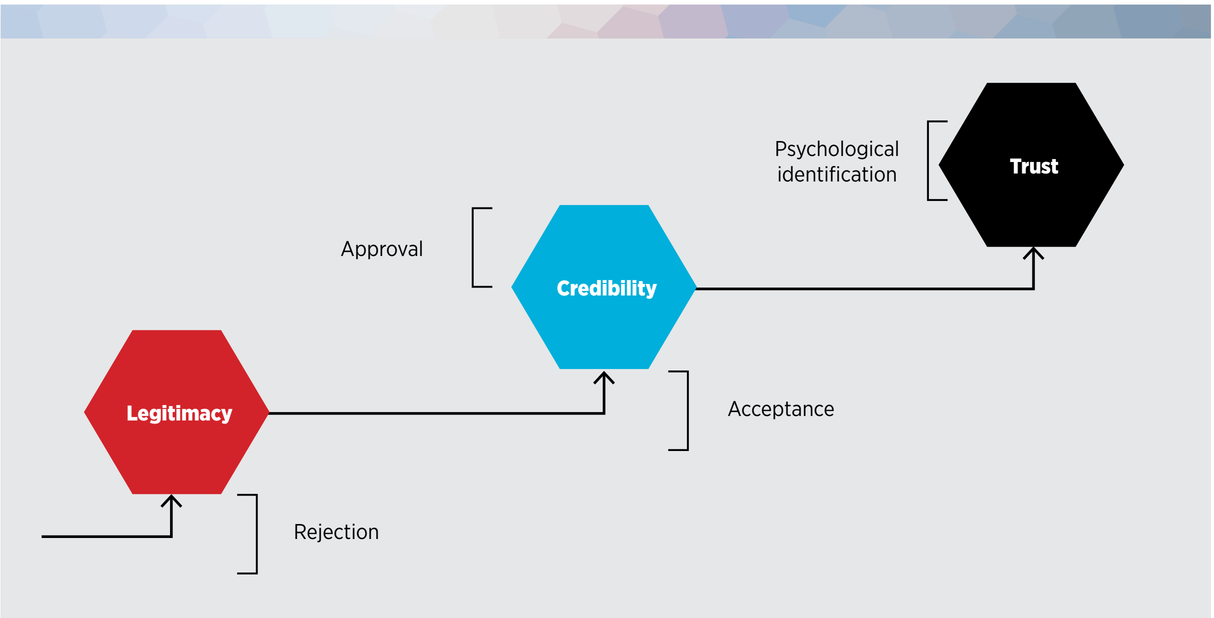
8 Thomson, I and Boutilier, R 2011, 'The social license to operate', in Darling, P 2011, *SME mining engineering handbook*, pp. 1779–96, Society of Mining Engineers, Littleton Colorado, cited in Newland, P (Balancia) 2015, *CSIRO global literature review,* CSIRO, United Kingdom, p. 65.

9 Van Gils, B 2014, as cited in Probert, T 2014, *Customer dislike for utilities is universal but can change* (www.intelligentutility.com/article/14/05/customer-dislike-utilities-universal-can-change), cited in Newland, P (Balancia) 2015, *CSIRO global literature review*, CSIRO, United Kingdom, p. 66.

10 Sylvan, L 2015, *Customer focused energy networks – what will success look like?*, ENA Regulation Seminar, Brisbane, 5 August.

11 De Martini, P 2015, *Customer oriented networks – A North American perspective*, Newport Consulting Group, California.

Figure 1.2: Hierarchy of social licence to operate



Source: Thomson, I and Boutilier, R 2011, 'The social license to operate', in Darling, P 2011, *SME mining engineering handbook*, pp. 1779–96, Society of Mining Engineers, Littleton Colorado, cited in Newland, P (Balancia) 2015, *CSIRO global literature review*, CSIRO, United Kingdom, p. 65.

Will customer satisfaction be enough for the future success of network businesses?

De Martini (2015) suggests that customer satisfaction is not enough in the increasingly competitive operations of the future, as customer choice increases and the prices of alternatives fall. Importantly, he argued it is a common mistake to measure customer 'satisfaction' and assume it is a proxy for customer loyalty:

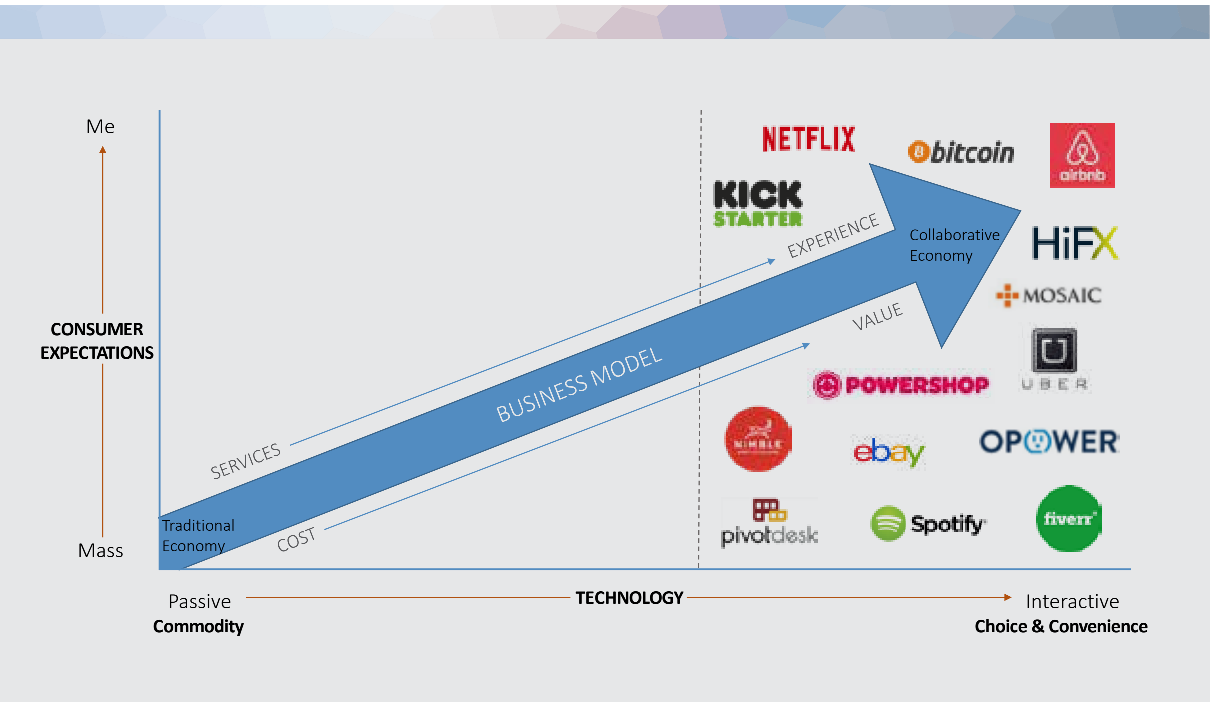
> *Customer satisfaction is not a measure of loyalty – meaning that high customer satisfaction doesn't mean a customer won't choose another alternative when given a choice. As such, loyalty may be a better measure to assess the future relationship with customers in the context of new business options. A key loyalty issue today is whether customers believe that 'my utility does what's right for me even if it's not best for them'.*[12]

Electricity network businesses must take opportunities to serve increasing customer needs and desires to remain relevant to customers. Alternative energy technologies and digitalisation trends are producing better informed customers with higher expectations (Figure 1.3). In the future, successful energy solutions must match the experiences and value that customers expect from other industries. Hence, energy networks facing disruptive forces must focus on customer empowerment.[13]

12 De Martini, P 2015, *Customer oriented networks – A North American Perspective*, Newport Consulting Group, California.

13 De John and van Dijk 2015, 'Disrupting beliefs: a new approach to business model innovation', in *McKinsey Quarterly,* vol. 3, 2015.

Figure 1.3: Future energy trends (expectation and technology)



Source: Sinclair, R (Energy Consumers Australia), 2015, *Future energy customers,* CSIRO/ENA Customer-Orientation workshop, Melbourne, 11 August.

The Roadmap program is developing a Consumer Engagement Handbook. The Handbook will support network businesses' current efforts to ensure a customer-oriented future.

As part of the Better Regulation Reform Program, the Australian Energy Regulator (AER) released a Consumer Engagement Guideline for Network Service Providers in 2013. The guideline provides principles and a framework for electricity and gas network service providers to better engage with their consumers. The guideline aims to help service providers develop consumer engagement strategies and approaches to apply across their business, and also to help them prepare spending proposals that reflect consumers' long term interests.

In 2014, ENA member businesses agreed to 'develop and publish a set of industry endorsed customer engagement best practice guidelines that provide practice guidance to network businesses for engaging with customers.' This agreement reflects one of the network industry's responses to the AER's new consumer engagement requirements (Box 1.2).

Box 1.2: Consumer Engagement Handbook

Developed in collaboration with a wide range of customer representatives and informed by CSIRO social science expertise, the Consumer Engagement Handbook goals are to:

- **Provide best practice guidance to ENA member businesses for engaging with customers** – The Handbook will not duplicate the AER engagement guideline, but will complement and build on it (and other guidelines) to help network businesses plan, execute, evaluate and continuously improve their engagement activities.
- **Strengthen relationships with customers and consumer groups** – The Handbook will support network businesses' engagement activities, provide transparency around engagement processes and goals, and address stakeholder expectations about engagement.
- **Support the use of performance measurement and indicator tools in engagement activities** – The Handbook will identify meaningful performance measures, promote consistency in metrics used across businesses and activities, and allow businesses to track their engagement performance over time.
- **Provide the opportunity for continuous learning and evolution of engagement activities** – The Handbook will provide a foundation for ongoing information sharing between network businesses and continuous improvement in their engagement activities.
- **Leverage and expand the relationships between networks** – The Handbook will enable and encourage collaboration between network businesses to maximise efficiencies and effectiveness of their engagement.

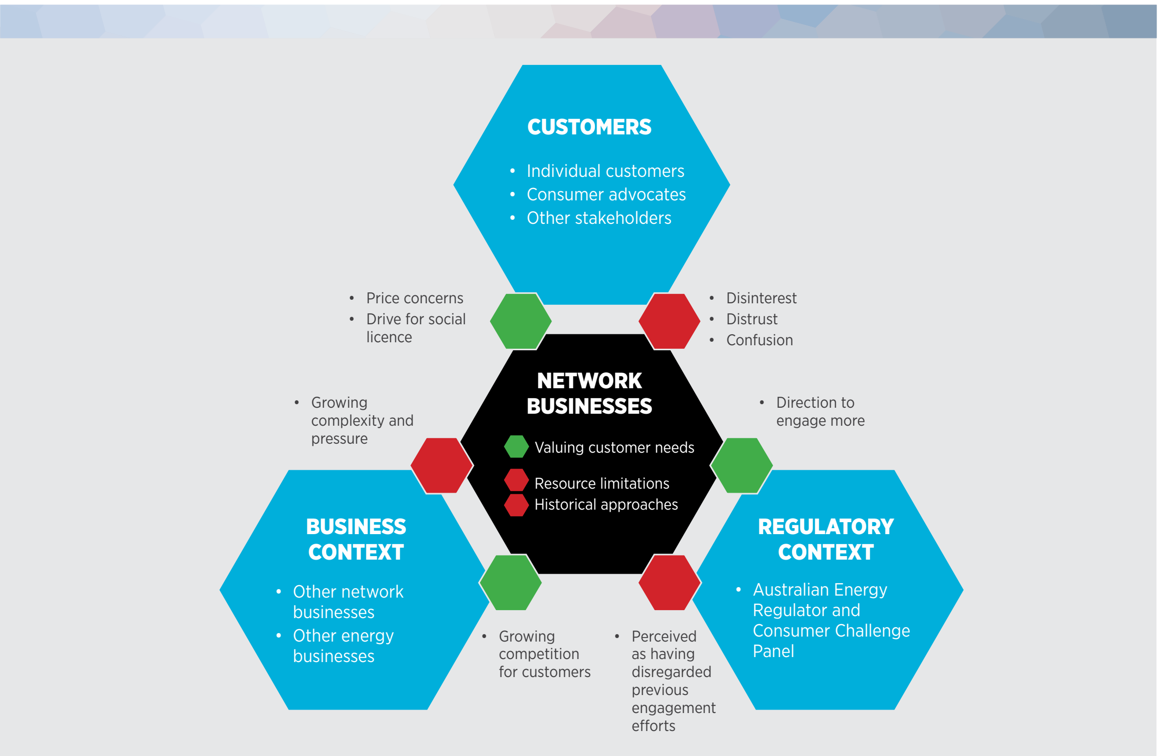
What we're learning

A background literature review and engagement conducted to date with network businesses and customer advocacy and engagement representatives identified competing pressures that network businesses experience when they engage customers and other stakeholders.

What the Handbook needs to do

The Handbook will outline consumer engagement principles, consumer engagement definitions, specific engagement examples, and performance indicators and other supporting metrics.

Competing pressures on network businesses to engage more (green links) and less (red links)



Who are the electricity customers of the future and what are their aspirations?

Most literature and industry work on customer segmentation reflects a current state perspective, rather than a longer term perspective more relevant to 2025. At the highest level, end-user customers have typically been categorised as:

» residential consumers
» small to medium enterprises (SMEs)
» commercial and industrial customers (C&I).

Moving into this period of industry transformation, it is necessary to expand the definition of network customers to include:

» traditional end-user consumers (residential, commercial and industrial) who primarily receive electricity from network businesses
» end-user 'prosumers' who both consume and supply electricity services, some of whom may disconnect from the network periodically or permanently
» new and existing service providers and other market actors who function as a 'value network', collaborating and/or competing with network businesses to provide diverse energy and other solutions to end-users.

Stage 1 focused on understanding what future end-user customers are likely to value. This end-user perspective is critical for Stage 2, which explores how market actors may collaborate and/or compete with network businesses to deliver what end-users value in 2025.

What future end-users will value

There is a body of literature about electricity business model transformation and technological evolution. Some of this research identified the various sources of value in the existing electricity system that can be unlocked and shared with customers, who provide benefits back to the network. While providing some insights into the future, these perspectives tend to focus on the *supply-side* of the system.

Consistently successful corporations, however, focus on what customers (the *demand-side*) are trying to achieve when developing new solutions. Empathy is the centrepiece of 'human-centred design' championed by leading solution developers such as Apple, IDEO, Proctor & Gamble, Google and Tesla Motors. Harvard's Professor Ted Levitt summarised this approach by noting that: 'People don't want to buy a quarter-inch drill. They want a quarter-inch hole!'[14] That is, understanding the 'hole(s)' that different customers are trying to achieve must be the starting point for shortlisting the 'drill' options that could be developed.

Energy service providers must not only listen to customers; they must also anticipate what customers may value and develop new markets through experimentation. Service providers cannot expect the majority of time-poor customers to scan potential technology developments and proactively identify their future service requirements. Most customers do not effectively anticipate what future technologies they will value: which Nokia owner anticipated the iPhone in 2003, for example? Henry Ford also understood this, apparently saying '… even if I had asked my (potential) customers what they wanted, they would have said faster horses'.

Plausible electricity customer segments for 2025

There is a risk any new customer segmentation exercise will only build on current customer expectations or experiences.[15] But, the 'Jobs to be Done' method helps to anticipate the expectations, needs and demands of future customers often before customers fully realise them.[16] Specifically, these tools help to conceptually develop, field test and refine a pipeline of new solutions targeted to the customers' emerging expectations.

14 Christensen, Cook and Hall 2005, 'Marketing malpractice: the cause and cure' in *Harvard Business Review*, December.
15 Christensen, Cook and Hall 2005, 'Marketing malpractice: the cause and cure' in *Harvard Business Review*, December.
16 For an explanation of the method, see Osterwalder, A *et al*. 2014, *Value proposition design*, Wiley & Sons, New Jersey.

Commentators agree grouping customers into value based segments is one of the most effective means of anticipating customer behaviours and preferences.[17] Characteristics derived from this approach provide a firmer basis for network businesses to prioritise, create and target the most suitable products and services to different segments.

The Roadmap program applied these considerations to produce the future customer segments outlined below. These segments are ‘plausible hypotheses’, not attempts at perfect predictions. Their primary purpose is to assist analysis that anticipates what different groups of customers may value in 2025.

Appendix C illustrates the process used to develop initial segment groupings and characteristics for ‘Jobs to be Done’ analysis.

Residential end-user customer segments

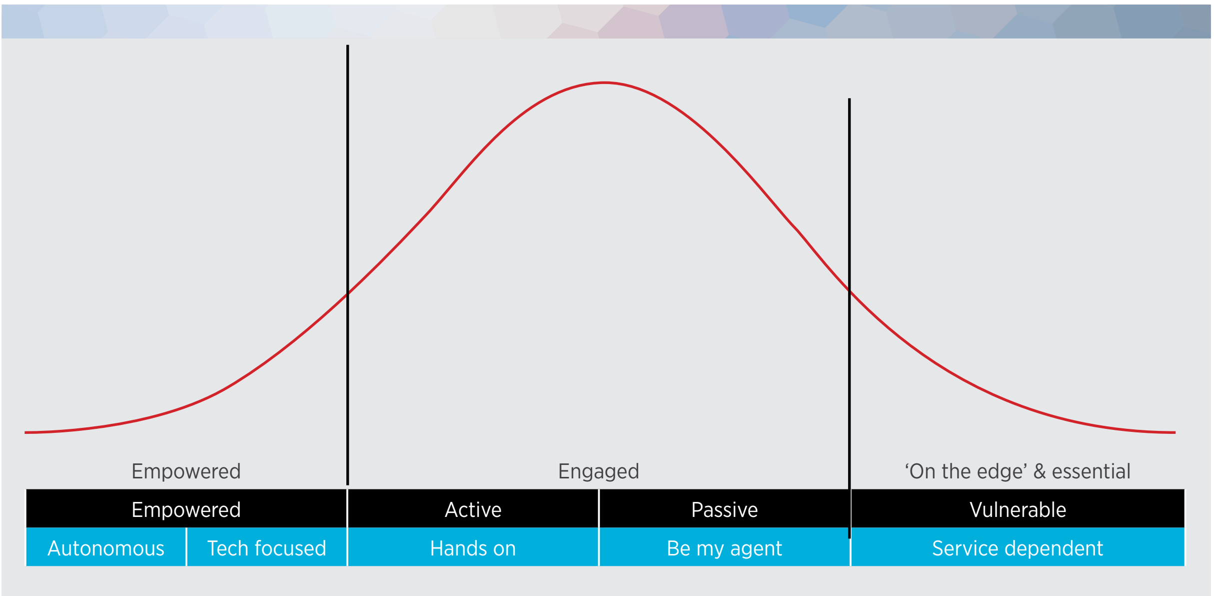
The majority of network assets around the country directly serve residential customer electricity needs. Further, the residential segment’s share of network value is expected to increase slightly by 2025, as the residential and services sectors grow relative to other sectors of the economy.

The global literature review identified many approaches to segmenting residential electricity end-user customers. The Roadmap program identified some common themes, which are reflected in the five segments (described in Table 1.1):

» Autonomous
» Tech focused
» Hands on
» Be my agent
» Service dependent (including vulnerable customers).

It is difficult to present the segments simply and easily. For this purpose, after reviewing the literature, the Roadmap program adapted a graphic developed by Energy Consumers Australia (ECA) (with ECA’s permission), representing residential customer segments. It is based on a standard market adoption curve, with highly engaged early adopters to the left, and more passive late adopters to the right. The passive late adopters includes the vulnerable customer group, who, for a range of reasons, will struggle to access more advanced market offerings but require ongoing access to affordable and reliable network services (Figure 1.4).

Figure 1.4: Proposed market segmentation curve for residential customers



Source: Plausible 2025 customer segments were informed by an international literature review, commissioned expert papers and structured stakeholder workshops. In particular, Rosemary Sinclair of Energy Consumers Australia is acknowledged for employing the market curve device to graphically represent customer segments (adapted with permission). See Appendix C for more detail on processes applied and sources used in undertaking customer-oriented segmentation.

17 Christensen, Cook and Hall 2005, ‘Marketing malpractice: the cause and cure’ in *Harvard Business Review*, December; Ernst and Young 2014, *From defense to offense. Distributed energy and the challenges of transformation in the utilities sector*, Ernst and Young, cited in Newland, P (Balancia) 2015, *CSIRO global customer-orientation literature review*, United Kingdom.

The future energy marketplace involves a spectrum of end-customer needs, drivers and aspirations. The customers at the far right are highly dependent on the grid to maintain their standard of living and require ongoing access to affordable, reliable and predictable services. By contrast, the customers at the far left are highly autonomous (and some may leave the grid). The bulk of future customers are likely to be either actively or passively engaged. However, actual proportions of customers in each segment will shift over time, as customers respond to emerging market and technology trends.

The segments are multidimensional and no single factor can suitably differentiate the behavioural characteristics between segments. Importantly, the segments do not represent income or socioeconomic status. That is, high levels of grid dependency and autonomy do not necessarily correlate with low and high income households respectively. There are many reasons why customers may not engage in the market (for example, rental barriers). Similarly, customers from lower socioeconomic groups may seek to leave the grid for a range of reasons.

Each segment represents a type of 'customer psychology' or 'way of thinking' about how a customer interacts with energy. Together, the segments represent a *'dependent–engaged–autonomous'* spectrum. The spectrum does not imply any value judgements (for example, autonomy is good, dependence is bad). However, we can assume customers that move and remain to the left of the diagram are willing to deal with increased levels of complexity, choice and possibly risk in exchange for some financial, social and/or emotional incentive or motivator. Table 1.1 describes the five segments in detail.

Non-residential customer segments

Most literature categorises non-residential end-user customers in the following high level groups:

- SMEs – typically smaller organisations such as small offices, businesses or home based offices
- C&I customers– typically large organisations with intensive energy requirements and large scale outputs.

In 2015, SME and C&I end-users consume approximately 74 per cent of Australia's grid-supplied electricity. While this is expected to decline slightly towards 2025, these end-users will remain a critical segment into the future.

However, there is little publicly available literature that describes SME and/or C&I customer segments. This reflects the commercially-sensitive and increasingly customised way that electricity market actors engage with non-residential customers, especially those consuming large volumes of energy. Traditionally, SME and C&I end-users were characterised largely by business type, electrical capacity, consumption and/or type of connection to the grid. These distinctions may be useful for some purposes, but they appear to assume uniform customer psychology and decision making. They provide little insight on the types of electricity solutions that the diversity of non-residential customers may value in the future.

The Roadmap program commissioned two specialist papers on how to segment non-residential customers to allow analysis of what they may value in the future. The Roadmap program workshopped these papers and materials with customer and industry specialists.

Table 1.1: Plausible residential customer segments in 2025

<table>
<tr><th rowspan="2">Segment</th><th colspan="2">Empowered</th><th colspan="2">Engaged</th><th>Vulnerable</th></tr>
<tr><th>Autonomous</th><th>Tech focused</th><th>Hands on (Active)</th><th>Be my agent (Passive)</th><th>Service dependent</th></tr>
<tr><td>Distinctive features</td>
<td>Independent: Wants full control, granular cost management and the ability to configure the operation of the electricity solution.
Will often involve disconnecting from the grid entirely, and may be motivated by locational cost or reliability issues.</td>
<td>Empowered: Has a strong affinity with technology and desires control.
Wants to influence directly the design and operation of the customised solution.
System cost is important but maximising returns on investment from trading energy services with the grid is critical.</td>
<td>Active: Wants to understand what each available option has to offer and to be involved fully in the selection process.
Willing to maintain a moderate to high involvement in the ongoing operation.
System cost and return on investment from interacting with the grid to trade energy services are both important.</td>
<td>Passive: Prefers electricity solutions that provide ease and convenience at a reasonable cost.
Desires an agent to provide a shortlist of options that make sense, are easy to deliver and require a minimum of ongoing involvement.
May invest in additional cost saving measures if simple and convenient.</td>
<td>Dependent: Needs affordable network services and help to identify the most suitable options.
Includes vulnerable customers experiencing energy hardship.
Also includes households that cannot adopt new electricity solutions, given rental property constraints or a lack of access to capital.</td></tr>
<tr><td>Common features</td><td colspan="5">All customer segments will value solutions that provide secure and reliable electricity for Australia’s modern lifestyle. Some customers may want to trade off some aspects that have been standardised traditionally, in return for a financial benefit.
Participation in a given segment is fluid and bi-directional. Households will transition between segments at different stages of the life cycle, either towards greater autonomy or increased dependence.
Customer segments are likely to be less affected by income level, as evolving business models and financing mechanisms make complex solutions available to larger proportions of customers.</td></tr>
<tr><td>Segment reference descriptors</td>
<td colspan="2">Actively invests in distributed energy resources to have, and to be seen to have, control.
Seeks a diversity of energy options and many will pay a premium.
Has an appetite for high degree of self-effort.
Willing to invest in distributed energy resources for interacting with market.
Features are very important; desire highly customised products/services.
At extreme, will choose greatest form of engagement, ‘self-reliance’.
Willing to be either highly integrated (on their perceived terms) or ‘disconnected’.
In future, new payment arrangements (for example power purchase agreements) may reduce the upfront cost barriers to make leaving the grid more accessible to customers. So cost alone may not be a barrier to customers who want to seek to leave the grid.
Technical complexity could be managed by third parties, but consumers in this segment would still have to accept increased complexity and risk that comes with being grid-disconnected or less reliant on grid supply.</td>
<td>Will invest in distributed energy resources to reduce costs and enhance sense of control.
Moderate market involvement and energy management.
Like technology and the ability to manage energy.
Willing to pay more but cost is still important (for most).
Prefer degree of customisation and individualised products/services.
Interconnected (energy and information).
Favour grid-integration of distributed energy resources to sell, buy and maximise financial value.</td>
<td colspan="2">Favour personal convenience and simplicity.
Want to reduce cost and complexity.
Relatively passive market involvement (either by choice or necessity).
Energy may be viewed as a simple commodity.
May invest in energy packages – but only if simple and convenient.
Vulnerable customer groups require ongoing access to affordable and reliable network services.</td></tr>
</table>

Primary factors for segmenting non-residential customers

Feedback from stakeholders suggests it is plausible to consider non-residential future customers across an *'essential—engaged—empowered'* spectrum, similar to the spectrum of residential customers. The following two factors will be particularly relevant in segmenting non-residential customers in the future:

- **Focus on energy** – A measure of how much focused attention an organisation places on energy costs and/or technologies. In general, we expect the level of focus to be proportional to the degree that energy costs affect operational cash flows and/or the scale of losses resulting from interruptions to supply.
- **Ability to act** – A combined measure of how motivated and capable an organisation is to change the way it interacts with energy to achieve desired outcomes. In general, we expect it to be proportional to organisational values, investment profile and market and environmental positioning (motivation) and the capacity to make energy use changes, integrate new technologies and/or fund new investments (capability).

These factors form the primary framework for segmenting non-residential customers outlined below.

Additional factors for segmenting non-residential customers

Other factors that inform representative groupings of non-residential customers include:

- size of the organisation[18]
- profitability of the organisation and relative impact of energy costs on profits
- energy dependence, or proportion of business operations dependent on energy or affected by energy costs
- cost of energy and/or access to tailored energy contracts/tariffs
- facility ownership structure
- industry sector maturity or life cycle stage.

Non-residential end-customer segments

The Roadmap program identified four non-residential customer segments (Figure 1.5):

- Autonomous
- Active
- Passive
- Vulnerable.

Like the residential customer segments, the proposed non-residential customer segments are 'plausible hypotheses', not perfect predictions, so they will be refined throughout the program. They are based on the factors outlined above and with feedback from stakeholders.

Figure 1.5: Proposed market segmentation curve for non-residential end customers

Source: Plausible 2025 customer segments were informed by an international literature review, commissioned expert papers and structured stakeholder workshops. In particular, Rosemary Sinclair of Energy Consumers Australia is acknowledged for employing the market curve device to graphically represent customer segments (adapted with permission).

18 Many SMEs, especially very small enterprises, interact with energy like residential customer types. But for this work, we included all non-residential end-user customers, including SMEs.

Table 1.2 describes the four segments in detail. Customer and industry experts also further segmented the Empowered and Active non-residential customer segments (Table 1.3).

Table 1.2: Plausible non-residential customer segments in 2025

	Empowered/ Autonomous	Active	Passive	Vulnerable
Focus on energy	High	Medium/High	Low	High/Medium
Ability to act	High	Medium	Medium	Low
Descriptor	I want to act and I can		I don't need to act	I need to act but can't
	Highly empowered set of business customers who will be very interested in how technology can reduce their costs, improve their green image or improve operational efficiency. Heavily focused on innovation and environment. They will seek highly configured and customised solutions and will spend more effort in research/engaging with complicated price structures or solutions. Value is important, because they need to know they are achieving their objectives. Will want to be highly integrated and interconnected with digital access to data and energy flows to customise and optimise operations and energy services. Likely to seek to stay at the forefront of technology and environmental issues.	Highly engaged and motivated to maximise savings and efficiency by engaging more with the energy system. This group is likely to be large. Willing to invest in technologies and accept a higher level of complexity, so long as they can offset the additional time and (potentially) investment with a positive return on their investment, reflected either in ongoing cost savings and/or a positive environmental impact. May be motivated to reduce carbon footprint, but only if the cost of carbon is passed onto them in an increased fashion. Will seek energy data to ensure cost objectives are being met and to understand optimisation/efficiency of operations and energy technologies. They will therefore readily engage with data and other intermediaries where savings can be made. Likely to heavily automate and manage operations via dashboards.	Extremely busy customers and have little time to understand their energy costs or needs. Any extra complexity is a challenge for these end-users, who are busy maintaining or growing their business. Require a simple set of solutions that take the worry and effort (time to manage, risk of interruption, potential cost savings or loss) out of energy – will remain largely passive to the energy system. Business is not concerned with energy costs and will accept any reasonable offer of service with minimum effort in decision making. Will attract intermediaries who have honed their products and tools on similar businesses in the mature phase. Likely to adopt technology that can be incorporated easily and with short payback periods.	Service dependent customers who are highly dependent on grid supply to keep their business running. Need help because they are unable to engage with new technologies or offers and will have a high level of cost sensitivity. Want to concentrate on running their business and keeping solvent, and increased energy costs or complexity are a barrier. Like residential customers, they want a basic and efficient service to maintain essential business operations. Reliability of supply is important, as it is to all business customers. Unlike small customers, these companies have no social regulatory support but in areas where employment is an issue, may have political support. Will potentially be served by intermediaries who have honed their products and tools on similar businesses in the mature phase but that are profitable. Some may be able to adopt some technology with short payback periods.

Table 1.3: Empowered and Active non-residential sub-groups

Segment	Empowered/Autonomous			Active		
	Leave the Grid	**Greenhouse response**	**Energy intensive**	**Self-active**	**Group-active**	**Agent-active**
Descriptor desires and needs	Where the cost of supply is excessive due to locational and reinforcement issues, there may be a case for non gridbased supply. This group may be near the edge of the meshed grid or, part of a community based microgrid. Likely to be small in 2025 because C&I customers are unlikely to leave the grid unless there are compelling cost or environmental drivers – historically, industrial development leads to interconnection for reliability and efficiency reasons.	High exposure to emission costs and is keen to portray a strong response to climate change and decarbonisation. Likely to wear green credentials with pride. Seek cost effective means of harnessing renewable technologies and using their energy supply more efficiently.	High exposure to energy and emission costs and has its own internal resources to analyse markets and sources of energy for trading purposes. Includes large customers that have energy sources (waste gas, heat sources etc.) as a byproduct of their business processes. Engage with intermediaries and market participants to ensure cost effective energy use including distributed energy resources and demand response. Likely to adopt new technology such as storage, thermal, electro-chemical, mechanical and gravitational storage.	Internal resources to manage energy costs and is managing high emission costs and the transition to decarbonisation. Engage with the industry and bring in consulting and intermediary resources as required to meet goals. Largely choose what they want and how to do it – control is a strong driver.	Similarly located commercial customers combine their business needs and complementary energy usages to exchange energy and jointly purchase energy. Similar to options considered for community groups of small customers but are currently occurring (for example, the Amsterdam Arena and Amsterdam AMC medical centre joint solar installation and energy contracts).	No dedicated energy resources but uses external agents and intermediaries to manage energy costs and emission costs. Likely to be engaged and steered by intermediaries/ trusted advisers but will adopt technologies that will provide a net benefit in the medium term.

Creating new value for future electricity customers

Stage 1 of the Roadmap program has placed the highest priority on working with diverse stakeholders to understand what end-user customers will likely value from future electricity solutions.

This ‘customer-oriented’ perspective is critical for navigating industry disruption, where traditional monopoly providers may need to transition away from existing business models, as they face expanding competition and potential product substitution. In the increasingly competitive ‘electricity solutions’ marketplace, for example, network businesses may choose to transition from a ‘single-product’ commodity orientation to developing, bundling, delivering and supporting complex programs and multiple products and services.[19]

19 Newland, P (Balancia) 2015, *CSIRO global customer-orientation literature review,* CSIRO, United Kingdom.

While there is no 'one size fits all' future business model for electricity networks, any effective business model innovation requires an understanding of the value that future customers will expect. A business that does not innovate its value propositions adequately risks reducing the effectiveness and longevity of even the most elaborate business model innovations.

Given the critical role of value proposition innovation, Stage 1 of the Roadmap program explored what electricity end-users will likely value in the future. A broad range of customer representatives and industry stakeholders participated, including advocates for vulnerable energy consumers.

These workshops applied the globally-recognised 'Jobs to be Done' method to identify customer needs, aspirations and future solutions that customers will likely value. (Appendix C describes this process further.)

What end-users are likely to value from future electricity solutions

In the workshops, participants explored three key questions:

- What is customer-orientation and why is it critical for navigating Australia's electricity transformation?
- Who are the electricity customers of the future and what are their needs and aspirations?
- What are plausible 2025 electricity customer segments based on what different customer types will value?

Observations about future electricity customers

At a high level, electricity customers:

- will have different expectations and priorities, and this diversity will not necessarily correlate with income levels, especially as new business models and financing tools evolve
- will continue to value electricity solutions that provide secure and reliable electricity, given Australia's increasingly automated and digitised economy and lifestyle
- in some cases, will value options allowing them to trade off electricity service features that have traditionally been standardised, in exchange for a financial benefit, such as being more responsible for their own reliability of supply (by choosing to install on-site energy storage, for example)
- will compare and contrast competing electricity solutions based on each option's ability to perform the combination of 'jobs' that they uniquely want done (including functional and financial 'jobs' as well as social and emotional 'jobs')
- will want simple, accessible choices, and may prefer bundled products and services that conveniently combine technologies, data access and/or entertainment
- will increasingly seek energy solutions that are highly customised and delivered in the emotionally and socially engaging ways that customers already expect from service providers outside the energy sector in 2015.

The stronger an organisation's trust or social licence, the more customers will be willing to invest in or adopt that organisation's products and services.

Future customer segments and what they may value

Tables 1.4–1.7 summarise the findings from Stage 1. They describe what residential and non-residential customer segments may value in the future and can be used by individual businesses in many different ways. This information may, for example:

- help map organisational strengths with specific future market opportunities
- highlight where organisations may require strategic partnerships with other market actors to deliver future value
- highlight areas where an organisation may not wish to compete
- inform, prototype and field test specific product offering concepts in areas where an organisation does want to compete
- provide input for innovating organisational value propositions and business models.

Table 1.4: Summary of future residential end-user segments and Jobs to be Done outputs

	Empowered		Engaged		Vulnerable
	Autonomous	**Tech focused**	**Hands on**	**Be my agent**	**Service dependent**
Distinctive features	**Independent**: Wants full control, granular cost management and the ability to configure the operation of the electricity solution. Will often involve disconnecting from the grid entirely and may be motivated by locational cost or reliability issues.	**Empowered**: Has a strong affinity with technology and a significant desire for control. Wants to influence directly design and ongoing operation of the customised electricity solution. While system cost is important, the ability to maiximise return on investment from interacting with the grid to trade energy services is critical.	**Active**: Wants to understand what each available option has to offer and to be involved fully in the selection process. Willing to maintain a moderate to high involvement in the operation of the electricity solution.	**Passive**: Prefers electricity solutions that provide ease and convenience at a reasonable cost. Desires an agent to provide only the shortlist of options that make sense, are easy to deliver and require a minimum of ongoing involvement. May invest in additional cost saving measures if convenient.	**Dependent**: Needs affordable network services and help to identify the most suitable options. Includes vulnerable customers experiencing energy hardship. Also includes households that are unable to adopt new electricity solutions, given barriers such as rental property constraints or a lack of access to capital.
'Jobs' that the customer wants help with	Provide autonomy, control and highly granular cost management. Highly customised, individualised solutions that enable customers to leave the grid when desired. Emphasis on either high degree of control of costs (either driven by carbon or network connection) or 'green' carbon reduction focus. Guaranteed performance through technologies that maximise distributed energy resource use.	Provide energy where I want it and when I need it. Assist significant energy market engagement through enhanced control and integration. Need real time (bi-directional) data. Willing to pay more if enhances control of costs. Enable a range of technologies to enhance energy flow and value. Integration and interconnectedness of technology and data is important. Desire to be seen as technology and/ or environmental leaders.	Provide a wide array of services to enhance lifestyle. Help see and evaluate energy data and understand how to manage and tailor their energy experience. Want to buy/sell energy to optimise their investment but must be simple. Trust and comfort are important. Desire to save money through choice and control over their energy – needs to be configurable but automated.	Maintain existing utility or lifestyle. Value choice but not at expense of convenience or comfort. Desire access to socially accepted technologies and energy services (but need to be established and proven – not market leading). Happy for new technology to enhance lifestyle but has to be easier than managing it themselves. Value simplicity, comfort, convenience and choice. Cost is important but secondary.	Need low cost and reliable supply to maintain essentials such as refrigeration, washing, heating and cooling, health, communication. Maintain basic entertainment and maintaining lifestyle requirements. Needs to be simple and easy with access to enough information to know what options are available. Support tailored to this group with simple, predictable and tailored tariff structures.
Common features	All customer segments will value solutions that provide secure and reliable electricity for Australia's modern lifestyle. Some customers may want to trade off some aspects that have been standardised traditionally, in return for a financial benefit. Participation in a given segment is fluid and bi-directional. Households will transition between segments at different stages of the life cycle, either towards greater autonomy or increased dependence. Customer segments are likely to be less affected by income level, as evolving business models and financing mechanisms make complex solutions available to larger proportions of customers.				

Table 1.5: Electricity solution features likely to be valued by future residential end-user segments

	Empowered		Engaged		Vulnerable
	Autonomous	**Tech focused**	**Hands on**	**Be my agent**	**Service dependent**
Valued solution features	Reliable systems and technology with guaranteed outcomes as a key feature. Extendable and modular technologies that can be easily added to or integrated with others. Ability to upgrade over time (future proofed – no stranded technologies). Real time and digital access to data on energy flow and technology performance. Access to community or shared experience with peers. Social recognition is important. Packages must provide predictable costs and savings. Must also provide back-up services and guarantees in event of breakdown or technical issues.	High degree of customisation and bespoke solutions. Want a high degree of choice and control over technology, energy management and configurability. Latest technology with complementary services (e.g. water, internet bundling). Willing to engage with complex arrays of tariff/pricing options to maximise returns. High degree of market access with options to maximise value (e.g. demand response, market bidding). Highly granular access to data and digitalised energy trading platform. Part of a digital community, but require assured levels of security and reliability.	Customisable range of options that provide automated control. Needs to be relatively easy. Digital platform access to data including energy, cost flows and outcomes. Configured solutions need to help customers save money, and data flow needs to highlight this with peer-to-peer comparisons. Need a degree of simplicity but willing to engage with a range of integrated technologies to enhance lifestyle and control. Access to latest technology and energy market is important if easy to work with. Guaranteed service levels/outcomes important with risk of breakdown or difficulty addressed in service promise.	Choice and simplicity offered through pre-packaged, bundled solutions providing comfort and convenience. A single and simple point of contact to get everything done (simple, coordinated single source of full options and information). Bundled energy solutions somewhat configured to energy profile. Bundles link technology, finance and energy management products into simple packages with range of options. Limited configurability but must be easy. Access to data and new technology important, but not too much and needs to be straightforward.	Simple payment options with predictable, stable costs. These can be connected with 'ramped' or guaranteed levels of supply. Supported by simple access to data and information. Access to better products and energy solutions through bundled solutions potentially incorporating efficient appliances to enhance key lifestyle outcomes, simple energy management and distributed energy technologies and data access packaged with simple finance solutions. Aim: relieve bill stress, lower costs and help customers access the energy market with better products while maintaining reliability.
Examples	Packaged off-grid solution targeted to customers who choose to move off-grid for financial reasons. Package includes all distributed energy resources, control and digital platform requirements at a guaranteed cost. End-to-end service with guaranteed back up and fault resolution options.	Digital platform allows range of choices and combinations of energy services and products (distributed energy resource highly integrated with grid and energy market), including digital platform access to two-way energy data and value flow. Technology should provide high degree of automation, but still allow configurability and control. Access to dynamic tariffs to optimise value.	Personalised bundled services integrated with other services (e.g. internet, water etc.). Integrated to grid with two-way energy flow/value flow, with digital platform providing immediate access to data for both. Bundles provide access to latest distributed energy resource technology, and allow high degree of choice, but packaged service still makes installation and service easy.	Single point of contact end-to-end service offering targeted solutions, installation and service (e.g. bundle of distributed energy resources combined with digital data platform and bill information targeted to customers with broadly appropriate energy profile). Easily combined payment plan for customers, guaranteed to achieve outcomes and enhance lifestyle.	End use energy services – bundled energy solutions aimed at serving essential needs (e.g. heating or cooling). Package includes financed efficient heating/cooling appliances – including installation – combined with flat, predictable payment plan including related energy costs).

Table 1.6: Summary of future non-residential end-user segments and what they may value

	Empowered/ Autonomous	Active	Passive	Vulnerable
	I want to act and I can		I don't need to act	I need to act but can't
Focus on energy	High	Medium/High	Low	High/Medium
Ability to act	High	Medium	Medium	Low
'Jobs' that the customer wants help with	Seek highly advanced options and energy technologies. Bottom line is critical but 'green' credentials and managing carbon impacts are also important. Leverage energy management capabilities to optimise operational efficiency (including more complex tariff structures). Technology maximises control over energy flows and ensures operational continuity.	Motivated to improve production and profitability outcomes. Seek a degree of control with enhanced business intelligence to provide capability to monitor business operations (including energy impacts). Willing to invest in capability to improve cost controls and seek enhanced flexibility in operations but based on return on investment. Seek to monitor and maximise business investments and asset utilisation – the bottom line is key.	Focused on running business – happy to reduce costs but only if it can be done without taking focus away from other important business activities. Monitor business to a degree and will integrate new technology if straightforward. Automated and simplified operations desirable to help focus on core business. Convenience and simplicity are key, especially if they help business to address cost impacts.	Need reliable and affordable access to supply to concentrate on and sustain business operations. Maximise cash flow by improving margins and business efficiency. Maximise time and resources to concentrate on running business. Need simple tools to manage energy costs including: » managing energy more efficiently » accessing simple information and data to provide advanced cost information » accessing simple and affordable technologies.

Table 1.7: Examples of future non-residential end-user products and services

	Empowered/Autonomous	Active	Passive	Vulnerable
	I want to act and I can		I don't need to act	I need to act but can't
Valued solution features	Highly tailored and configured technologies and access to distributed energy resources enhance business operations and bottom line. (Return on investment is important.) Control platform provides highly granular access to data, energy flows and value flows across business operations (not just energy technologies). Also provides high level of predictability over operations and costs. Enhanced brand through 'green' credentials and innovation. Financial and operational drivers will motivate to trade with market or even leave the grid. Both these drivers require high service level guarantees.	Array of options and technologies to enhance business operations and improve the bottom line. Technology for energy management but that also enhances business operations through control capabilities, automation and improved business analytics. Access to energy market and trading platform to both buy and sell energy to maximise asset utilisation. Enhanced data and controls provide confidence in business operations and cost controls. Modular and configurable solutions allow customers to tailor packages to degree required by business.	Simple solutions to help manage business (primarily) and energy (secondarily). Straightforward access to new technologies to simplify business and enhance operations (e.g. distributed energy resources, energy management and data monitoring). Packaged solutions with simple access to technology, financing and data platform, including delivery and support. Targeted and tailored communication without being complex – help take complexity out of running business. A call to action to optimise operations with minimum of effort and complexity.	Low cost, pre-packaged, bundled solutions with flat (pay as you go), predictable payment arrangements (e.g. Power purchase agreement). These include: energy management technologies (including distributed energy resources and energy efficient technology) and digital access to simple energy data that provides warnings on cost triggers. Simple packages that reduce stress related to energy costs and allow business to focus on operations. Simple education and turnkey solutions that help business run more efficiently.
Examples	Highly tailored and individualised service will assess and recommend options for each site. Highly configured and individualised installation of automation, control, distributed energy resources and data technologies follows – highly customised to customer objectives.	Range of options serves either customers who want to do it themselves or agents acting on behalf of customers. Range of choices for technology and digital platform access with clear financial benefits. Modular options allow customers to pick and choose and integrate a range of options with confidence, with simple grid integration.	One stop shop includes cost management and energy management technologies in an easy-to-choose-and-arrange format. Limited data access allows just enough information to improve business operations and automation, without being overly complex. End-to-end service and installation with single point of contact.	Technology package (bundled with electricity pricing – predictable payments) provides business with basic access to automation and energy efficient options. Digital portal provides option assessment, installation and service.

How you can help

Your feedback on the following questions is welcome. This feedback will be used during Stage 2:

1.1 Are there any perspectives on what future customers will value and/or how they may interact with electricity systems and solutions in the future?

1.2 Are there any Australian or international sources, either from within the energy industry or external to it, which are highly relevant to the content of this Chapter?

1.3 Are there any particular expert opinion(s) and/or contrary views that should be sought on any of the matters discussed in this Chapter?

KEY FINDINGS

F1.1 Future electricity customers are expected to be increasingly different in their expectations across a broad *vulnerable—engaged—empowered* spectrum of market segments. These market segments:

- represent discrete combinations of outcomes and priorities (or 'jobs') that different customers will want electricity solutions help them to achieve
- highlight the different levels of customer willingness and ability to engage with technical complexity and/or assume some responsibility for their electricity supply, in exchange for a financial or non-financial benefit
- are likely to be less affected by household or enterprise financial status, as evolving business models and financing mechanisms make complex solutions available to larger proportions of customers
- are fluid and bi-directional, as households and enterprises likely transition between segments at different stages of the life cycle, either towards greater autonomy or increased dependence.

F1.2 While recognising the diversity of customer segments, it is likely that future customers will generally:

- continue to value solutions that provide secure and reliable electricity for a modern economy and lifestyle that is increasingly digitised and automated, and includes a growing role for electric transport
- prefer offers that are simple, accessible and delivered in the engaging ways already expected of service providers outside the energy sector
- may increasingly prefer bundled solutions that combine a number of elements including energy technologies, data services and/or entertainment services
- in some cases, trade off aspects of traditional electricity service that have been standardised, in return for a financial benefit.

F1.3 Network businesses and their strategic partners must be committed to customer-orientation in this increasingly complex, dynamic and competitive operating environment. This approach will be critical for electricity networks to:

- comprehend and anticipate ever-changing customer expectations and priorities
- optimise existing services to foster social licence, trust and loyalty
- innovate new electricity solutions and business models in collaboration with supply chain or 'value network' partners.

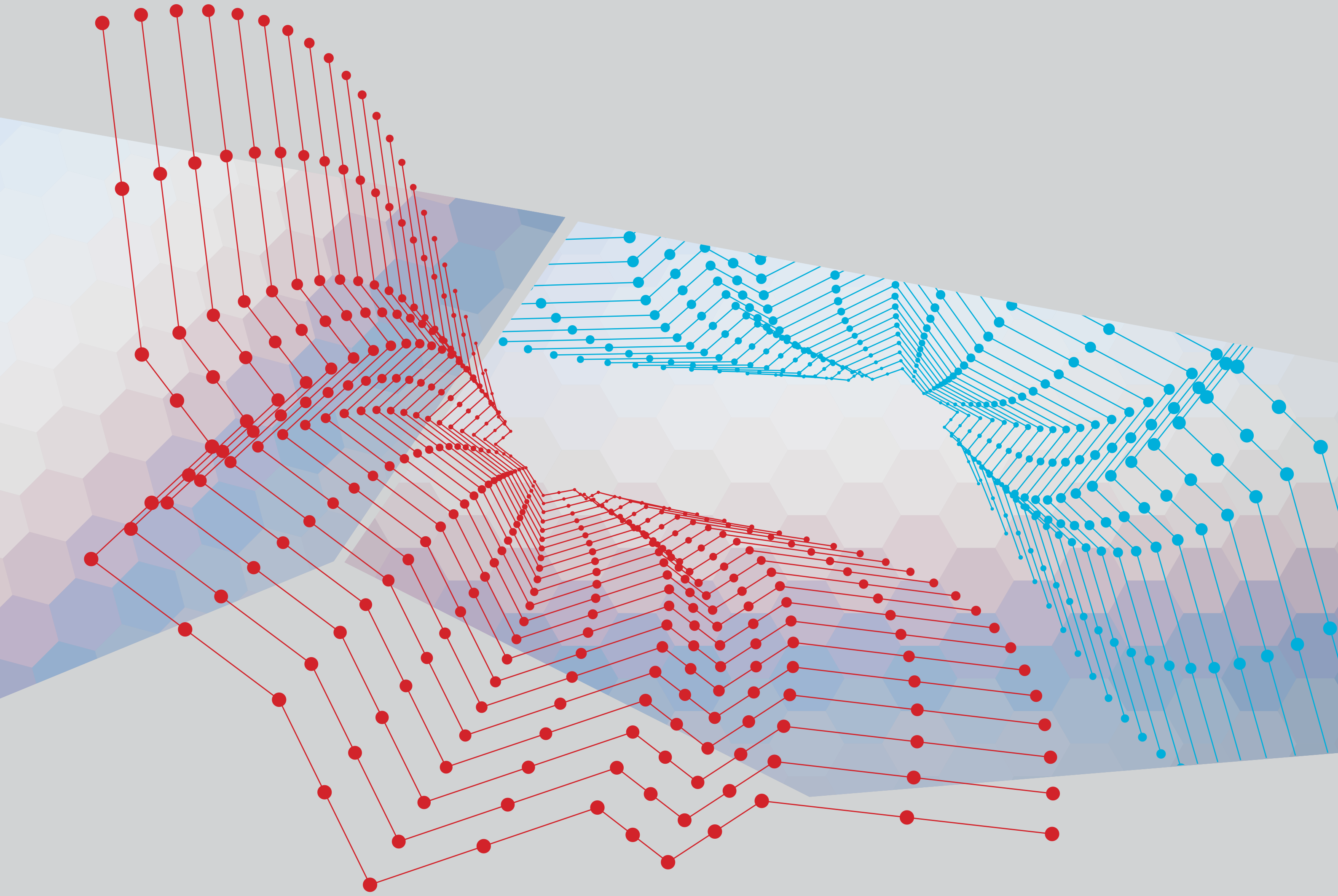
RECOMMENDATIONS

R1.1 The detailed appreciation of future residential, commercial and industrial customer segments developed in Stage 1 should:

- be applied across the entire Roadmap program, to ensure all elements focus on a customer-oriented electricity future that benefits Australian households and enterprises
- inform CSIRO's quantitative modelling, to compare the 'balanced scorecard' outcomes of alternative transition options for distinct customer segments
- be reviewed and updated periodically, as additional information becomes available during the Roadmap program.

R1.2 This expanded view of what future end-users are likely to value from electricity solutions will enable Stage 2 of the Roadmap to explore:

- Which market actors individually and/or in combination will be well-positioned to create and deliver the value that future end-users will expect?
- How might network businesses and other market actors work together as a value network?
- How can network businesses continually identify commercial opportunities and evolve as organisations to successfully meet customer needs?



CHAPTER 2
WHAT'S DRIVING AUSTRALIA'S ELECTRICITY SECTOR TRANSFORMATION

Quick look

- CSIRO has updated the original Future Grid Forum (Forum) scenarios of 2013 to provide four plausible views of Australia's electricity future to 2050. The 2015 scenarios provide an up-to-date and more nuanced view of the change impacting Australia's electricity system and a baseline for evaluating Roadmap options against a 'balanced scorecard' of societal outcomes.
- The 2015 scenarios confirm that customer adoption of distributed generation, especially rooftop solar photovoltaic (PV) systems, together with global carbon abatement efforts remain the main transformation drivers. Mass adoptions of energy storage (batteries) and electric vehicles are likely to bring subsequent waves of transformation to electricity systems.
- Updated residential customer bill projections are lower than CSIRO estimated in 2013 owing to greater confidence in the ability of demand management technologies, such as battery storage, to play a role in managing grid utilisation.
- Stage 2 of the Roadmap program is likely to focus on developing counterfactual cases for the 'no regrets' options to be included in the Roadmap. It will also develop a better understanding of the likely impact of the different scenarios on the full range of residential, commercial and industrial customers 2025.

What we know

The complex and accelerating change facing electricity systems globally presents significant challenges for the electricity industry. These challenges are especially pronounced given the electricity systems' critical national infrastructure function and historical status as a relatively stable, capital intensive and long-life infrastructure investment.

Prior to the Roadmap program, the 2013 Future Grid Forum (Forum) was an important information source for comprehending the nature and scale of change underway in Australia's electricity sector. CSIRO convened the Forum in August 2012 and brought together about 100 experts from across Australia's electricity value chain. Over 15 months, participants systematically debated key issues and developed four integrated scenarios of Australia's plausible electricity futures to 2050. Extensive technical and economic modelling quantitatively assessed the impacts of the four scenarios.

The 2013 Forum scenarios describe and quantify four reasonable 2050 'destinations' for Australian electricity systems. The Forum designed the scenarios to expand the nation's thinking about quite divergent alternatives without endorsing any one of them as most likely or most desirable. In fact, the process showed that each scenario would affect each stakeholder group differently – that is, no one scenario is universally advantageous to all and informed trade-offs will need to be made to deliver efficient customer outcomes. The Forum also noted that actual energy system outcomes are likely to reflect elements from each of the four scenarios rather than be a precise match to any one of them.

Scenario development and industry transformation efforts, such as from the Forum and Roadmap respectively, are related but different activities. Scenarios are 'descriptive' in that they explore possible futures without judging whether any are desirable or preferred. Roadmaps, by contrast, are more 'normative' in that they extensively consider the characteristics of preferred futures which then informs the development of actionable pathways towards them.

In the case of the Roadmap program, participants developed a 'balanced scorecard' of overarching success measures to guide the process and ensure it is focused on both customer and societal benefits for Australia.

What we're doing

Given the national significance of the 2013 Forum scenarios and how quickly many of the input assumptions have changed since they were created, a first step in the Roadmap program was to collaboratively update the Forum scenario work to create a 2015 scenario set. The 2015 scenario set provides both current perspectives on Australia's electricity transformation and a baseline for evaluating the many possible transition options open to consideration in the Roadmap program.

Before CSIRO could develop the 2015 scenario set through further quantitative modelling, the Roadmap program sought broad participant input to and consensus on the key assumptions, data sources, and analysis underpinning them. Participants received a working paper and engaged in robust debate through national workshops in September and October 2015. This process greatly improved the reasoning, consistency and quality of the scenario assumptions. CSIRO used these revised input assumptions in quantitative modelling for the 2015 scenario set.

What we're learning

Key drivers of change

In 2013 the Forum identified customer adoption of distributed generation (especially rooftop solar PV) and energy storage (batteries) together with global carbon abatement efforts as the main drivers of major structural change in Australia's electricity sector. The following section provides a brief snapshot of these drivers two years on.

Distributed generation and energy storage

The customer adoption of solar PV, particularly in the residential sector, has continued strongly as illustrated in Figure 2.1. The cost-curve of panels has also continued to improve at a faster rate than anticipated in the original Forum analysis. Some Australian states now have the world's highest penetration of grid-connected, rooftop solar PV.

Compared with solar PV, the uptake of energy storage remains in its infancy. However, similar to the experience with solar PV, the energy storage cost-curve has improved at a significantly faster rate than anticipated in the original Forum analysis, as illustrated in Figures 2.2 and 2.7.

Carbon abatement measures

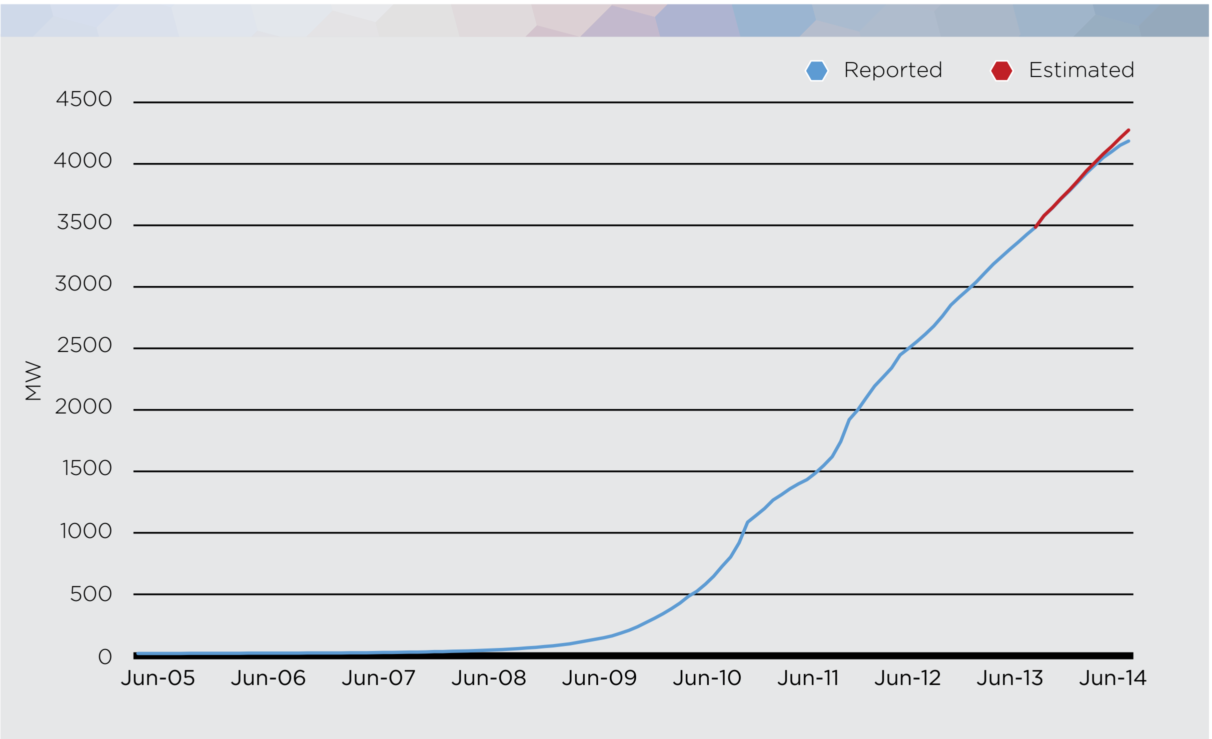
There were signs in 2014-15 that the emissions intensity of the electricity sector had begun to increase again after a period of decline since 2008 (Figure 2.3). Despite this, the long term bipartisan policy intent is still to decrease the sector's greenhouse gas emission intensity, as indicated by the August 2015 announcement of a proposed national commitment to reducing emissions by 26–28 per cent by 2030 relative to 2005 levels.

While the Government is still developing the policy mechanisms for this target, the Large-scale Renewable Energy Target – which in 2015 was reduced from 41 terawatt-hours to 33 terawatt-hours by 2020 – is the main mechanism for limiting emissions growth in the sector to 2020.

Electric vehicles

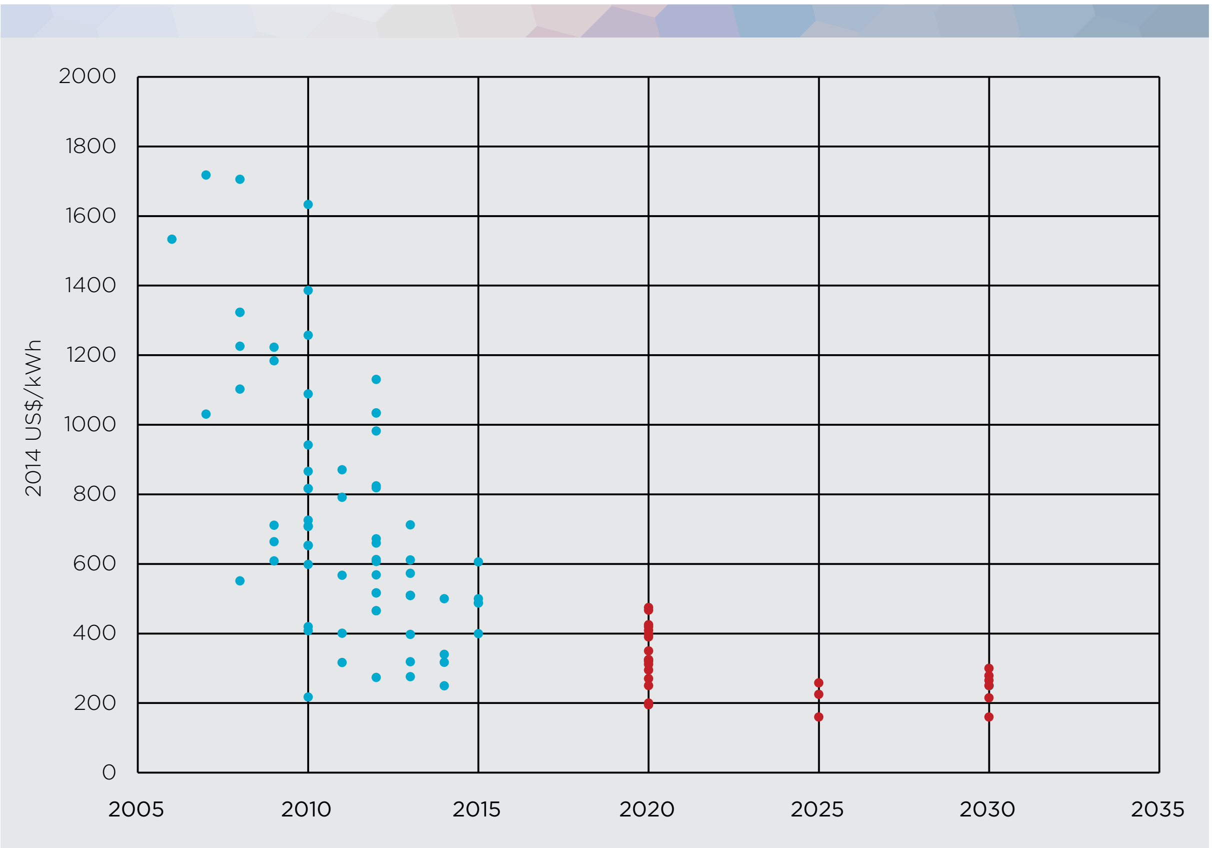
When CSIRO looked at disruptive change in other sectors, such as telecommunications, it found there is typically several waves of disruptive change rather than a single wave caused by a sole transformative driver. If solar PV is considered the first major disruption, and energy storage a likely second wave, it is anticipated that electric vehicles is a possible third wave.

Figure 2.1: National cumulative installations of rooftop solar PV systems



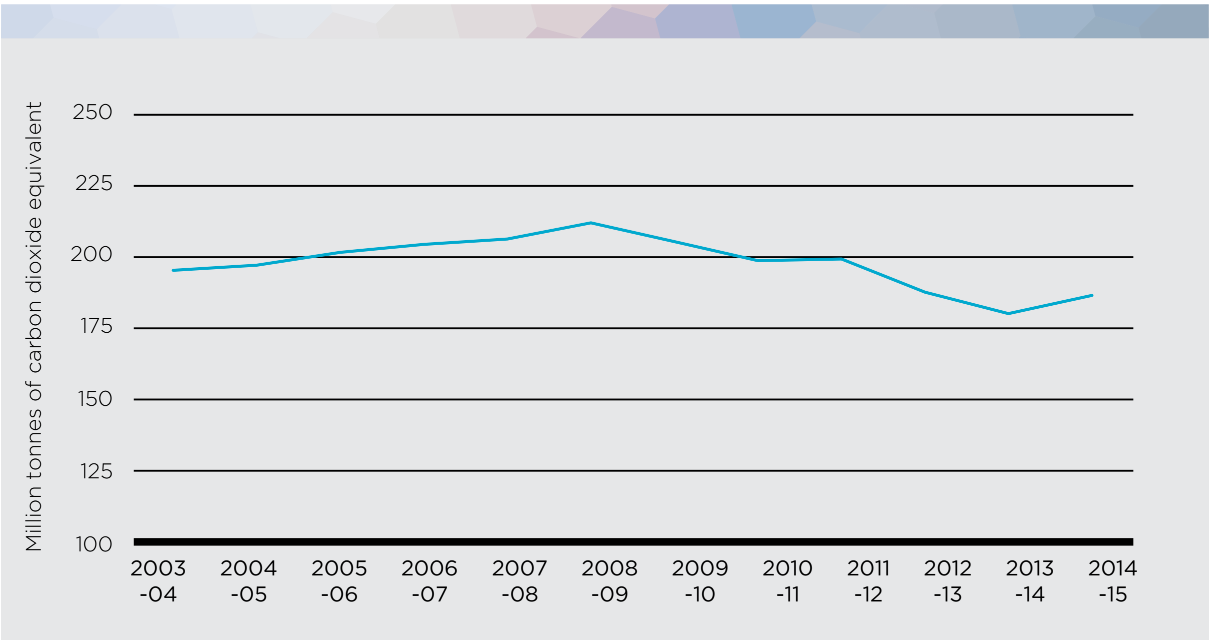
Source: Australian Photovoltaic Institute 2015.

Figure 2.2: Historical and projected costs of Lithium-ion battery packs



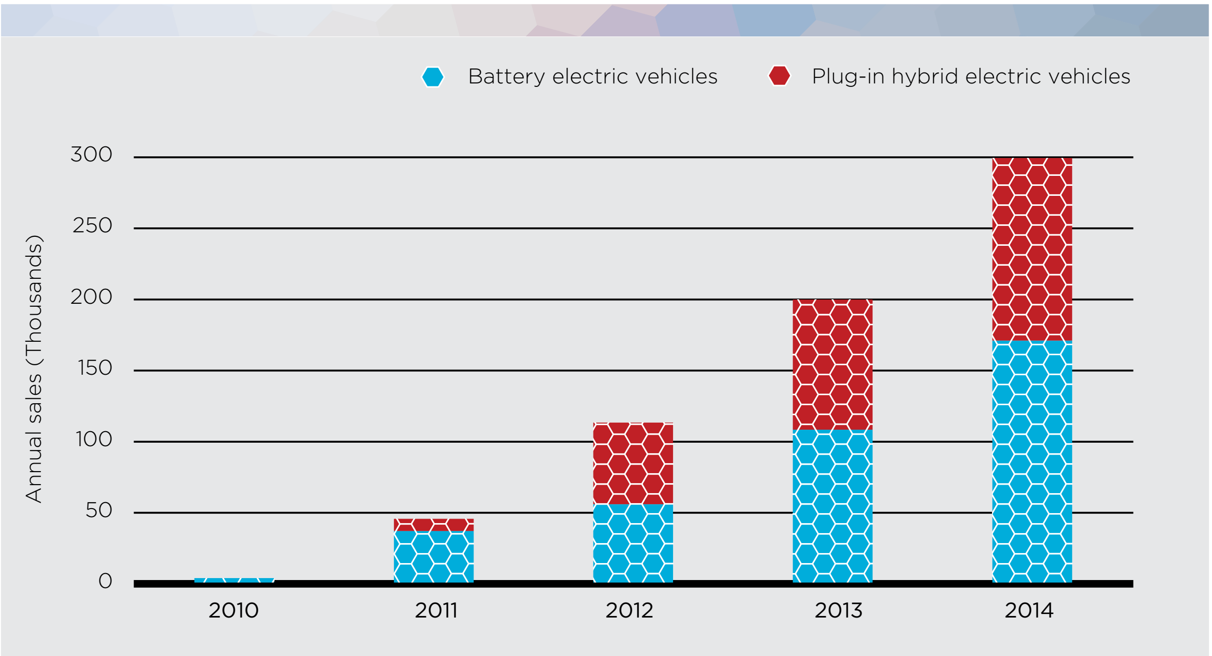
Source: Nykvist & Nilsson 2015.

Figure 2.3: National electricity sector greenhouse gas emissions



Source: Department of Environment 2015, and Pitt & Sherry 2015.

Figure 2.4: Global electric vehicle sales



Source: International Energy Agency 2015.

Like rooftop solar PV, electric vehicles have been around in niche applications for a very long time. Solar panels reached a clearly observable ‘tipping point’ in about 2010. They became cost competitive in many countries, including Australia, due to both the significant support of government-mandated policy incentives and the manufacturing scale efficiencies that the global accumulation of those policies enabled. Electric vehicles could follow a similar path to market, with several countries offering incentives and global manufacturing appearing to scale up (Figure 2.4). Anticipated reductions in energy storage costs will also boost the likelihood of vehicle electrification.

Continuous stream of new information

New information about the transformation of Australia’s electricity sector is emerging almost monthly, which is a major challenge for the Roadmap program work. It’s not surprising that stakeholders now have a much better understanding of some important factors than they did at the end of the Forum. The major changes in the 2015 modelling are:

- **Generation** – lower capital costs, especially solar PV; 2020 Large-scale Renewable Energy Target reduced to 33 terawatt-hours; delayed carbon abatement policy to 2020; slightly higher carbon policy price signal by 2050
- **Distribution and transmission** – reduction in some capital and operating costs; greater use of batteries at lower cost; significant pricing reform proceeding
- **Retail** – no major changes; retail pricing response to distribution and transmission pricing reform remains uncertain
- **Customers** – consumption volume growth rate lower; pool pumps included as residential demand management option; larger and lower cost batteries available to commercial and residential sector; solar panels the preferred distributed generation option for most customers, crowding out gas based options.

Following is a closer look at some of the new information.

Variation across states and customer groups

Common stakeholder feedback is that the assumptions of the 2013 scenario set generalised too greatly across Australian states and customer groups. State differences are substantial. For example, it is clear from 2015 data that Queensland, South Australia and Western Australia have significantly higher rates of residential solar adoption than the other states and territories (Figure 2.5). The states also differ in the way they price electricity services and in the types of services and infrastructure they offer. Victoria has 100 per cent deployment of smart meters but only 0.3 per cent adoption of the electricity tariffs that use that technology, such as time of use tariffs.[20] This is despite current discussions between networks and retailers in this state to explore opportunities to progress more cost reflective pricing structures.

New South Wales is the most advanced in deploying time of use tariffs, but has recently identified potential changes to proposed distribution tariffs given the current distribution operating environment and the fact that the majority of households do not have smart meters. Queensland has a comparatively high proportion of customers engaging in demand management programs, receiving rebates in exchange for having their airconditioning and pool pumps included in controllable loads.

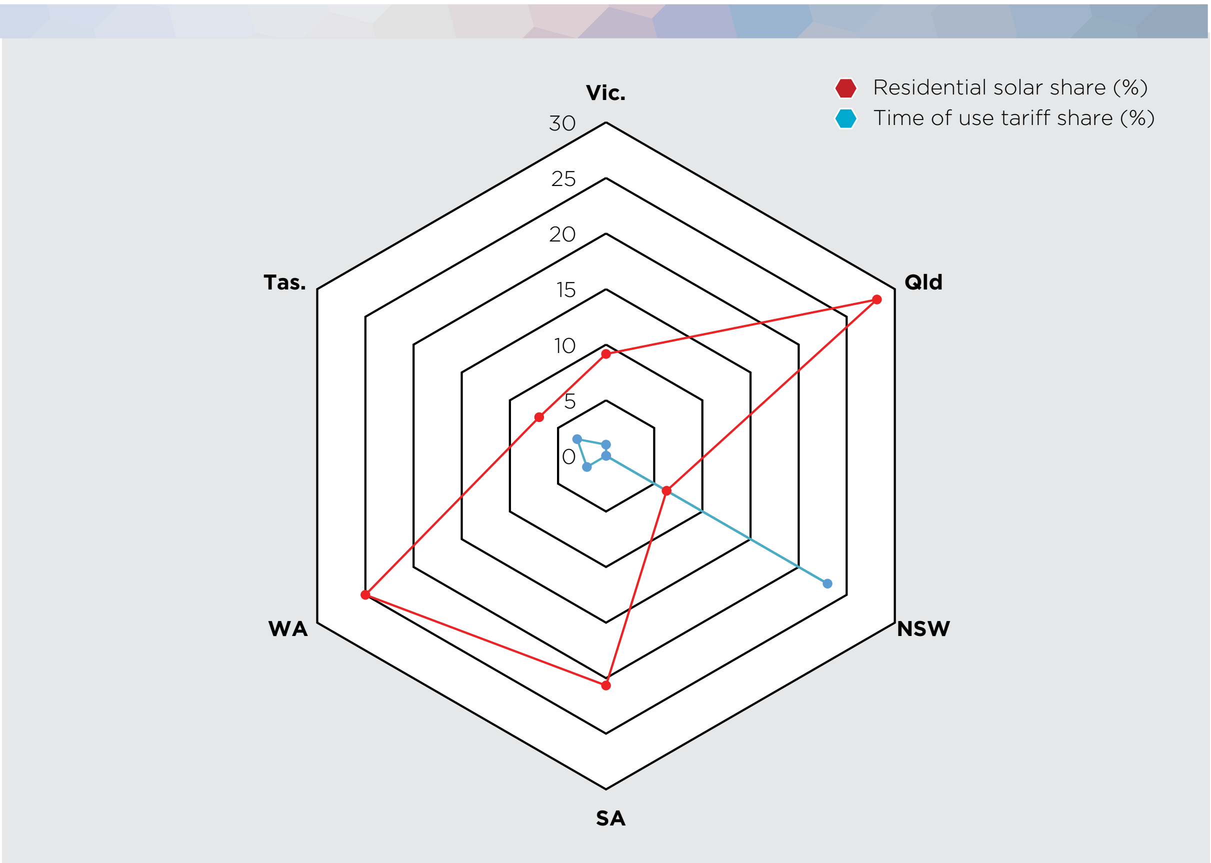
The assumptions for the 2015 scenario set better reflect these differences across states. The Roadmap program also assumes there will be some convergence over time as the state policies that encouraged these differences start to harmonise through the involvement of institutions such as the Council of Australian Governments (COAG) Energy Council.

When interpreting the long term scenarios, another point of difference between the 2013 Forum set and the 2015 set relates to customer behaviour. All four scenarios (both 2013 and 2015 sets) feature a particular customer behaviour:

- Scenario 1 ‘Set and forget’: passive; prefers agents to manage services
- Scenario 2 ‘Rise of the prosumer’: engaged; active involvement in service selection and management
- Scenario 3 ‘Leaving the grid’: lacking trust in utilities; interest in disconnection as an unintended response to incentives
- Scenario 4 ‘Renewables thrive’: warmth, familiarity and preference for renewables and storage.

20 Victorian Auditor General 2015, *Realising the benefits of smart meters*, Victorian Government.

Figure 2.5: 2015 shares of residential adoption of solar panels and time of use tariffs, by state



Because customers aren't uniform in their attitudes or behaviours, the scenarios cannot be uniform in their representation of customers. Each scenario can represent only a particular mix of customers who share a strong bias towards a particular attitude and behaviour. While the 2015 scenario set retains the same construction as the 2013 scenario set, this issue is important to how the Roadmap program will assess customer outcomes in this analysis. Ideally, the Roadmap needs to be able to represent mixes of different customer types – both customers represented by the scenario bias and the remaining diversity of customers. The analysis in this Chapter only partly achieves that, and so the Roadmap program will be including this topic as a development challenge for further research on how to model customer impacts in Stage 2 of the Roadmap.

Little change to date in electricity services pricing structure

The Forum had high expectations for electricity pricing reform in Australia in 2013 based on the widely accepted view that pricing structures for residential and small commercial customers were leading to inequities between customers, and were incentivising investments that may not be in the long term interests of all. The need for more cost reflective electricity pricing seemed obvious.

Two years on, there is very little change in the way electricity services are priced and, going forward, the rate at which more cost reflective pricing will be deployed at the retail level is unclear. There are positive signs in a National Electricity Rule change that distribution service providers have a clearer mandate to introduce more cost reflective pricing of services to retailers for small customers. Some research shows most customers would benefit from a different distribution pricing structure and that this new pricing structure would likely provide better customer incentives and rewards for adopting storage and other demand management technologies.[21]

21 Australian Electricity Market Commission (AEMC) 2014, National Electricity Amendment (Distribution Network Pricing Arrangements) Rule 2014, Sydney, www.aemc.gov.au/getattachment/de5cc69f-e850-48e0-9277-b3db79dd25c8/Final-determination.aspx

There remains a number of practical barriers to electricity pricing reform, including the limitations of most Australian electricity meters, jurisdictional constraints, and uncertainty over the extent to which the distribution pricing signal will be reflected in retail prices.

Apart from Victoria, most states don't have the smart meter infrastructure to take on more sophisticated tariff structures. The deployment of advanced meter infrastructure in other jurisdictions will depend on a range of factors. These factors include the introduction of a new contestable metering framework and its implications for a 'market led' rollout based on energy service offers to customers, or policies governing the meter to be installed for new connections, or the need to replace an end-of-life meter. Other factors that could affect the pass through of a cost reflective distribution tariff 'signal' to retail customers include the approach to migrating customers to cost reflective tariffs and retailer market behaviour, such as the use of price differentiation strategies.

Given these competing forces, the 2015 scenario set reflects the difficulty in forecasting electricity pricing frameworks. A challenge in creating the 2015 scenario set was assigning alternative electricity services pricing frameworks to each of the four scenarios. These frameworks are a key contingent factor likely to impact on customer outcomes and this will be addressed further in Stage 2 of the Roadmap.

Links between customer attitudes, electricity services pricing, and technology adoption

Because so little was known about the potential of some technologies and the future of pricing structures in 2013, the assumptions on these topics were fairly generic across the 2013 scenario set. Stakeholders challenged the Forum to develop a consistent approach to matching these assumptions to the scenarios and representing a diverse set of outcomes.

Given each Forum scenario includes a customer attitude bias, in creating the 2015 scenario set CSIRO used that bias to set the electricity service pricing environment in each scenario, in particular the extent to which prices become more cost reflective (Figure 2.6). CSIRO did not specify in each scenario what form the more cost reflective pricing would take.

It assumed networks have a general preference for their part of the retail pricing structure to be represented by either demand or kilowatt based charges. Over time it may be beneficial to go significantly beyond that and introduce other aspects of cost reflective pricing, such as locational and temporal pricing signals, to recognise differences in network congestion across these parameters. Chapter 5 discusses the types of cost reflective pricing and incentives that could be considered a 'Second wave' of tariff reform.

The exception is Scenario 3 ('Leaving the grid') in which CSIRO assumes a pricing structure with a fixed distribution charge, which does not therefore change with the volume of electricity consumed. This pricing structure is particularly suited to this scenario because it makes the decision to disconnect from the grid more plausible. That is, a fixed distribution charge means customers wishing to use more solar and storage to reduce their electricity bill would eventually need to disconnect to do so (once economically viable). They get no more rewards from the pricing structure for reducing their consumption below a certain level.

The pricing structure in the scenarios is aligned with the level of technology adoption. Less cost reflective pricing structures that recover a greater portion of costs through volumetric charges see an increase in the adoption of distributed generation (dominated by rooftop solar panels that reduce a customer's net volume of electricity consumption). By contrast, greater use of cost reflective pricing leads to relatively lower adoption levels of distributed generation (but tends to encourage storage which can shape a customer's load, to match incentives provided by alternative pricing structures). However, even in these scenarios, there is still significant growth in distributed generation (see Figure 2.11 below).

CSIRO assumed the availability of willing customers with smart meters determines the adoption of storage and other demand side management across the residential and commercial sectors. That is, these technologies are generally associated with high cost reflective pricing scenarios, but not exclusively so.

Figure 2.6: Methodology for assigning pricing and technology assumptions

Social attitude implied by scenario	Determines retail CRP, advanced meter and solar adoption	Determines DSM & storage adoption to minimise bill
Set and forget: passive; open to others selecting best tariff and technology for them	High retail CRP; low solar adoption	High storage & DSM
Rise of prosumer: engaged; markets waits for their lead; opt-in pricing to suit them	Medium-low retail CRP; very high solar adoption	Medium-low storage & DSM
Leaving the grid: lack of trust in grid; responding to unintended incentives (e.g. fixed charges, volume tariffs)	Medium retail CRP and high disconnected solar adoption	Connected: Low DSM Disconnected: high storage
Renewables thrive: trust, warmth and familiarity for renewables, storage and centralised power supply	High retail CRP and medium-low solar	High storage & DSM

CRP = cost reflective pricing
DSM = demand side management

Changing price trajectories of solar PV, energy storage and fossil fuels

The cost of solar PV and energy storage technology reduced faster than the Forum anticipated in 2013 (Figure 2.7). As a consequence, CSIRO brought forward the adoption of these technologies in the 2015 scenario modelling, through a combination of selecting least cost in the modelling process and relaxing non-cost related assumptions.

Prices of fossil fuels (coal, gas and oil) have also fallen, which is opposite to the 2013 expectation of a steady rise. Fossil fuel prices are still expected to rise in the long run, according to leading institutions' outlooks, but the price path will commence from a lower base level in 2015.[22]

The lower outlook for gas prices (Figure 2.8) improves the prospects for adoption of gas based distributed generation across the scenarios, but this change in fossil fuel price assumptions is not a significant enough advantage for gas based technologies to mirror the success of solar (without a specific breakthrough, such as in the the costs of fuel cells).

22 International Energy Agency (IEA) 2014, *World Energy Outlook 2014*, OECD/IEA, Paris; International Energy Agency (IEA) 2015, *Global EV outlook*, IEA/OECD, Paris, http://www.iea.org/topics/transport/subtopics/electricvehiclesinitiative

Figure 2.7: Previous (2013) and updated (2015) battery (right axis) and rooftop solar panel (left axis) projected technology costs

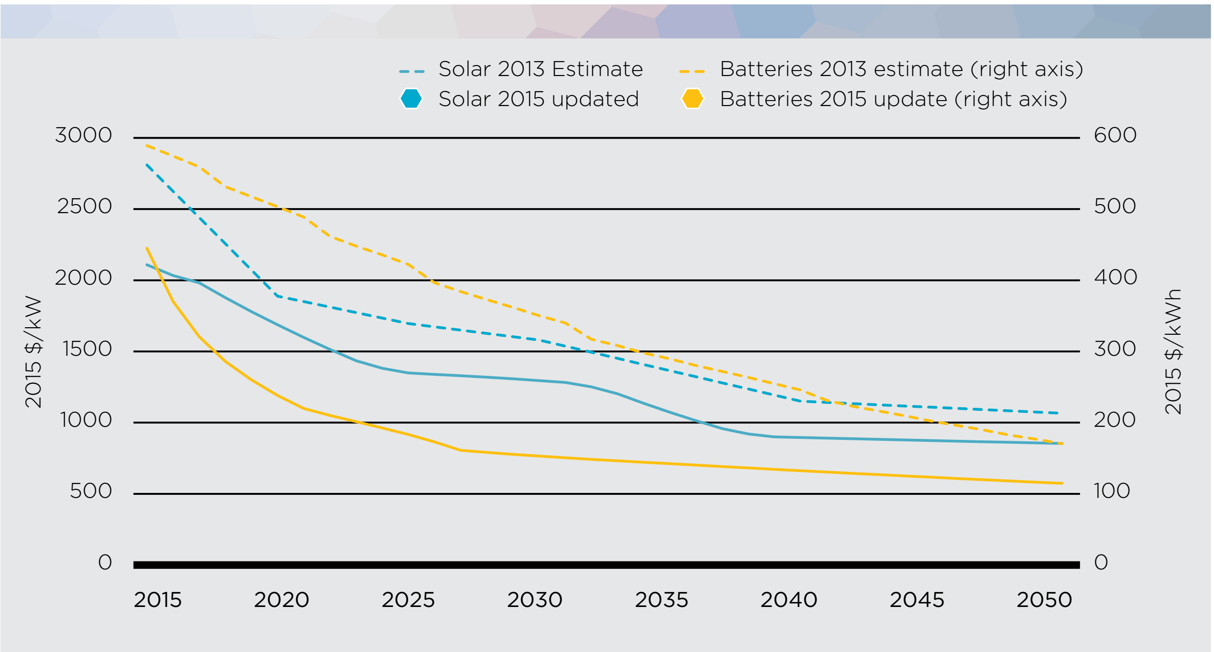
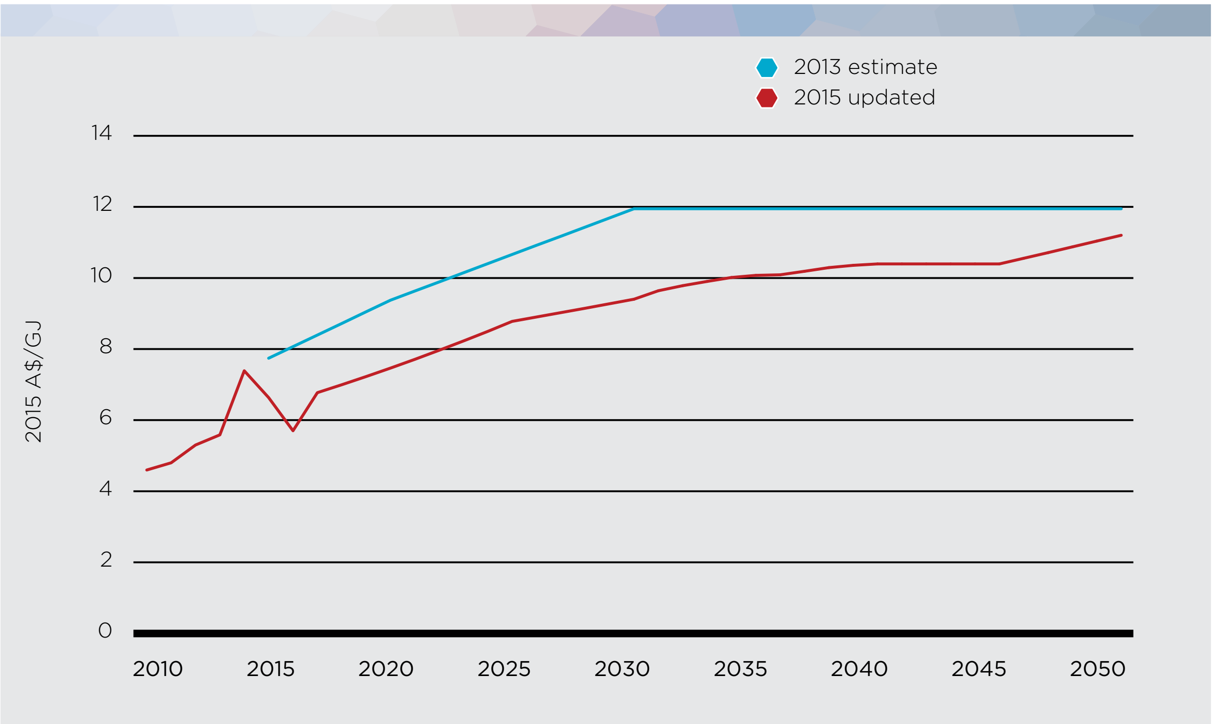


Figure 2.8: Previous (2013) and updated (2015) gas cost projections



What the 2015 scenario set is telling us

This section presents highlights of the 2015 scenario set modelling results.[23]

Electricity consumption and distributed generation

The projections of growth in consumption in the 2015 scenario set are partly an assumption and partly a projection. CSIRO assumed that underlying growth in consumption in all scenarios matches the 2015 medium case projections from the Australian Energy Market Operator and the Independent Market Operator. However, the CSIRO used its own transport modelling to project an additional level of consumption on to this assumed growth due to electric vehicle adoption. This begins around the mid-2020s (a five-year delay compared with 2013 assumptions, recognising the impact of lower oil prices but arriving at a similar level by 2050). Based on CSIRO's review of available projections, including its own and those from other organisations, and the increasing confidence in energy storage costs reducing, CSIRO believes electric vehicle adoption is more likely than not. Therefore, it is justifiably included in the 2015 scenarios (although not yet part of the methodologies of the Australian Energy Market Operator and the Independent Market Operator).

The resulting National Electricity Market consumption Forum projections are shown in Figure 2.9 and the Australian Energy Market Operator projection is included for comparison.[24] Scenarios 1 to 3 ('Set and forget', 'Rise of the prosumer' and 'Leaving the grid') are each assigned the same level of road vehicle electrification. By contrast, Scenario 4 ('Renewables thrive') is assigned a higher level given it has a low cost of energy storage (resulting from the wider deployment of energy storage in that scenario).

The level of distributed generation is partly a result of least cost economic choices in the modelling, but also partly a result of adjusting non-price related assumptions to achieve the intended outcome for the scenario. That is, any distributed generation projected in each scenario is economically viable, but there are different pricing structures and attitudes expressed as adoption constraints across the scenarios that change the level of projected uptake.

The projected uptake of distributed generation is shown in Figure 2.10. Reflecting the continued cost reductions in rooftop solar panels, not surprisingly around 84–87 per cent of distributed generation across the scenarios is solar, and the remainder is gas and biomass-fuelled.

After distributed generation is accounted for in total consumption, the remainder is the amount of consumption that electricity supplied from the grid must meet. This is shown in Figure 2.11. Under Scenario 3 ('Leaving the grid'), in the period between 2030 and 2050, all customers with distributed generation gradually disconnect from the grid.

Peak demand and demand management

Consistent with the approach outlined, CSIRO determined the level of demand management activity (including energy storage adoption) in each scenario by:

- the social attitude the scenario captures
- the subsequent openness of customers to alternative electricity service pricing structures and associated demand management opportunities
- underlying or market led growth in smart meter adoption.

The projected growth in peak demand in the National Electricity Market based on these assumptions is shown in Figure 2.12.

Scenario 1 ('Set and forget) has the highest level of demand management, followed by Scenario 4 ('Renewables thrive'), but CSIRO projects the lowest peak demand will occur in Scenario 3 ('Leaving the grid') in the period from 2035 as a result of customers completely removing their volume and their peak demand from the grid through disconnection. Scenario 2 ('Rise of the prosumer') has the highest peak demand given an assumed bias towards existing volume based pricing of electricity services for small customers.

23 Graham, P, Brinsmead, T, Reedman, L and Ferraro, S 2015, *Electricity transformation and Future Grid Forum refresh: final report*, Energy Networks Association.

24 Australian Energy Market Operator (AEMO) 2015, *National electricity forecasting report (NEFR) 2015*, http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report

Figure 2.9: Combined electricity consumption from network and distributed generation sources for National Electricity Market states under the Australian Energy Market Operator 2015 medium projection and 2013 Forum scenarios

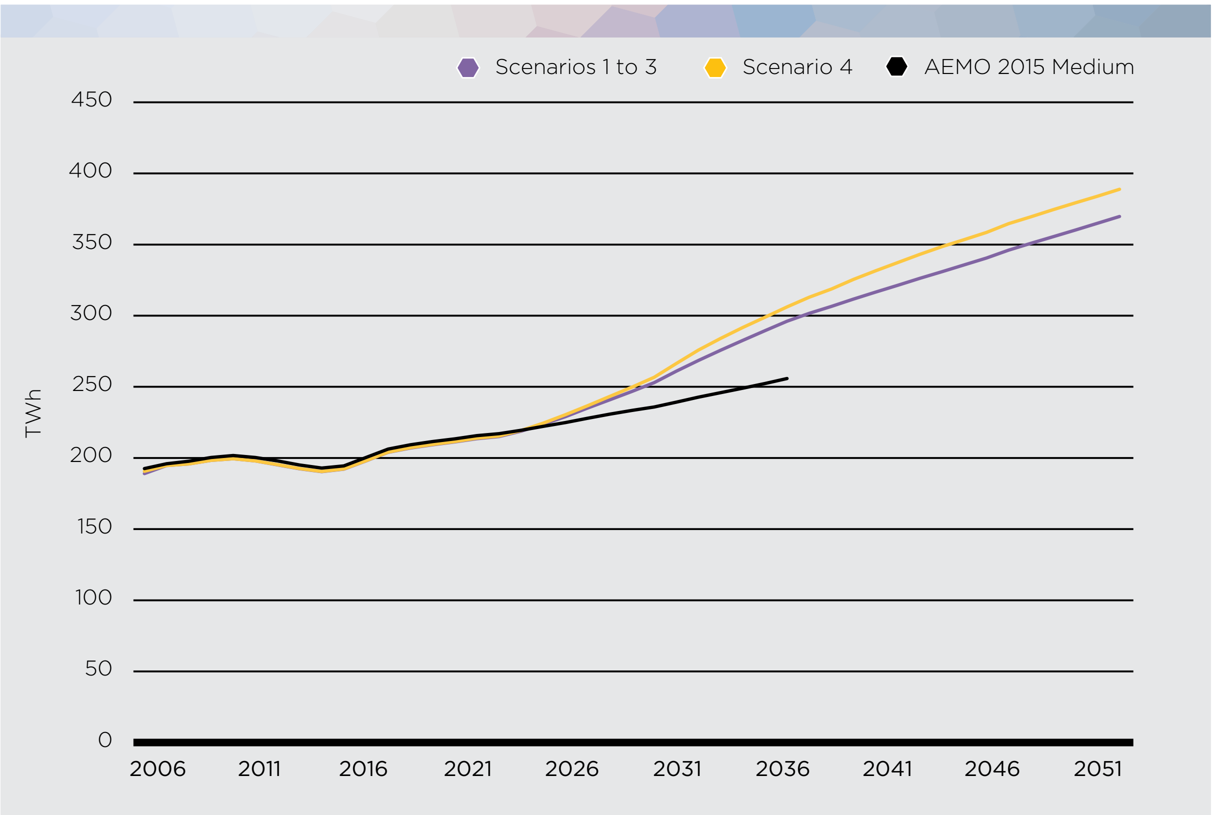


Figure 2.10: Projected share of distributed generation (mostly rooftop solar PV systems), by scenario

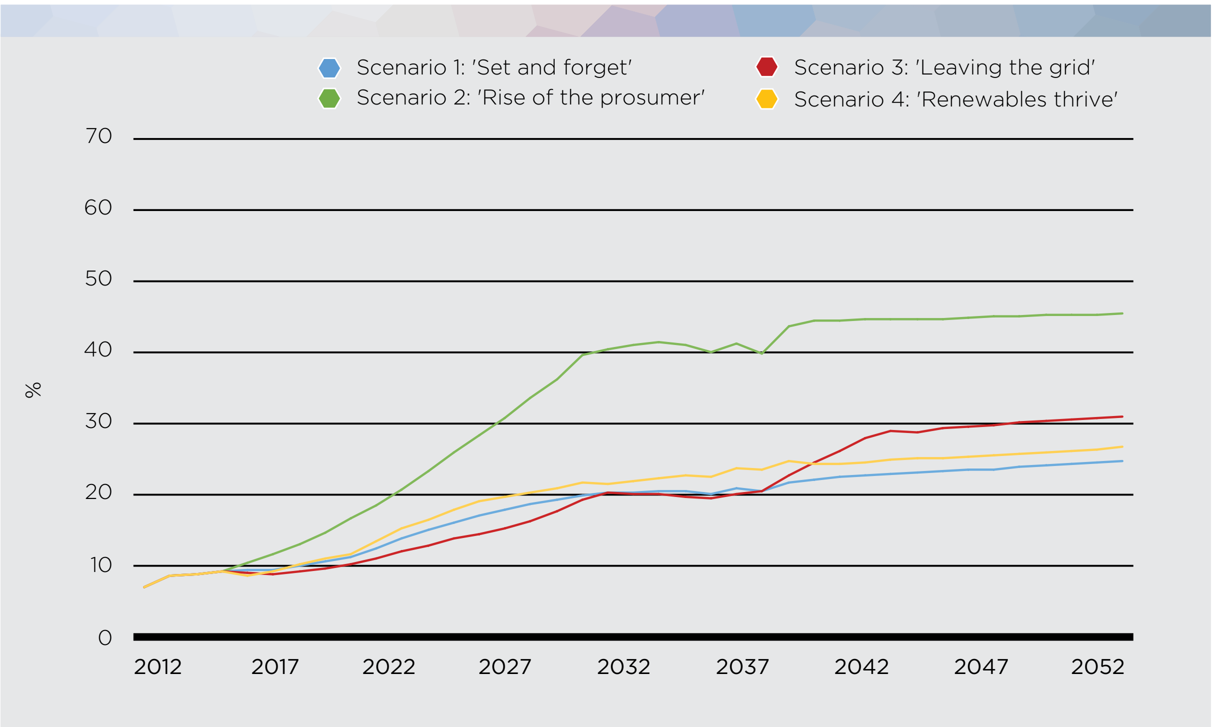


Figure 2.11: Projected consumption that only the grid must meet (after distributed generation is removed from total consumption)

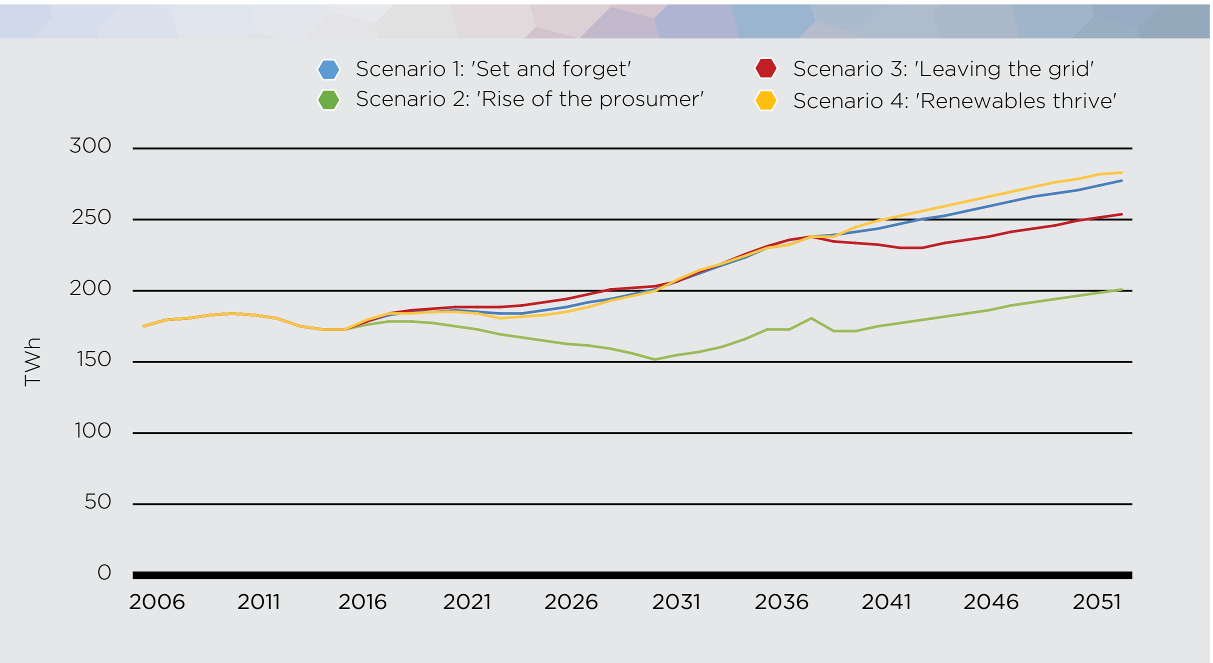
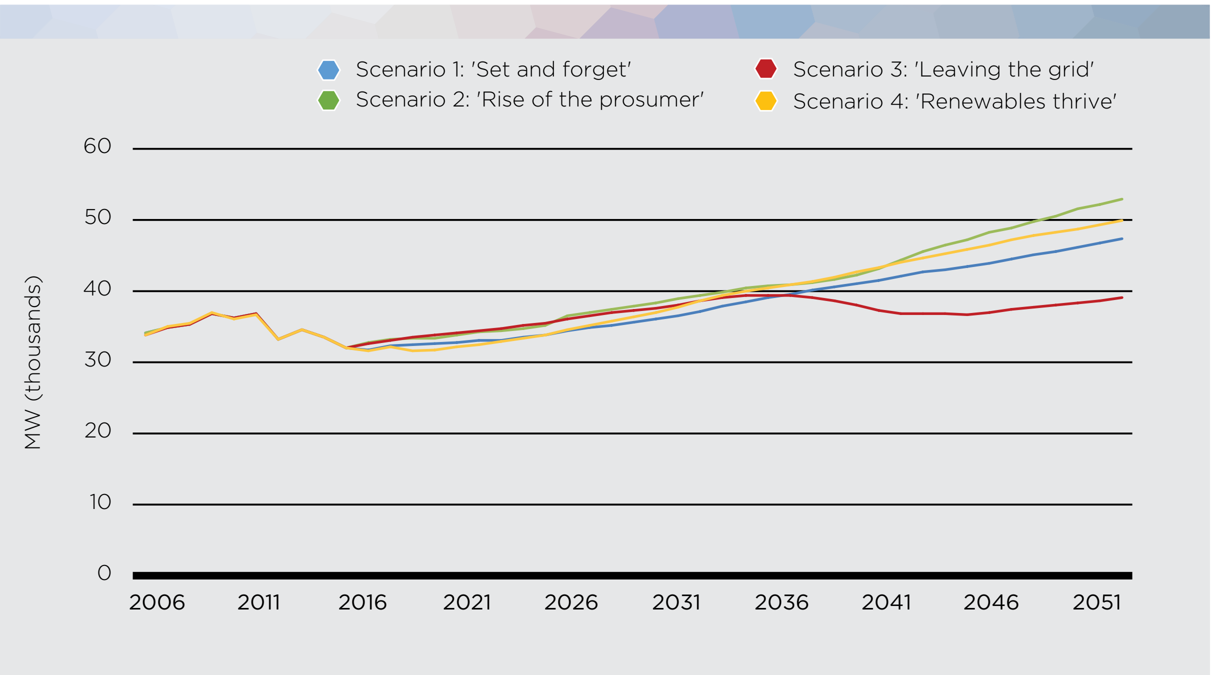


Figure 2.12: Projected National Electricity Market peak demand, by scenario



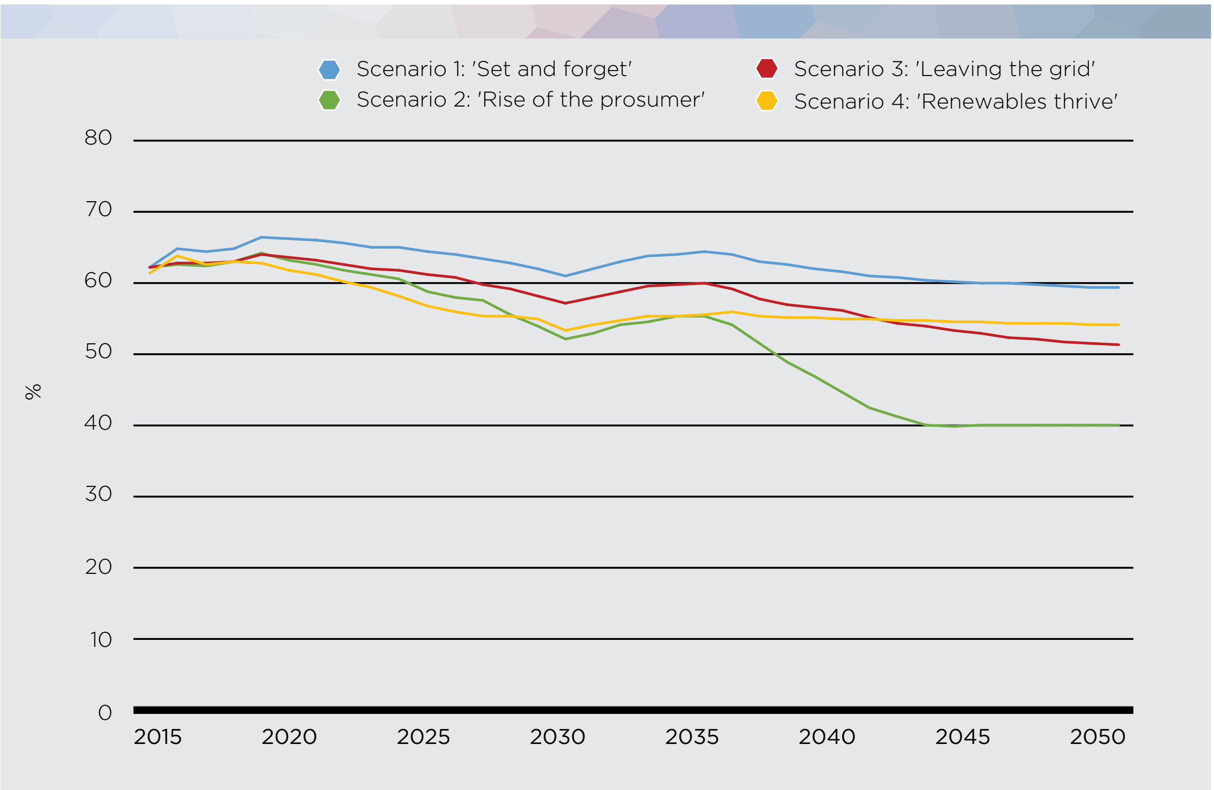
Implied aggregate grid utilisation

Total system costs and customer bill outcomes under all scenarios reflect both the investment in distributed energy resources and the grid infrastructure required to support the electricity system. Consequently, different scenario assumptions of the take-up of distributed energy resources and demand management will have consequences for grid utilisation. As in the 2013 Forum report, CSIRO has calculated an aggregate measure to indicate how the combination of electricity pricing structure and technologies is likely to impact grid utilisation. By calculating the ratio of the projected volume to be carried through the grid with its carrying capacity that will be built to meet projected peak demand, CSIRO projects the implied aggregate utilisation of the grid, shown in Figure 2.13.

The more limited growth in distributed generation and strong demand management in Scenario 1 ('Set and forget') could result in maintaining the grid at slightly lower than its current utilisation. In the remaining scenarios, the degree of demand management, while significant, has not been sufficient to significantly offset the impact of distributed generation on volume growth.

As in the 2013 Forum scenario analysis, the worst case outcome for efficient investment is Scenario 2 ('Rise of the prosumer') where there is both high distributed generation and more limited adoption of demand management. Scenario 3 ('Leaving the grid') and Scenario 4 ('Renewables thrive') lie between the two extreme results. Scenario 3 has the greater distributed generation and demand management, although 'demand management' in this scenario is achieved by customers, who would otherwise contribute to peak demand leaving the grid altogether, rather than through grid facilitated actions.

Figure 2.13: Projected implied utilisation of the grid



Wholesale electricity generation and prices

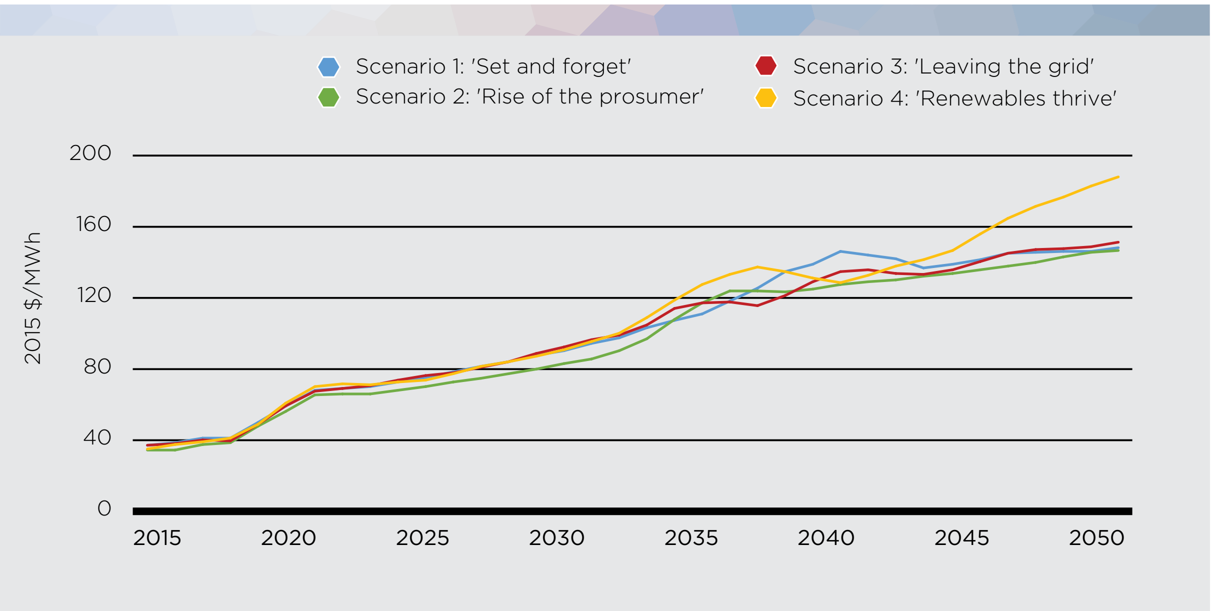
All the 2013 scenarios include a carbon price in their modelling as a proxy for any one (or a combination) of the many possible policy mechanisms the Government might eventually introduce to reduce greenhouse gas emissions in the electricity sector. The Forum took this approach to simplify the modelling rather than to state a preference for any particular policy mechanism. It was necessary to include some carbon constraint in the modelling since the 2013 scenarios included that in their design – reflecting that Forum participants did not believe it plausible to have a future without a carbon constraint.

The effect of the carbon price is to increase the cost of fossil based technologies, particularly those without carbon capture and storage, and make it possible for other low emissions technologies to compete. While the projected costs of some low emission technologies (such as solar PV) have significantly reduced, each scenario experiences an increase in generation costs as a result of the introduction of low emission technologies (Figure 2.14).

Scenario 4 ('Renewables thrive') has an additional policy mechanism forcing all electricity to be generated from renewable sources, implemented as an extension of the Renewable Energy Target to 100 per cent by 2050 beginning from 2035. To overcome the intermittency of some renewable electricity generating technologies, CSIRO used battery storage in this scenario as the main load-following technology since it is emission free, and gas peaking, 'the conventional back-up capacity method', is not. Recent analysis indicates the projected reductions in battery costs could mean that such an approach would come at no additional cost relative to gas peaking.[25]

Overall, however, adopting renewables to the exclusion of other technologies in Scenario 4 does lead to higher costs relative to Scenarios 1–3. By 2050, the projected generation costs are over $40 per megawatt-hour higher (or 28 per cent higher) than in the other three scenarios. The trade-off is an emission free electricity sector (except for a minor amount of diesel based distributed generation which is assumed not to be subject to the policy mechanism) compared with around 14 per cent of emissions remaining in the other scenarios relative to 2010.

Figure 2.14: Projected generation costs, by scenario



25 Brinsmead, T, Graham, P, Hayward, J, Ratnam, E and Reedman, L 2015, *Future energy storage trends: an assessment of the economic viability, potential uptake and impacts of electrical energy storage on the NEM 2015-2035*, CSIRO report to the AEMC, Report no. EP155039, CSIRO.

Transmission and distribution residential network prices

On average, network costs currently comprise 53 per cent of residential retail electricity prices. Distribution costs are the larger share, accounting for 44 per cent alone. However, there are substantial variations across jurisdictions, with network charges representing only 46 per cent of Victoria's residential retail electricity prices. Accounting for common structural factors (such as the turnover of capital stock in each transmission and distribution region and current allowable costs, as well as scenario-specific changes like the level of grid utilisation), CSIRO projected average residential transmission and distribution prices in dollars per kilowatt-hour. As discussed in Chapter 5, it is unlikely networks will continue to charge for services under this type of pricing structure in the future, given the structure's poor relationship to a cost base that does not change with the level of energy (watt-hour) throughput. However, CSIRO illustrated the price in this form because it gives an indication of the extent to which network utilisation could drive retail price increases. This would place upward pressure on retail prices, in addition to the upward pressure in price per watt-hour from the generation sector (discussed earlier).

Under current tariffs, a lower volume of *delivered* electricity to customers over the network would mean a higher price per watt-hour, even if:

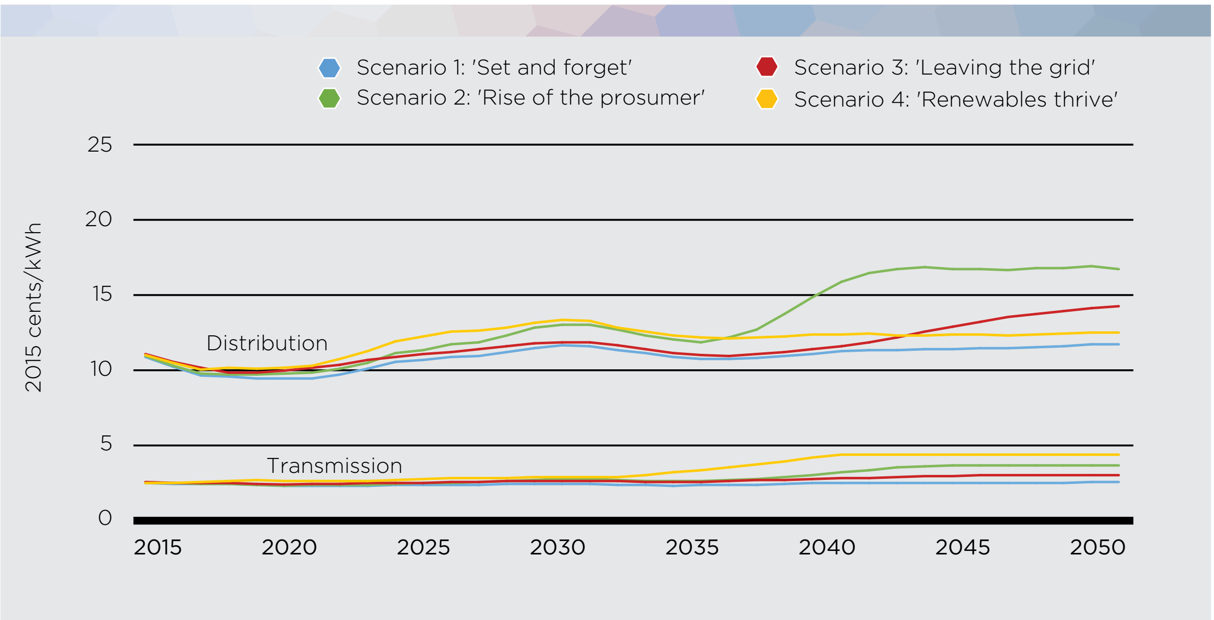
» network use at peak times did not fall commensurately

» exported electricity from customers to the network was significant.

In practice, the absolute cost of the network service on the customer bill would not reflect the same increases as the average price per watt-hour shown in Figure 2.15.

The result, shown in Figure 2.15, is network prices that are somewhat lower than those forecast under each scenario in the 2013 Forum set. The analysis indicates that network costs are likely to be reduced and maintained in the medium term, reflecting limited growth in peak demand. The scenarios begin to experience price increases, particularly the distribution sector in the period from the late 2030s as a result of declining network utilisation; less so for Scenario 1 ('Set and forget') where grid utlisation is stronger. The worst outcome is associated with Scenario 2 ('Rise of the prosumer') where the price in 2050 is 53 per cent higher than in 2015. However, the highest transmission cost outcome is under Scenario 4 ('Renewables thrive'), which experiences a 75 per cent increase by 2050. This rise reflects the need to extend the transmission system significantly, to connect a greater number and diversity of renewable electricity generation sources.

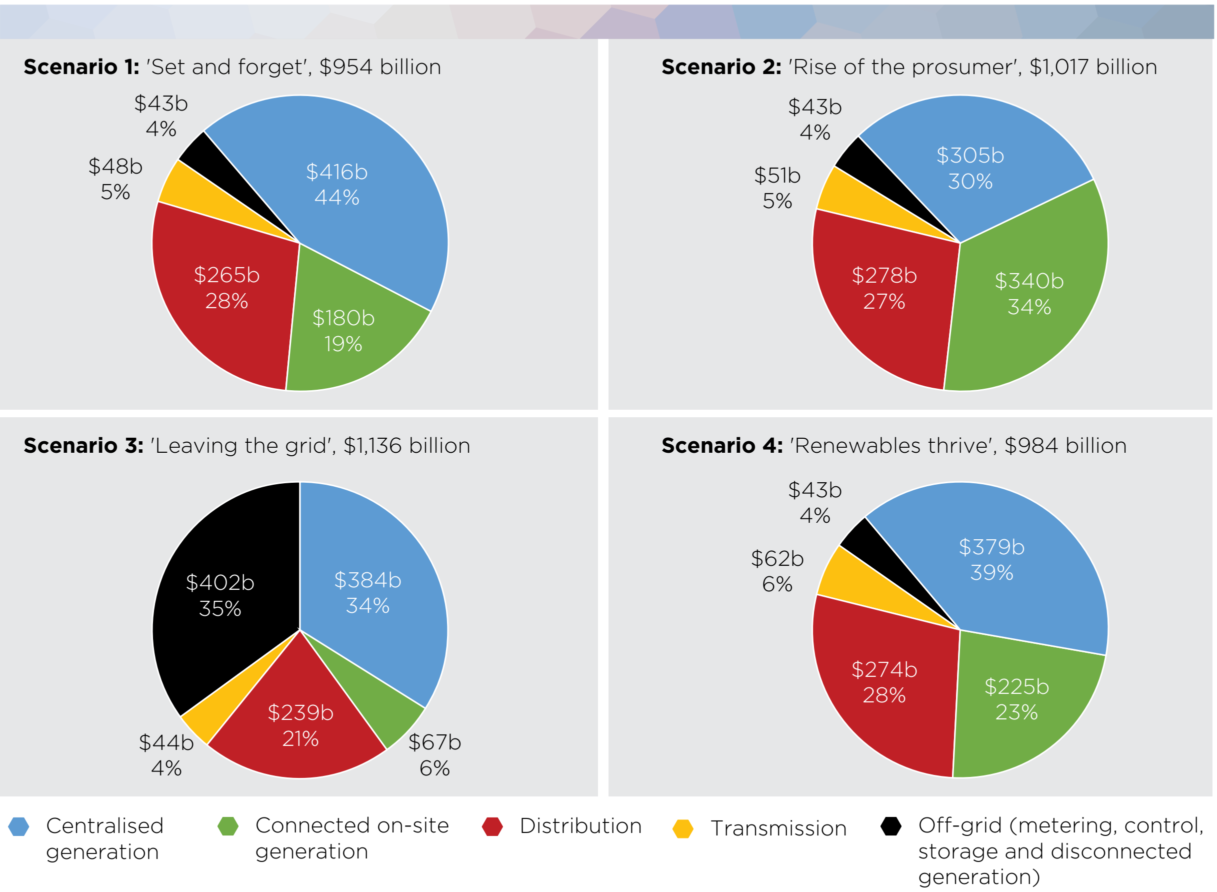
Figure 2.15: Average residential network costs per kilowatt-hour, by scenario



Total system impact

The scenario analysis identifies total system expenditure (including capital and operating expenditure) of $950 to $1,140 billion over the next 35 years (Figure 2.16). Between $220 and $470 billion is required in on-site or off-grid expenditure by customers and their agents. Significant network expenditure of $280 to $340 billion is also required, which represents about one third of total system expenditure in all scenarios.[26]

Figure 2.16: Projected cumulative electricity sector investment and operating expenditure to 2050 (including percentage contribution of each supply chain component), by scenario



26 These numbers appear very large, but across the economy, these electricity sector expenditure projections amount to approximately $1,000 per capita per annum to 2050. This amount is similar to the current level of expenditure and does not represent an unaffordable level of expenditure. (Indeed, as with previous modelling, household electricity bills are projected to retain their current share of household income , approximately 2–3 per cent.) Rather, it demonstrates that even small improvements in electricity sector efficiency can deliver substantial, multi-billion dollar dividends to the economy and directly to end-users who are expected to play a larger direct role in technology investment.

Financial impacts on customers

The combined effect of the generation cost and network cost increases shown across the scenarios means residential retail electricity prices are likely to increase. However, this is a poor indicator of customer impact because there is much more to an electricity bill than the retail price.

The mitigating factors for an increase in the residential retail electricity price are:

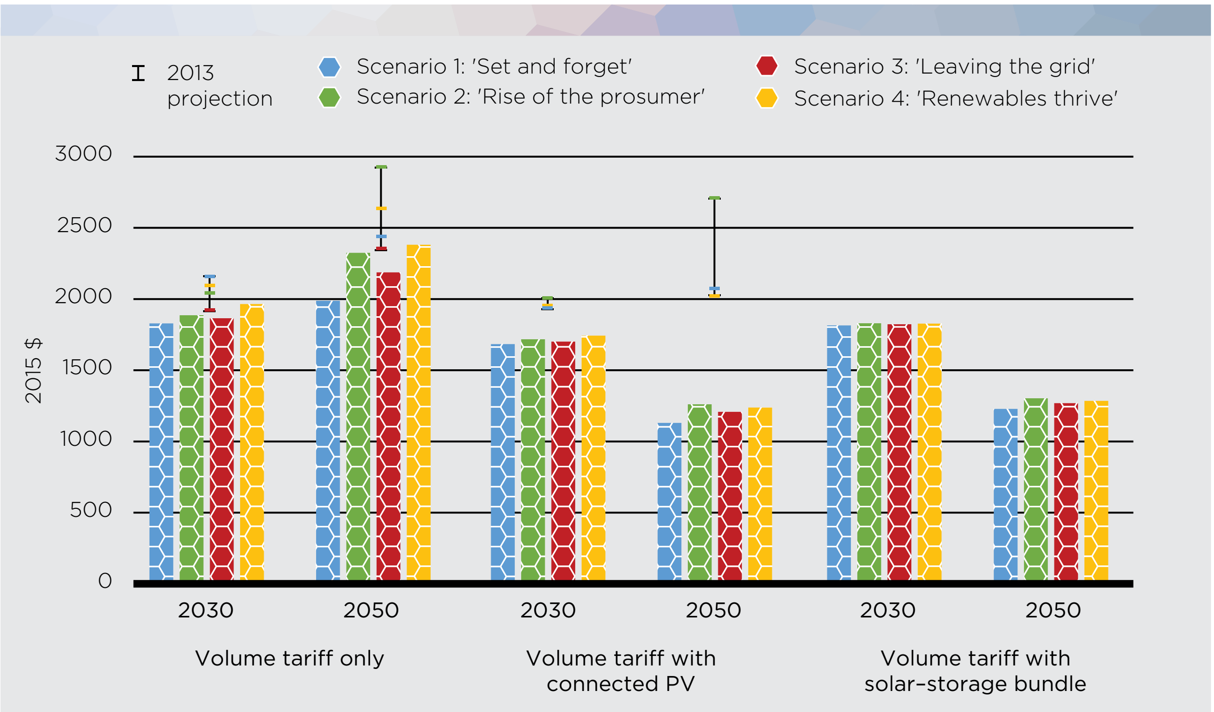
- changes in electricity consumption, for example, through more energy efficient electrical appliances and passive building efficiency
- changes in electricity use, through distributed generation and demand management
- changes in the structure for pricing electricity services to the customer.

To understand the financial impact of electricity sector changes on the customer, all factors must be considered, so CSIRO projected future electricity bills with these factors included in different combinations. As discussed, while there's a dominant customer type in each scenario, there's also a smaller share of customers with different behaviours, technologies and retail electricity service contracts. Where technology is included in the customer's profile, CSIRO included the annualised costs of purchasing and installing that technology and any required enabling technology in the annual bill. [27]

The projected average residential electricity bills for different types of customer tariffs and technology ownership are shown in Figures 2.17, 2.18 and 2.19. The bill is constructed for the average size residential customer in 2030 and 2050 and includes:

- the projected costs for generation, transmission and distribution
- assumed levels of solar feed-in tariffs
- a retail margin.

Figure 2.17: Projected average annual residential electricity bills under volume tariffs, by technology ownership and comparison with the 2013 Forum projections



27 In Scenario 3 ('Leaving the grid'), the customer cost outcomes (for on-site generation and storage) reflect the reasonable minimum cost at which a customer could leave the grid at that time. The quality of customer experience in terms of reliability and quality of supply would not be fully equivalent to the grid-connected service, but it is assumed to be acceptable to the customer at the time of leaving.

Figure 2.18: Projected average annual residential electricity bills under combined capacity and volume tariffs, by technology ownership

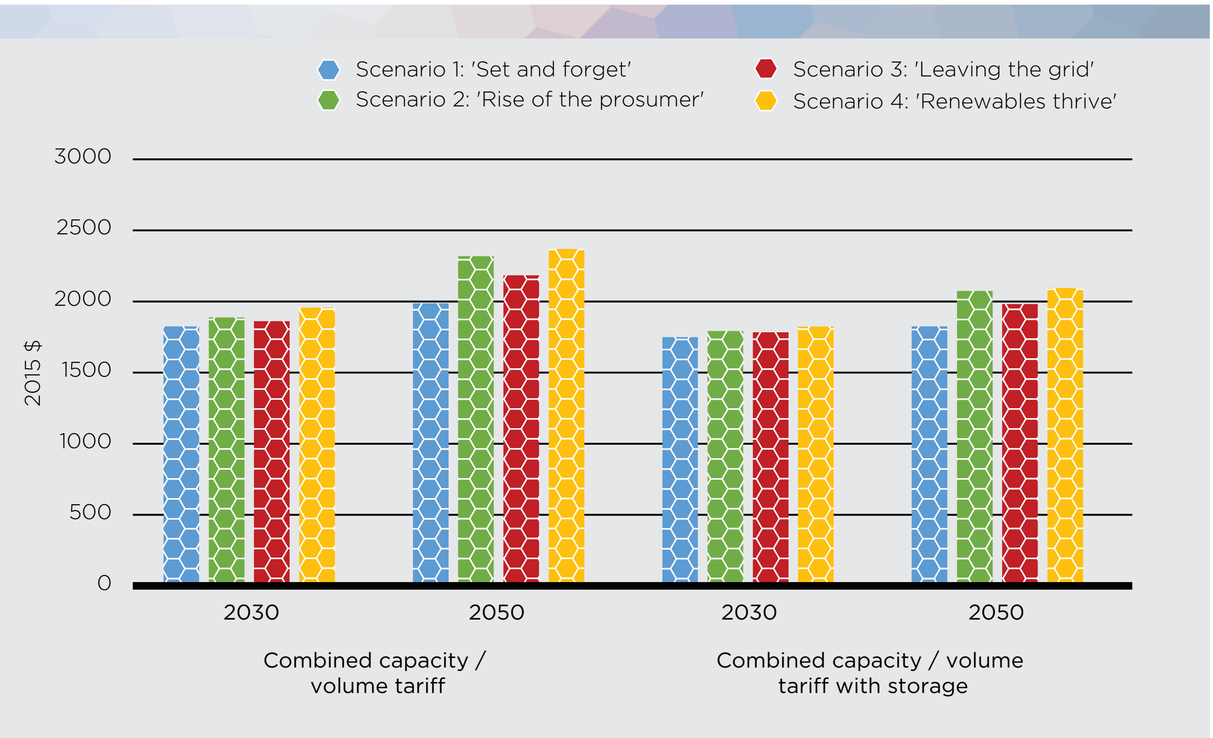
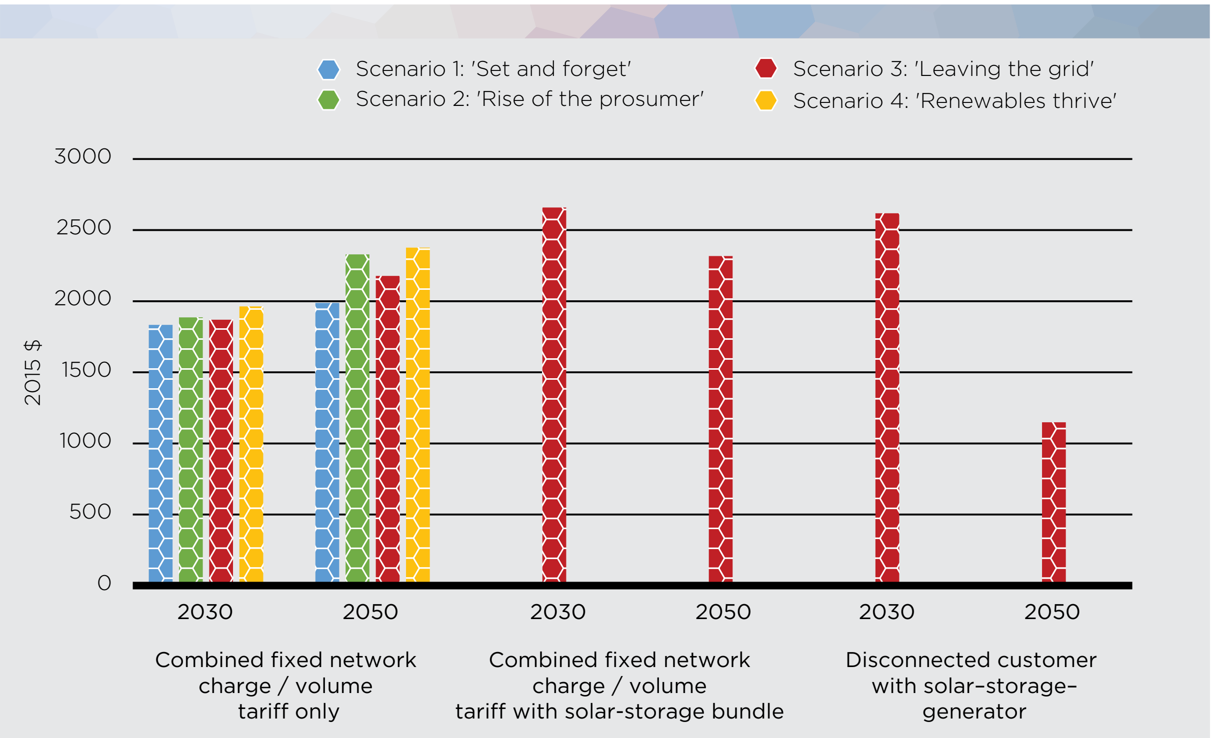


Figure 2.19: Projected average annual residential electricity bills under combined fixed distribution charge and volume tariff, by technology ownership



CSIRO assumed all tariffs or pricing structures would be set so they recover the same amount from the representative customer who has no technology. This may not be the case but is a useful simplification to give a common starting point irrespective of the tariff type before technologies are added in to the mix.

Figure 2.17 projects the electricity bill for customers with volume only tariffs who have no additional technology, install rooftop solar or install a rooftop solar–storage bundle. It also compares these projections with the 2013 Forum projections, which only included the first two customer types. Under the assumptions, installing rooftop solar leads to an improvement in the electricity bill relative to no technology in 2030, and a much greater improvement by 2050 because electricity system costs have increased and the cost of solar panels has fallen further.

In the case of the combined solar–storage bundle, the storage helps to reduce exports and minimise imported electricity to maximise the value of solar. Adopting this bundle leads to a modest bill improvement relative to no technology by 2030, but most certainly improves a customer's bill by 2050. Initially, larger customers are likely to find a bundle approach more worthwhile than the average customer because there's a high level of equipment costs that needs to be offset by avoided electricity contract costs.

Overall customer bills are lower than was estimated in the 2013 Forum projections and the relative merit order of scenarios has changed. Network costs are lower in the updated projections, reflecting stronger confidence in the system's ability to implement demand management, particularly through battery storage, to reduce the rate of decline in grid utilisation. Consequently, the increases in generation costs to achieve different emission reduction outcomes more strongly dominate changes in residential bills. As a result, Scenario 4 is the highest cost (but lowest emission) scenario for residential bills in this update compared with Scenario 2 in the 2013 projections which has the highest distribution costs.

Figure 2.18 examines a customer who selects a combined volume and capacity tariff where they are charged for both their volume and individual peak demand (the capacity of the distribution network they use). However, their volume charge is reduced so that their bill, with no technology, is the same as in the previous volume only tariff example. In this case, the area of interest is how installing battery storage might reduce the customer's exposure to peak demand charges and reduce their bill. They have not installed solar and so this option might reflect someone who lives in an apartment or dwelling that's less amenable to solar than the average house. However, these specific outcomes illustrate that it would be possible for customers to install storage by 2030, as a response to the incentive of a capacity tariff. Even without on-site storage, such a customer may achieve cost savings through a storage investment, reflecting their ability to lower their capacity charge.

Figure 2.19 examines a customer with a combined fixed distribution charge and volume tariff. The customer bill includes a fixed charge independent of the amount of electricity consumed, which could represent the cost of fixed distribution assets, and a smaller volume rate charge so that, with no additional technology, this bill is the same as those in the previous two examples. To assess Scenario 3 ('Leaving the grid'), CSIRO assumed this to be the mandated tariff type for customers with grid-connected technology installed.

This tariff recovers the cost of serving the customer, reflecting the fixed cost structure of the distribution network, and is likely to provide little incentive to install a solar–storage bundle. This is because the effect of solar and storage (reducing the volume of electricity imported) only partially reduces the bill (because of the fixed component of the tariff structure) and is not enough to offset the annualised cost of installing those technologies. However, this type of tariff structure is susceptible to encouraging customers to leave the grid when it becomes economic to do so.

A customer facing this tariff profile could choose to increase the value they get from solar and storage technologies by disconnecting from the grid altogether, as demonstrated in the bill for a customer who is disconnected with a solar–storage–generator bundle. This option is projected to be economically unviable in 2030, but by 2050 (with parity reached from around the late 2030s) leads to an improvement in the average customer electricity bill. This is consistent with the design of Scenario 3 ('Leaving the grid') whereby customers only begin to disconnect from the late 2030s. An important caveat here of course is that the electricity service the disconnected customer receives may meet their needs, depending on many factors, but is not the same as that delivered by the grid.

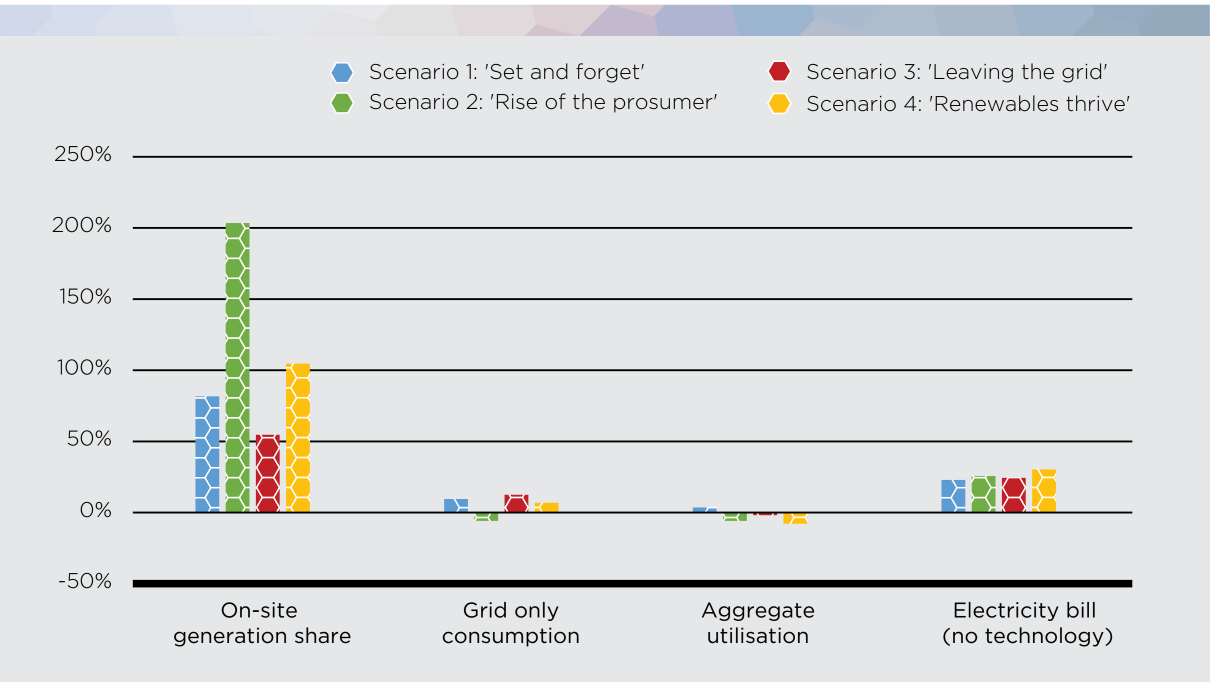
The financial impacts on large electricity customers is also an important scenario metric. Briefly, because large customers' pricing structures are more closely linked to the generation price, the projected increases in prices in that sector affect them more significantly. On the other hand, large customers are less affected by changes in distribution and transmission costs. Given the diversity of large customers as a customer segment, it is much more difficult to talk about an average electricity bill for them.

The 2025 intermediate state and baseline

The Roadmap focuses on the decade from 2015 to 2025 and so CSIRO targeted modelling results at that time period, without losing sight of the longer term picture. CSIRO began with no expectations of 2025 results across the scenarios.

From the perspective of simplifying the baseline for Roadmap actions and industry planning in general, it would be beneficial if some scenario results were almost identical in 2025, and then diverged later in the projection period. Figure 2.20 is a cross-scenario snapshot of 2025 changes relative to 2015, comparing the key modelling projections. It highlights that the growth in share of distributed generation remains very uncertain and in 2025 could be between a half to three times higher than in 2015. Grid consumption is expected to be slightly higher, except in the highest distributed generation adoption case (Scenario 2), but in all but the strongest demand side management case (Scenario 1) peak demand grows faster, leading to a slight decline in grid utilisation.

Figure 2.20: The percentage change in key scenario projections in 2025 compared with 2015, by scenario



Residential electricity bills are expected to be between 23 and 30 per cent higher in 2025, but this reflects the form of carbon abatement policy chosen. Actual implemented policy formulations may not have the same impact on electricity costs or may be compensated, for example, with offsetting tax arrangements.

The comparison indicates that scenarios 2 and 4 (‘Rise of the prosumer’ and ‘Renewables thrive’) are the most different across the various projection parameters, and this is no surprise since they both include very strong distributed generation adoption. If the focus narrows in on grid consumption and utilisation, the scenarios are fairly similar by 2025. This may serve as a useful guide to how to construct baseline comparisons in the future.

The pathways we’re currently tracking

Australian solar PV cell adoption since 2013 and into the future is tracking at the high end of the range of distributed generation share projected under the 2013 scenario set and modelling. In that respect, the electricity system is tracking further away from Scenario 1 (‘Set and forget’) than the other scenarios on this point alone. On the other hand, the early improvement in battery storage costs and regulations encouraging more cost reflective network pricing provide some elements necessary to create a system that benefits consumers without relying so heavily on solar panels to address ‘bill shock’ or consumers being required to play an integral role in its day-to-day operation.

Other important scenario features, such as electric vehicle uptake, climate policy, and grid disconnection, may take a decade to play out and as such provide no early guide for tracking scenario progress. The system is still grappling with the issue of cost reflective pricing (discussed in Chapter 5).

Overall, all the scenarios remain generally similar in their plausibility. They are perhaps less plausible towards 2050 since their explorative nature means they were not designed with a full range of industry, regulatory and policy responses included. Consequently, the scenarios can appear at odds with steps that one could reasonably anticipate as being beneficial and that are partly outlined in Chapter 4. This partial disconnect will be resolved during Stage 2 of the Roadmap program as it begins to examine preferred future states.

What the Roadmap needs to do

Updating the 2013 Forum scenarios to create a 2015 scenario set confirmed two important factors:

- The key drivers transforming Australia’s electricity sector, identified in 2012 and 2013 as part of the Forum, are still current.
- Transformation of Australia’s electricity sector will be ongoing.

Ultimately, Australia’s electricity sector transformation can be viewed as a ‘customer-driven revolution’ predominantly brought about by the continuing deployment of rooftop solar panels and the significant potential for increasing adoption of energy storage in the next decade. Other innovations, such as the potential for accelerated adoption of electric vehicles, may deliver a third wave of technological change.

The Forum participants and many other commentators argue these changes deliver new value for some customers but present risks for the system and customers as a whole. They say the current electricity network rules, regulations and pricing structures are not set up to deliver appropriate signals for the most efficient investment in new technologies on both sides of the grid and for the equitable distribution of the costs and benefits that flow from them. While there are some differences between the 2013 and 2015 scenario sets, in general the 2015 scenario set confirms these risks remain.

The main difference between the two scenario sets is that solar plays a stronger role in the 2015 set. There is greater confidence in the availability of cost effective storage technologies, which lessens the expected impact of solar depending on the incentives provided to owners.

As well as confirming important factors for the future of Australia’s electricity value chain, the 2015 scenario set is acting as a useful baseline for the Roadmap program. It tracks the possible trajectories of Australia’s electricity system ahead of any Roadmap-inspired actions. These trajectories reveal the likely characteristics of electricity systems in 2025 en route to the 2050 scenarios, and are making it easier to explore potential ‘no regrets’ Roadmap options capable of enabling more efficient, equitable and resilient outcomes for all Australians regardless of which long term (2050) scenario materialises. From there, the Roadmap program can also look at the similarities and differences between, and the likely impacts of, any proposed actions for the subsequent 2025–35 decade.

Before the Roadmap program can evaluate and compare all potential options, it is important to understand what the likely outcomes of each of the four scenarios will be for all customer segments identified in Chapter 1. Also, customer representation will need to be broken down into components, such as:

» customer sizes
» representative loads matched to equipment/ appliance ownership
» pricing structures
» new technology ownerships and their context as an individual or part of a mini grid.

A major focus will be to identify and develop counterfactual cases for the 'no regrets' Roadmap options. The Roadmap workshops delivered some examples, such as greater application of technology standards, options to accelerate electric vehicle adoption, and giving customers greater choice in electricity service pricing options. Combinations of 'no regrets' options will be the basis of developing a preferred end state for the Roadmap.

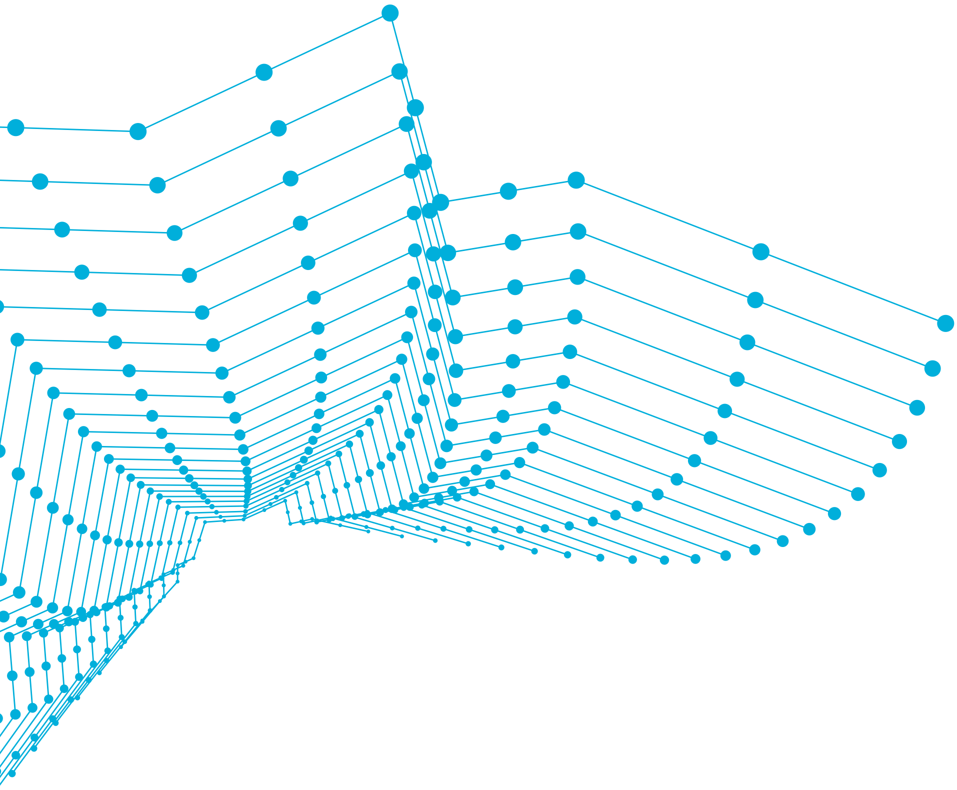
How you can help

Your feedback on the following questions is welcome. This feedback will be used during Stage 2:

2.1 Is any important new information about the future of the electricity system missing from this analysis?

2.2 Do you know of any modelling frameworks the Roadmap program could use to improve customer representation?

2.3 Can you suggest any 'no regrets' actions (by any stakeholder) that the Roadmap program could consider evaluating in Stage 2?



KEY FINDINGS

F2.1 The energy transformation drivers identified in Future Grid Forum scenarios remain plausible and provide important context for the Roadmap.

F2.2 Australia faces a broad spectrum of potential energy futures that vary greatly in the adoption of new technology, mode of customer engagement and the role of the central electricity network.

F2.3 Customer bills outcomes are slightly lower than forecast in 2013, reflecting the role of storage in facilitating economic integration of solar PV and other distributed generation.

F2.4 Solar PV takeup is dominating embedded generation and tracking to the high end of the 2013 projected share, while battery storage cost trends have improved further.

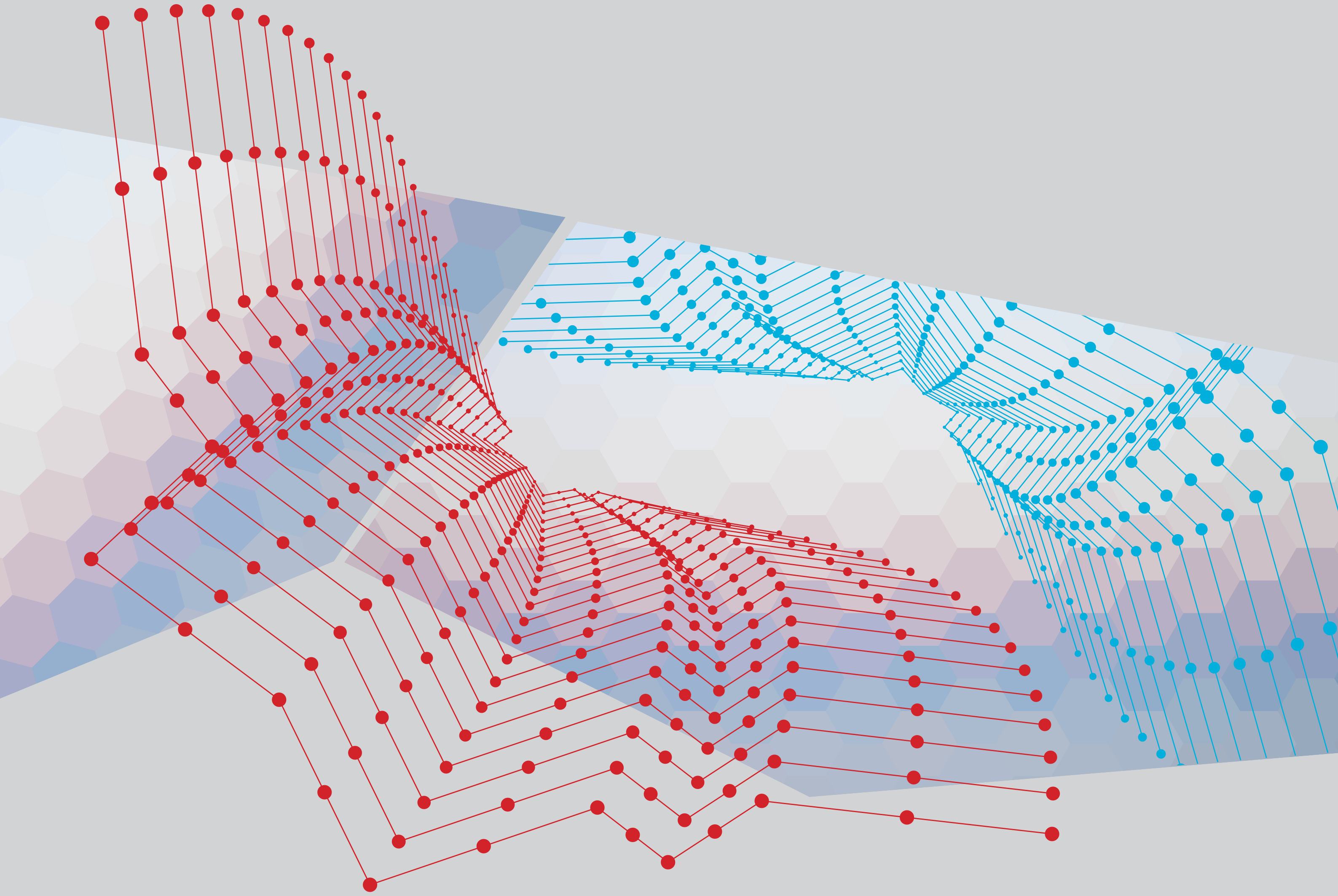
F2.5 The updated scenarios continue to reflect electricity networks performing an evolving range of critical roles to 2050, supporting diverse energy use and services for customers.

RECOMMENDATIONS

Stage 2 of the Roadmap can use 2015 Future Grid Forum scenarios as a baseline set of assumptions and projected outcomes for Australia's electricity sector transformation.

R2.1 Stage 2 of the Roadmap is expected to include:

- expanding the representation of customer segments and how they are impacted by the sector's transformation
- identifying and, where possible, quantifying counterfactual cases for 'no regrets' Roadmap options
- developing a preferred end state for the Roadmap, combining priority 'no regrets' options.



CHAPTER 3
TECHNICAL CHALLENGES AND OPPORTUNITIES OF DISTRIBUTED ENERGY RESOURCES

Quick look

- The ongoing strong customer adoption of distributed energy resources, especially rooftop solar photovoltaic (PV) systems, is changing how the electricity industry operates from the 'bottom up'. The approaching anticipated mass adoption of energy storage (batteries) and electric vehicles has the potential to bring subsequent waves of transformation.
- All of CSIRO's updated (2015) Future Grid Forum scenarios to 2050 anticipate distributed energy resources will have a growing presence in Australia's electricity future. Distributed energy resources include various forms of distributed generation (both renewable and non-renewable), energy storage systems, demand response systems, electric vehicles and other distributed technologies.
- The electricity system was historically designed as a highly centralised one-way system. However, by definition, distributed energy resources are decentralised in terms of geographic location, ownership status and operational profiles. At the same time, they introduce two-way energy flows into the system.
- As the growing customer adoption of grid-connected distributed energy resources poses challenges for the grid, Australia needs to rethink electricity system design and operation. This network transformation is critical to ensuring ongoing efficient and resilient network operation and fair energy access for all customers, to ensure the electricity system can continue to deliver long term value to diverse customer needs and the nation as a whole.
- This Chapter examines how ongoing growth in distributed energy resources can impose technical challenges on electricity networks. It explores how the effective integration of distributed energy resources can address these challenges and deliver positive benefits for both customers and networks.
- In particular, Stage 1 of the Roadmap has identified integration options capable of addressing technical challenges and unlocking the benefits of distributed energy resources both now and in the future. This analysis included identifying critical gaps in the current suite of Australian Standards, which need to be overcome to leverage the full value of distributed energy resources.

What we know

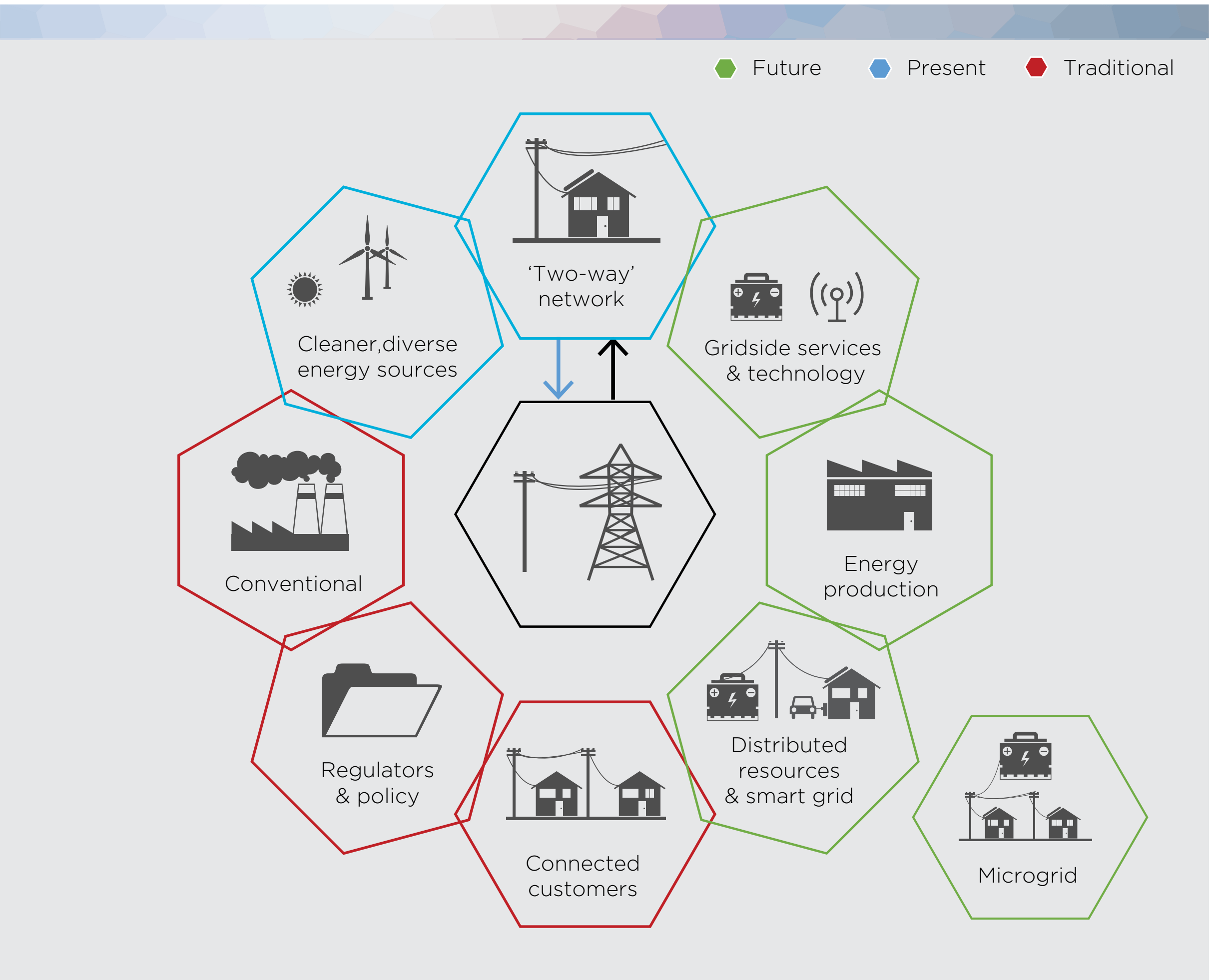
Over recent years, established electricity systems in many parts of the world have experienced complex and unprecedented change arising from the strong adoption of distributed energy resources by customers. As a result of this customer driven adoption, Australia now has the world's highest penetration of grid-connected, rooftop solar photovoltaic (PV) systems. In some states, one quarter of all customers generate their own electricity, and subsequent and significant waves of energy storage and electric vehicle adoption are expected.

Until recently, almost all electricity was provided by a relatively few centralised generators that delivered electricity in a single direction through networks to largely passive consumers. In this context, the notion of electricity being produced by millions of distributed micro-generators (mostly 'fuelled' by intermittent renewable sources) was inconceivable.

Today, networks need to adapt so that millions of future customers, both consuming and selling electricity, can be interconnected in a way that continues to ensure reliable '24/7' energy supply at a fair price for all.

Distributed energy resources present both good news and bad news for traditional electricity systems. If integrated well, they can deliver operational benefits and efficiencies to electricity distribution networks; however, if integrated poorly, they can impose technical challenges, inefficiencies and even inequitable costs. The difference between these two outcomes largely depends on whether a 'whole-of-system' approach can be used to integrate distributed energy resources. Such an approach will ultimately include considerations such as technological impacts and benefits, regulatory and business models, pricing and the market operation required to encourage the efficient integration of distributed energy resources into the electricity system (Figure 3.1).

Figure 3.1: Transformation of electricity networks



What we're doing

This Chapter outlines the opportunities and challenges posed by the increased penetration of distributed energy resources. In particular, Stage 1 of the Roadmap assessed both:

» how continued growth in distributed energy resources can negatively affect electricity networks

» how the effective integration of distributed energy resources can deliver benefits for both customers and the efficient operation of electricity networks.

It identified integration options capable of providing benefits both now and in the future. It also identified critical gaps in the current suite of Australian Standards, which need to be addressed to leverage the full potential value of distributed energy resources.

These considerations are becoming more critical as the historically highly centralised electricity system transitions from functioning just as a one-way bulk energy delivery system to functioning as a meshed network, capable of interconnecting millions of distributed energy resources, managing multi-directional energy flows and maintaining operational reliability.

What we're learning

The following five sections summarise the key technical findings of Stage 1 research:

1. **'Dealing with existing technical challenges'** highlights the prevailing and impending issues that may limit networks in deriving maximum benefits from increasing distributed energy resources penetration.

2. **'Addressing restrictions on the integration of distributed energy resources'** explores strategies for addressing the identified issues, drawing on theoretical and practical studies to assess the early strides made in this space.

3. **'Optimising the use of distributed energy sources'** underlines the potential for distributed energy resources to deliver meaningful value to Australia's networks and, ultimately, customers. It illustrates that effectively managed systems provide genuine opportunities in this space.

4. **Addressing the technical challenges** shows how emerging technologies can help to incorporate new distributed energy resources, to maximise network productivity, without compromising the benefits of community access to safe and reliable power supplies.

5. **'Leading grid innovation with advances in standards**' highlights the rich suite of standards relevant to the distributed energy resources space. It identifies where further refinement, modification or addition may help optimal distributed energy resource performance.

While distributed energy resources present an exciting opportunity for networks and customers alike, they also present new challenges and issues that can better understood and addressed through this Roadmap program.

1. Dealing with existing technical challenges

This section outlines the ways in which distributed energy resources can affect the function, operation and maintenance of electricity networks, and how they can cause or exacerbate network constraints. However, it also shows they can, when managed effectively, benefit network operations and reduce the need for network augmentation to address constraints.

The increasing penetration of distributed energy resources in Australia – including greater uptake of rooftop solar PV systems and other embedded generation – is changing load profiles on Australian electricity networks and making network load prediction more challenging. Appropriate planning and management of network load demand is thus required – as customers adopt distributed energy resources and change their load patterns across different timeframes – to ensure adequate power quality and an affordable and reliable supply of electricity.

Power regulation

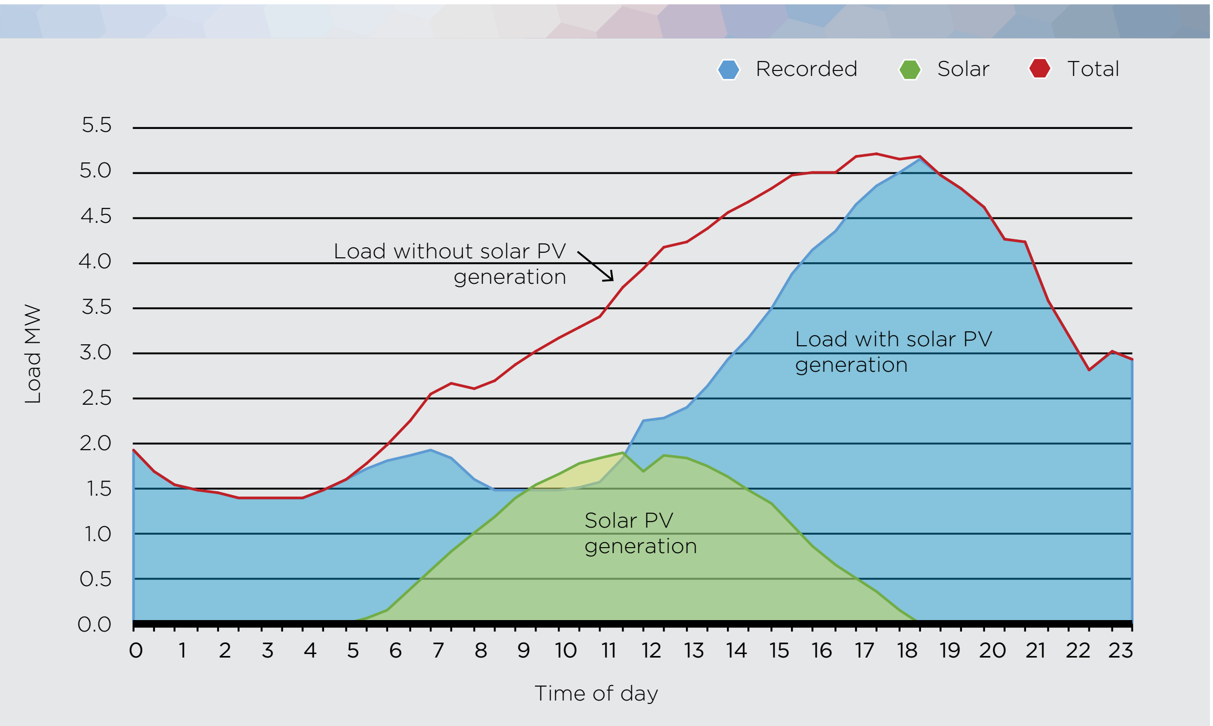
Many operational issues faced by networks relate to their regulation of stable power flows. Poor management of power within a network results in the inefficient use, and reduced lifespan, of key network assets and customer appliances.

Power management issues include:

- **Peak load management** – Each segment of an electricity network is designed to operate up to a certain maximum load capacity (measured in megawatts, or MW). On a residential network, the peak load generally occurs in the late afternoon or early evening. When a network segment is operating below its maximum load capacity, it is being underused. Over a typical day, the load or demand on a network can vary considerably, with the peak load usually approached for only a relatively short time. In some cases, peak load conditions will be experienced for only a few hours on the hottest few days (or as little as 1–3 per cent) of the year. For most of the time, networks operate far below this 'high water' point, and the extra capacity required to service short term peak load periods is not efficiently used.

  Figure 3.2 illustrates how network loads (in this case, a typical residential load curve) can vary over a peak day. It also demonstrates that solar PV generation has the effect of reducing loads on the network earlier in the day without reducing the local peak load. While a high penetration of rooftop solar PV helps reduce total daily load on the network, it does not generally help to reduce peak residential loads. For this reason, in many residential areas, the same network infrastructure capacity is required to delivery peak loads while its overall use is reduced.
- **Asset lifetime** – All network assets age as they are used, and have to be maintained and eventually replaced, in a period known as the asset lifetime. Factors such as ambient temperature, operating environment and 'thermal loading' influence the rate at which assets age. Under conditions of higher power flows during extreme peak events, transformer insulation experiences increased thermal loads, leading to more frequent replacement requirements.
- **Frequency** – For power networks of any size, the balance of generation and load determines the frequency of the network (measured in Hertz, or Hz) across the entire grid. Large deviations from Australia's target 50 Hz frequency can cause serious network instability and issues for customers. Even small deviations can adversely affect some household appliances.

Figure 3.2: Load on a south east Queensland residential feeder on a peak demand day



Source: Energex, *Distribution Annual Planning Report*, 2015

Network stability

For isolated power networks, the frequency challenges of power regulation are more prominent, affecting network stability and reliability. Isolated power networks may be regional networks or 'islanded' microgrids, including off-grid systems that serve small, remote or industrial communities. For isolated power networks, even a short term imbalance between generation and load can have a large impact on the system frequency and subsequent power reliability for customers. In the extreme case, poorly balanced generation and load can cause a small off-grid power system to collapse entirely or damage customer appliances.

2. Addressing restrictions on the integration of distributed energy resources

While distributed energy resources pose challenges to efficient network operation, they also offer opportunities that will grow as storage technologies mature, network forecasting improves and supporting inverters become smarter, and as systems emerge that can unify these elements to deliver highly responsive load and generation resources. This section explores such potential opportunities for networks to eliminate or, at least, minimise the potential negative impacts of distributed energy resources while realising the benefits for customers.

Network protection

While distributed energy resources may ameliorate some grid problems, they may exacerbate other problems. 'Protection' is the term for a range of systems and devices that ensure safe network operation. Limitations imposed by these critical systems and devices, to maintain network reliability, may restrict the number of distributed energy resources that can be accommodated within different parts of a network.

In the existing grid, power flows are typically one way, from generator to customer. Network protection systems are designed to protect customer supply and operate to strict programmed limits on how much power can be allowed to flow in the event of a fault. When distributed energy resources are introduced to this grid model, the operation of protection systems can become more complex and impact customers by, for example:

» making it more difficult to detect faults, particularly in fringe-of-grid or off-grid networks
» increasing the current that can flow in the event of a fault, such that a network could approach, or even exceed, set fault levels
» increasing the likelihood of nuisance tripping due to reverse power flows on radial networks
» increasing the risk of an electrical island forming during a fault, with significant safety implications.

While these issues are significant, they can be addressed by existing and emerging mechanisms for enhanced protection system management. However, networks will need to develop more sophisticated operating rules for protection systems to ensure reliable and efficient performance in a more complex, integrated grid model.

3. Optimising the use of distributed energy sources

This section emphasises the benefits that well managed distributed energy resources will deliver, such as addressing network peak loads, deferring network upgrades, reducing operating and maintenance costs, supporting grid frequency management, managing network voltage and supporting a high reliability grid.

The primary aim of moving to an integrated grid model is to incorporate more diverse energy resources so 'the whole is greater than the sum of the parts'. The existing grid is a complementary resource and can become the natural integrator, or a platform, to maximise the value of more complex types and patterns of energy supply and demand driven by customers. This approach aims to define the optimal deployment and use of multiple energy resources.

In effect, it manages the features of distributed energy resources that might lead to restrictions or network issues, to counteract negative impacts and promote opportunities. In other words, it deals with networks' core tasks – the management of reliable and safe power flows, and power quality – becoming more complex as the penetration of distributed energy resources increases.

Power regulation

- **Power ramp-rates** – Some distributed energy resources (particularly intermittent forms such as solar PV systems) can experience rapid and significant variations in output (due to the variability of cloud cover etc.). This variability has flow-on effects for voltage management and the lifetime of network assets. In the case of isolated power networks, increasing power ramp-rates can also affect network stability.
- **Reverse power-flow** – The existing grid caters primarily for one-way power flow, from centralised generation, through transmission and distribution networks, to low and medium voltage networks serving customers. However, distributed energy resources can generate power flows at the customer end of the network, potentially reversing power flows. These reverse flows can cause problems with network protection systems and, in isolated power networks, can adversely affect network stability.

Power quality

The grid must be able to provide a stable, well regulated voltage, with minimal high frequency oscillations (called harmonics).

- **Voltage intermittency and flicker** – Some distributed energy resources produce variable amounts of power. This situation is common in urban areas with large areas of rooftop solar PV, for example. Rapid changes in power output cause rapid voltage fluctuations known as voltage intermittency and flicker. These fluctuations are only a minor nuisance to customers, but they reduce the life of network assets and thus increase network costs.
- **Harmonics** – Distributed energy resources may generate current that carries high frequency oscillations. These oscillations can carry through to the local network, with the potential to weaken the reliability of (and shorten the life expectancy of) network and customer equipment.

4. Addressing the technical challenges

A range of emerging technologies can help to incorporate new distributed energy resources, to maximise network productivity, without compromising the benefits of community access to safe and reliable power supplies. The technology enablers of the integrated grid can be grouped as:

- storage (power on demand)
- intelligent distributed resources
- adaptive systems (demand response and prediction).

The technologies described in this document are reasonably mature. That is, they have already been demonstrated to be effective in dealing with the challenges of grid integration. Some mitigation strategies deploy specific technologies, some use interchangeable technologies, and some use technologies working in combination.

Storage – power on demand

Energy storage is a broad term for a variety of chemical, mechanical and electrical systems capable of storing electrical energy for later use. In its many forms, it is an incredibly versatile distributed energy resource. Storage can help to manage a large variety of challenges relating to the existing grid, as well as many of the additional challenges relating to the increasing penetration of distributed energy resources. In particular, storage helps to deal with the conditions and effects of intermittency in distributed energy resources. It can also play a key role in holding and scheduling bulk energy to help manage power flows.

While the upfront costs of storage are currently significant, technology improvements and increasing market penetration are driving these costs down considerably. Storage helps to resolve many of the challenges of grid integration, so falling costs have the potential to drive a renaissance in electricity systems in Australia and worldwide.

Commonly deployed electrical energy storage technologies include batteries (electrochemical storage), flywheels, pumped hydro storage, specialised storage systems such as compressed-air energy storage, superconducting magnetic energy storage, supercapacitors and fuel cells (with electrolysers).

» **Network storage** has the potential to provide a range of network benefits supporting the integration of distributed energy resources, including voltage management, energy balancing, and improved network stability. These benefits can increase the flexibility, reliability and efficiency of power delivery to consumers. Network storage can be operated (charged and discharged) to maximise network efficiency and performance by:

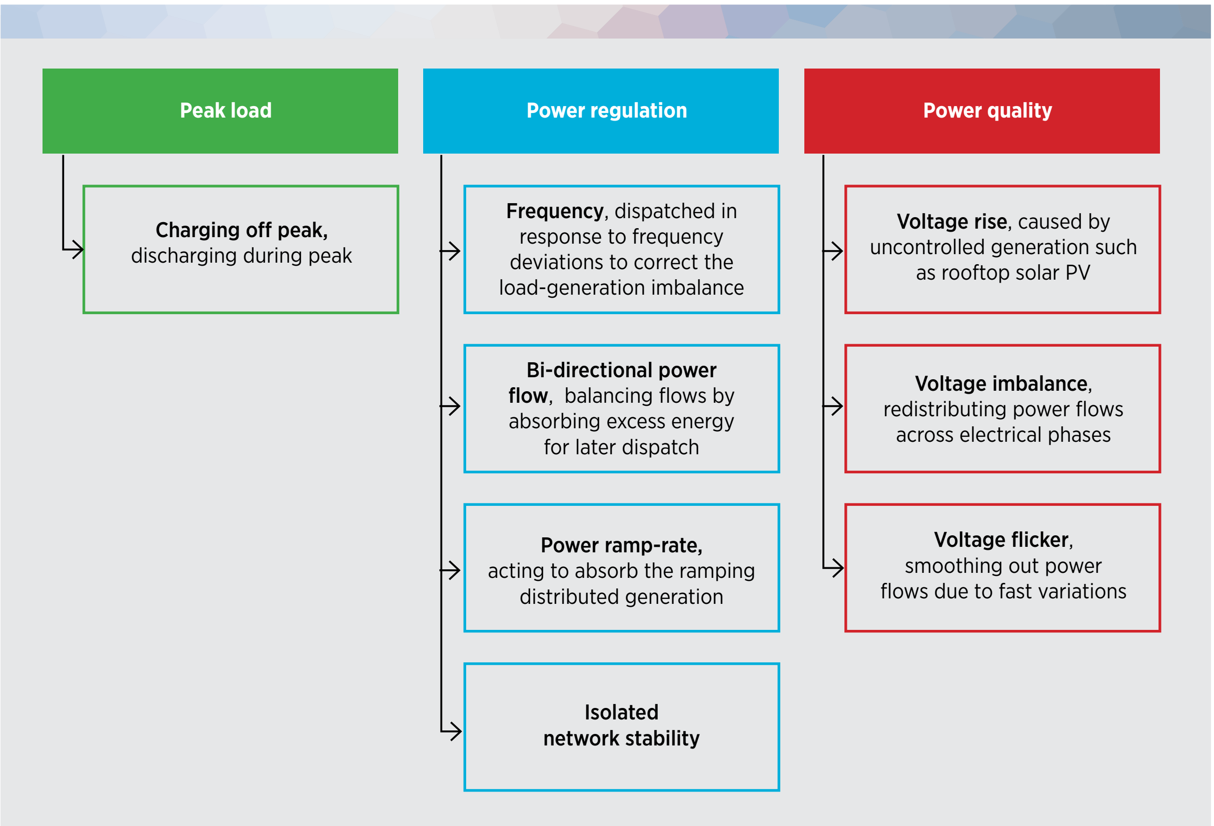
- maximising the use of network assets
- improving power quality experienced by customers
- reducing costs associated with network operations, maintenance and replacement.

To date, the high cost of installation has limited uptake of network storage to niche applications, and restricted installations to relatively high level positions in the network. The resulting control capability of these installations is relatively coarse, compared with a more fine grained responsiveness that might be achieved from network storage deployment at deeper levels of the network. Energy storage is already being trialled or deployed by a number of Australian networks.

» **Customer-owned storage** is installed primarily for customers' own use and benefit (often on the customer side of the meter), such as helping customers respond to tariff signals or arbitrage time-of-use energy charges. However, given appropriate signals and incentives, customers can benefit by providing services needed by the network, including improved management of voltage and power flows, peak load and generation management, and reactive power support. Network benefits can be derived from the relatively deep deployment of customer-owned storage within the network (at medium and low voltage levels), where it can be made responsive to more localised conditions.

Figure 3.3 shows energy storage can help resolve many of the grid integration challenges, including those associated with peak load, power frequency and power quality. Box 3.1 contains an example of an energy storage trial in New South Wales.

Figure 3.3: Storage applications to support integration of distributed energy resources



Box 3.1: iDemand PV storage trial

TransGrid, a New South Wales transmission services provider, has commenced a hybrid demand management trial known as iDemand. The trial, located in western Sydney, incorporates solar PV systems and a lithium polymer system. It aims to demonstrate how PV and storage can work together to provide a resilient and versatile mechanism for managing peak load. TransGrid has also collaborated with researchers to help identify new ways of operating, and new benefits of network storage.

iDemand consists of the following resources:

- 400 kWh lithium polymer battery energy storage
- 53 kW of polycrystalline silicone PV
- 45 kW of thin film cadmium telluride PV.

The system is integrated with energy efficiency measures on-site, aiming to reduce the local peak load by as much as 50 per cent.

Source: Based on http://idemand.transgrid.com.au/

Intelligent distributed resources

Distributed energy resources, such as rooftop solar PV systems and embedded/distributed wind turbines, are already reducing customers' electricity bills and providing significant benefits and cost savings to energy networks. The addition of smarter control, better storage, or both, enhances these benefits to improve power quality and increase reliability.

Here are some key opportunities:

- **Smart energy resources such as power electronics** – Power electronics, such as the inverter connected to every rooftop PV solar installation, have a voltage control that can be deployed independently of a generation or storage system, and can provide a service to network power quality control. Adding intelligence to distributed energy resources can provide reactive power, so the system can both inject to and absorb reactive power from the network to control voltage levels. This feature is known as volt/var control. Some advanced power electronics solutions can also reduce potentially harmful harmonics on the grid, whether they derive from loads or other distributed energy resources.
- **Voltage control** – PV generation has been identified as a leading cause of voltage rise in residential networks during the day, when demand is low and solar PV generation is high. However, volt/var control or storage can avoid or mitigate voltage rise. Voltage drop is a constant challenge, especially in managing rural networks that extend over long distances. In these cases, solar PV (or solar PV combined with storage) is particularly beneficial in reducing the voltage drop.

Adaptive systems – demand response and prediction

The ability of networks to understand and influence the loads that they service is central to maintaining a stable, reliable and cost effective energy network. As grid-connected distributed energy resources grow in number and become more varied, network loads also become more dynamic, and more adaptive techniques are needed to manage this complexity. Adaptive systems are thus critical to predicting and controlling network loads in the integrated grid. These systems include demand response and net load prediction.

» **Demand response** allows networks and customers to shape network loads in response to changing conditions within the network operating environment. The suite of AS/NZS 4755 standards 'Framework for demand response capabilities and supporting technologies for electrical products' provides a simple and versatile mechanism for enabling demand response in Australian networks. The standard covers demand response functionality for airconditioners, pool pumps, hot water systems, energy storage (in draft form) and inverters (through the recently released AS/NZS 4777 Part 2).

The PeakSmart controlled airconditioner program (Box 3.2) undertaken by Energex and Ergon demonstrates that customers, given the right incentives, are willing to permit networks to manage their airconditioning systems during relatively short periods of high demand, without impacting customer comfort. Innovation driven by recent Australian and international standards and adopted by industry means 15 different manufacturers now provide hundreds of models of airconditioners that comply with the AS/NZS4755 demand response architecture across Australia.

Box 3.2: PeakSmart airconditioning

Energex, a Queensland power distribution company, developed the PeakSmart program to take advantage of new 'smart' airconditioning units to offset peak load conditions. Over the five years to 2015, 650 different models of airconditioners have been enabled for matching with demand control signal receivers. Energex supplies these receivers to participating customers, and over 35,000 customers have opted in to the PeakSmart program, with up to 500 additional customers joining each week.

PeakSmart airconditioning units operate in a similar way to the economy setting on airconditioners. When activated, they cap their energy consumption for short periods on the few days of the year when the electricity system experiences peak loads. For customers, the technology is 'set and forget', with minimal impact on comfort due to the efficiencies activated in these 'smart' units.

The chart below illustrates a PeakSmart event. Airconditioning units received a signal to reduce demand during a two hour period from 3 pm to 5 pm. The return to full airconditioner load was staggered over a 20 minute period to maintain network stability. The total load over the period (red line on the chart) was reduced by about 0.5 MW compared with the total load immediately before and after the PeakSmart event.

Source: Based on www.energex.com.au/residential-and-business/positive-payback/positive-payback-for-households/households

- **Net load prediction** is used by networks to estimate the likely net load over a range of time periods. This estimate informs planning for additional network and network maintenance schedules. Very short term load prediction is used for load exchange and contracting with neighbouring networks, and to maintain a balanced power system. Distributed energy resources can alter the supply and demand patterns experienced across the grid, introducing greater variability in energy flow and generation. Networks need to modify their estimate of net loads, therefore, to account for the greater complexity and uncertainty of loads flowing across an integrated grid.

  Possible techniques include direct prediction of renewable generation, for example, by analysing weather patterns and cloud tracking. Smart metering information and associated new customer channels may facilitate better understanding of customer choices.

5. Leading grid innovation with advances in standards

Standards are likely to be a critical issue in the integration of distributed energy resources. Developed through rigorous and unbiased processes under Standards Australia, they have the potential to achieve consistency while promoting innovation for the benefit of consumers. In the following ways, the development of potential new technical standards is likely to be critical to the technology enablers of the integrated grid:

- **Storage safety standards** – While current and emerging Australian standards contain some coverage of energy storage systems, significant standards gaps need to be addressed to ensure storage systems are appropriately connected to the network. Most importantly, standards need to be developed or extended to ensure comprehensive attention to safety issues for the full range of energy storage types as they develop.
- **Electric vehicle standards** – Electric vehicles have the potential to perform similarly to other forms of energy storage when connected to the grid. Australian standards and regulations do not presently cover the integration of electric vehicles and similar distributed storage with grid supplies. Ideally, existing standards should be extended to cater for issues such as energy feed to the grid, charging arrangements and safety.
- **Inverter standards** – As noted, inverters can help to address existing grid limitations (such as power and voltage excursions) and may self-adjust to minimise the potential for power quality problems (such as voltage rise and imbalance and harmonics). However, to achieve these benefits, inverters need specific features and functions, as specified in the recently released version of AS/NZS 4777 (Part 2). However, these power quality functions are currently non-mandatory in the standard.
- **Protection relay standard** – Protection is a requirement of current standards for grid connection of most types of generation, to avoid unintentional islanding of network segments, and bi-directional power flows. However, current protection standards are inadequate for ensuring a consistent approach in new equipment entering the market. It is costly for each network operator to have to test and verify each new type of device. Technical standards are needed for protection relays, to improve consistency, enable better integration of these systems, and reduce costs.
- **Smart meters** – Smart meters are a key component of many of the technology advances to a more integrated grid, including energy storage, distributed storage, electric vehicles, and load and renewable prediction. They are critical to the deployment of these technology solutions, and for applying incentives and decision support regimes to influence customer behaviour for greater network efficiency and customer value. Currently, no standard communications protocol applies for smart meters across all jurisdictions. While this absence has potentially increased the pace of smart meter roll-out, common communications protocols are a key means of driving the design and provision of new electricity services.

Responsibilities of the producers of distributed energy resources

Distributed energy resources can carry risks, in terms of safety and performance reliability, similar to those of any electrical power system or network. Standards and regulations are the methods used to track and document, inspect and test, and maintain these systems in the interests of community safety and service resilience.

Evolving to an integrated grid entails greater penetration of an increasing array of distributed energy resources and related technologies. So, in addition to filling the above gaps in current standards, Australia will need to continually review and update its understanding of system risks and appropriate limits and mitigations. Box 3.3 is an example of such effort in Europe.

Box 3.3: The Stallion Project

The Stallion Project is a European collaboration developing a safety framework for lithium ion batteries. The project demonstrates the highly critical and complex issues to be addressed in storage safety standards. Undertaken by a consortium of seven partners from five European countries, it is developing a clear safety framework for lithium ion batteries in all stages of their lifecycle, including commissioning, transport, installation, operation, maintenance, repair, decommissioning and recycling.

The project found more than 100 standards dealing with batteries in general, of which 25 include safety tests on batteries (always at cell and module level). More than 400 standards exist for related systems (for example, PV installations, microgrids, fuel cells).

The project's root cause analysis indicated the following key risks:

» propagation of thermal runaway between cells or modules
» internal short circuit in a cell
» overcharge of a module
» undercharge due to extended storage
» rough handling of the battery container during transport or installation
» module cycling without cooling
» deformation of module due to an accident
» flooding of the battery container
» external short circuit of a module
» malfunctioning of the battery management system.

Source: Based on www.stallion-project.eu/images/documents/Mulder_ Battery_regulation-SMi_Utility_energy_storage_conf2014.pdf

What the Roadmap needs to do

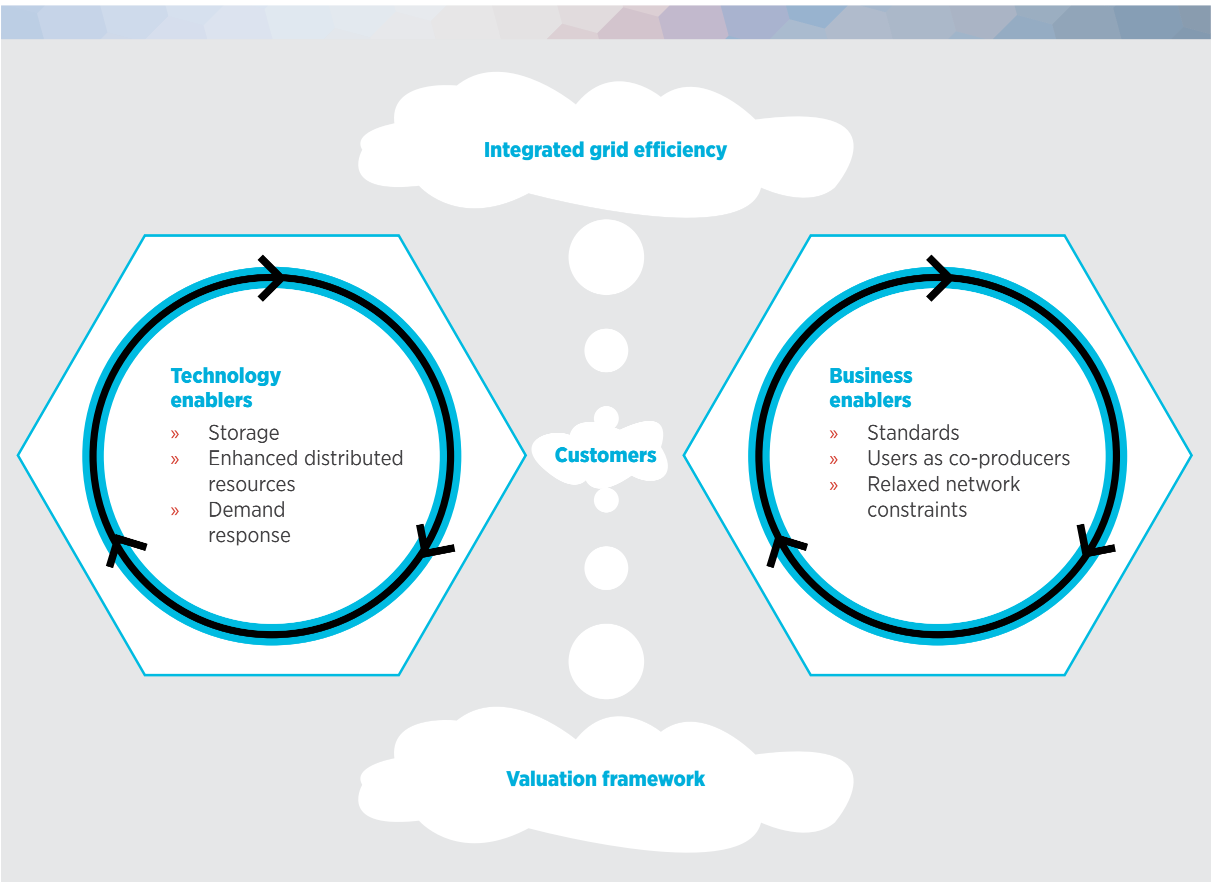
The existing grid delivers affordable, safe and reliable power supplies while also maximising user flexibility in terms of demand load and pattern. Power supplies have formed the backbone of Australia's economic growth and prosperity over a long period. The Roadmap program will focus on assured generation capacity to meet the anticipated future system demand with grid connection to balance both centralised and decentralised supply and demand over larger geographic areas.

The Roadmap program will explore options to develop a fully developed integrated grid that provides a platform that is more accessible to customers and that allows them to better participate in the provision of electricity services. The dynamic nature of the integrated grid will render it responsive to the more complex and uncertain shifts in supply and demand that accompany increased penetration of distributed energy resources.

By improving the efficiency of the entire system, the integrated grid will maximise the benefits of low carbon generation and share these benefits with customers across the grid.

Figure 3.4 illustrates how a combination of business and technology enablers is required to drive the successful transition to the integrated grid. Users and producers of energy must cooperate to produce a network efficiency dividend. In turn, the achieved benefits will help sustain and improve integrated grid performance, resulting in reduced costs to customers.

Figure 3.4: Enablers of smart grid transition



How you can help

Your feedback on the following questions is welcome. This feedback will be used during Stage 2:

3.1 How can networks maximise the benefits of distributed energy resources for all stakeholders and customers? How should well integrated distributed energy resources look in 2025?

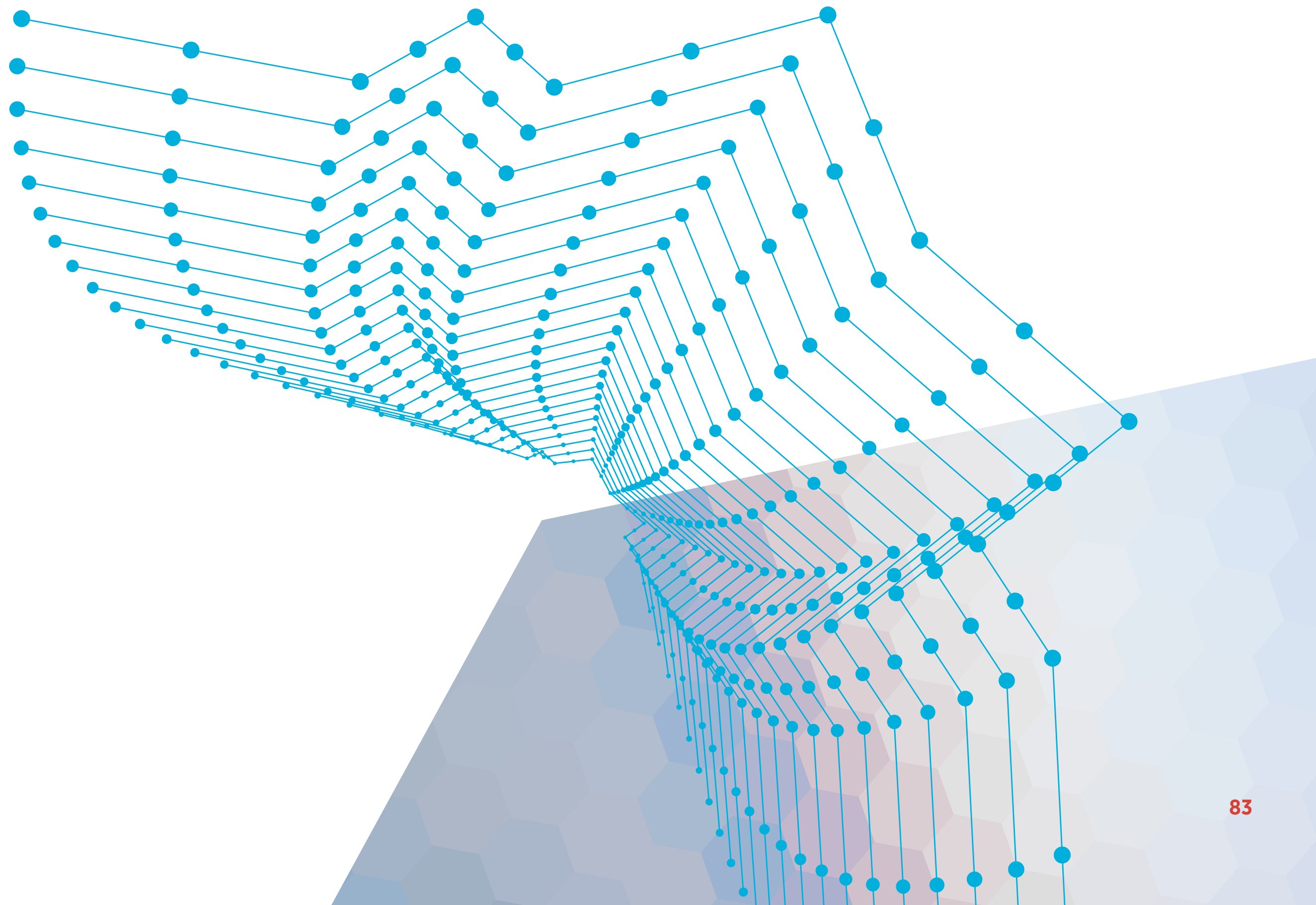
3.2 What do you consider are the key principles that need to underpin the integration of distributed energy resources?

3.3 How should network system planning look in a future of highly integrated distributed energy resources?

3.4 As the industry adapts to the growing presence of distributed energy resources, will the distribution system become simply a 'smarter' version of itself, or will it be something more?

3.5 How can networks be more proactive in accommodating high penetrations of distributed energy resources?

3.6 What role will microgrids play in the energy systems of the future?



KEY FINDINGS

F3.1 Energy storage, in its many forms, is an incredibly versatile distributed energy resource. Storage can help to manage a large variety of challenges relating to the existing grid, and mitigate many of the additional challenges from the increasing penetration of distributed energy resources.

F3.2 Customers can become active participants in a cooperative structure under which their distributed energy resources (typically solar PV and storage) are integrated to maximise the value of electricity services for all participants.

F3.3 Network service providers are well placed for coordinating the integration of distributed energy resources into the electricity grid in a way that maximises performance and shared benefits for all customers.

F3.4 Adaptive systems (that is, demand response and net load prediction) are critical to predicting and controlling network loads in the integrated grid. If enabled appropriately, they can bring multiple benefits to both networks and customers.

F3.5 A number of new technical standards are critical to the efficient and safe deployment of technology enablers of the integrated grid. They include, for example, storage safety standards, electric vehicle and similar distributed storage standards, inverter standards, protection relay standards and smart meter standards.

F3.6 Maximising the benefits from growth in distributed energy resources requires complementary action in technology and the business environment, encompassing policy, regulation and standards, and commercial models.

RECOMMENDATIONS

R3.1 The successful integration of distributed energy resources into existing grid systems will involve engaging and empowering new participants in electricity services and building network efficiency and resilience.

R3.2 Stage 2 of the Roadmap is expected to include:

- modelling the impact of distributed energy resources on Australia's LV and MV networks
- quantifying the operational and maintenance issues and performance of grid-connected energy storage
- identifying critical gaps in the current and future skills and training requirements for electricity supply industry workers
- identifying potential solutions for delivering the new technologies, protocols and business models needed to facilitate the new Smart Grid and network businesses for 2025 and beyond
- looking at network segment and microgrid emulation for embedded generation / distributed energy resources integration and performance testing
- identifying opportunities for electric vehicle and other volume growth opportunities.

CHAPTER 4
BUSINESS MODELS FOR AN EVOLVING ELECTRICITY FUTURE

Quick look

- Key insights come from the recent Accenture review of how transformational forces are impacting network business model evolution, with a particular focus on distribution networks. Accenture considered international case studies and examined future roles and business model options relevant to Australian electricity distribution networks. It noted four broad business model approaches: Platform Enabled, Intelligent Grid, Beyond-the-Meter Services, and Information Services.
- The most progressive utilities globally are planning multiple evolutions of their business models. Australian electricity networks will need to respond to their own unique set of circumstances.
- Importantly, there is no 'one size fits all' approach to future business models for electricity networks, and no 'optimal final state' business model suitable for all networks.

What we know

Traditional electricity network business models were based on transmission and distribution networks providing a one-way flow of electricity from distant centralised generators to largely passive customers. This was considered an essential service, provided by a regulated monopoly business.

As noted in earlier chapters, transformative change is impacting centralised electricity systems around the world. Australian householders and enterprises are now integrating new and old ways of engaging with electricity at record levels. For many reasons, Australia is increasingly noted globally as one of the locations where the future shape of electricity business models will likely emerge first.

Given the complexity arising from multiplying customer aspirations, technology options and new competitive and collaborative opportunities, the range of response options for network businesses is expanding. Australian electricity networks will need to appropriately respond to their changing circumstances, and these responses will typically vary across jurisdictions. Individual network responses will be influenced by many factors, including location, climatic conditions, geographic spread, customer characteristics and density, demand profile, growth factors, and company structure and skill base.

While some features are unique to Australian electricity networks, such as their respective market and corporate structures and regulatory circumstances, there is much to be learned from international experience with network business model innovation.

What we're doing

ENA had started considering electricity network business models before the Roadmap program commenced. It had commissioned Accenture to conduct a review of the impact of current transformational forces on electricity network business models.[28] The review considered case studies from overseas electricity businesses to guide analysis of key trends, impacts and functions as a significant input to Stage 1 of the Roadmap program.

Accenture investigated future roles and business model options relevant to Australian electricity networks, including opportunities for leveraging network assets and resources to deliver expanded value offerings to customers, including new market actors. It also recognised that business model frameworks need to support flexible choices for network services and operations to suit differing circumstances, strategies and key objectives of individual network companies.

Stage 2 of the Roadmap program will build on the Accenture work to identify the range of potential business models applicable to Australia and the current barriers or constraints to their operation. It will also identify changes that will be essential for Australian network businesses, and other market actors that may partner with networks, to deliver the value that customers will demand in 2025 and beyond (as identified in Chapter 1).

What we're learning

Providing electricity across the world's largest island is a significant achievement. Appendix A gives an overview of Australia's diverse electricity network businesses. It highlights how the range in size, structure (urban, rural, remote, independent or integrated), generation sources, population density and geographic spread of Australian networks results in widely divergent conditions and challenges for individual network companies. This great diversity influences how each network might approach and apply different business model options, and it's clear a 'one size fits all' approach is increasingly inappropriate as the different networks transform to meet their particular challenges.

How the Australian networks developed

Historically, Australian energy systems generally operated as independent, state-confined and state-owned monopoly vertically integrated businesses covering all aspects of generation, delivery and retail to customers. Different regions and states have progressed at different speeds to change their operational structure. Below are some relevant points:

» Amalgamation of retailers and generators requires a partial revisiting of the National Electricity Market, which was established in eastern Australia in the 1990s with the separation of generation, transmission, distribution and retail operations (Figure 4.1).[29]

» Separation of retail operations and the introduction of retail competition are occurring at different times across the states.

» Some distribution businesses are now privatised (Victoria and South Australia); New South Wales is undertaking this process in 2015-16; and Queensland, Western Australia, Tasmania and Northern Territory remain government owned.

Energy reforms sought greater efficiency from interconnection and the introduction of competition, based on assumptions around continuation of centralised energy generation and monopoly supply. These assumptions were overtaken by changes in the energy operational environment, including the rapid spread of solar panels to over one million Australian households (especially in South Australia, Western Australia and Queensland), the emergence of alternative retail models, and the introduction of new technologies in communications, appliances and equipment.

The effects of government policies, including solar feed-in tariffs and encouragement of renewable energy sources (including growth of wind farms) that are connected to the grid at different locations with varying degrees of reliability, have resulted in significant changes to operational frameworks and assumptions that are still affecting the electricity system. The development of storage options at commercial rates, which is expected to have an impact in the near future, along with potential for significant increases in electric vehicle adoption, will continue to disrupt the earlier business model assumptions.

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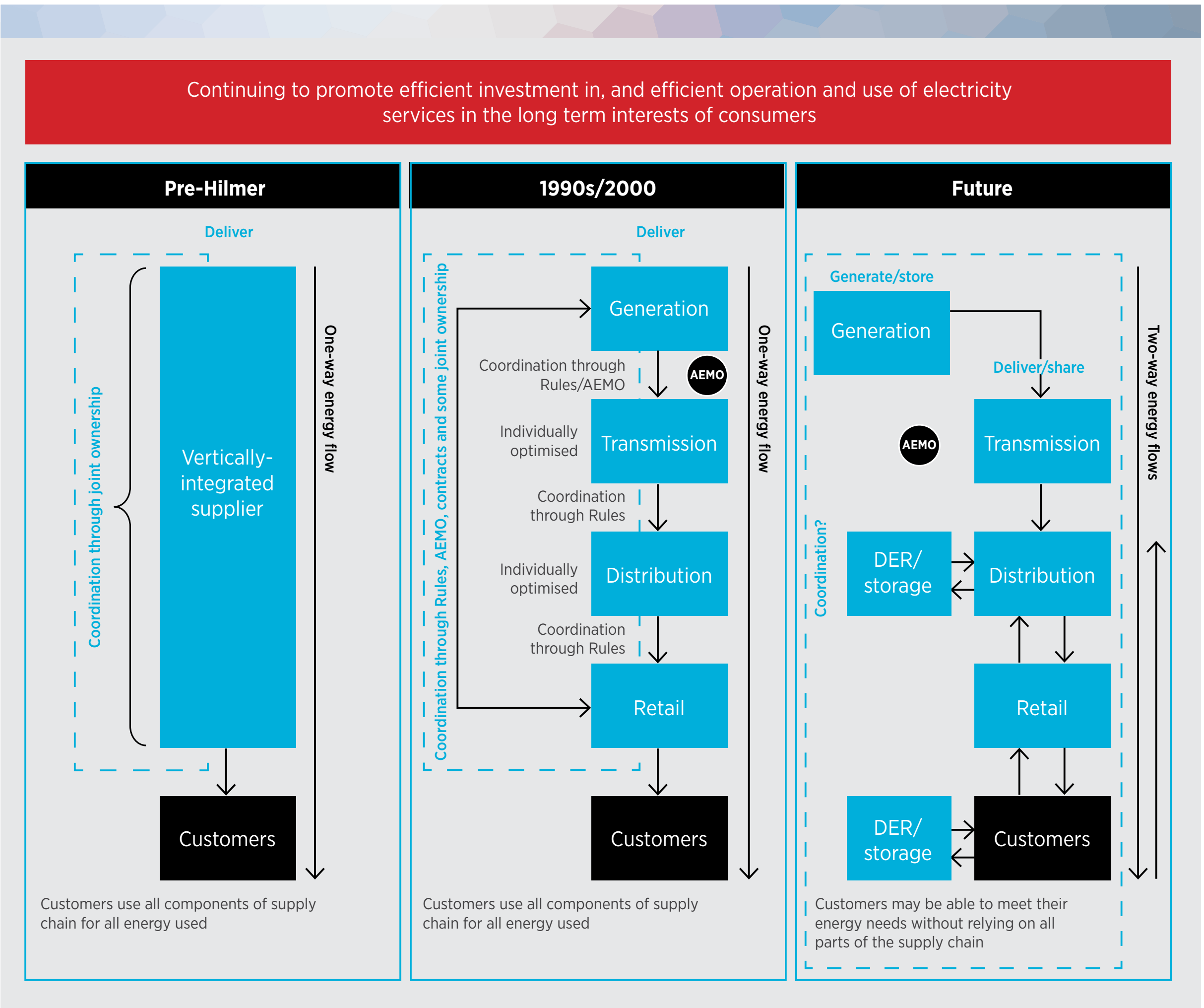
28 Accenture 2015, *Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution*, Melbourne.

29 Australian Energy Regulator 2014, *State of the energy market*, Australian Competition and Consumer Commission, Melbourne, p. 40.

Figure 4.1: Electricity system transformation



NOTE: DER = distributed energy resources

Defining a 'business model'

It is widely recognised that the growing challenge of managing uncertainty and complexity in the business environment will require companies to constantly adapt their business model in response.[30] The Roadmap program interprets the 'business model' of energy network service providers as a 'conceptual model that represents the business and money earning logic of a company [and] … a business layer … between business strategy and processes'.[31]

The analysis of business model frameworks provides a backdrop for thinking about the future business model options for Australian networks. Business models provide a mechanism and logic for connecting strategic visions to objectives and their optimal organisational delivery.

30 Osterwalder, A 2004, *Thesis: The business model ontology – a proposition in a design science approach*, University of Lausanne, pp. 13, 18.
31 Osterwalder, A 2004, *Thesis: The business model ontology – a proposition in a design science approach,* University of Lausanne, p. 15.

Global network experiences

ENA commissioned Accenture to review the operational environment for electricity networks globally to identify key aspects that may inform the Australian experience. The Accenture report identified that utilities internationally are facing a continually changing environment. It made the following observations:

» High electricity prices are dampening customer demand in countries such as Australia, Sweden and Germany.

» Regulatory bodies such as the Hawaiian Commission are rejecting infrastructure proposals that cannot demonstrate efficient expenditure/alignment to customers' needs.

» The subsidies available for renewable energy are growing. For example, Germany's subsidies cost approximately €20 billion a year). These subsidies have led to an increase in costs to the distributors, which must integrate distributed energy resources, so the network charges have also increased.

» Greater environmental awareness has led to greater consumer interest in renewables and increasing ambition for renewables and carbon emissions reduction targets.

» Consumers want greater personalisation of energy services. There is increasing demand for a broader range of products and offerings that can be tailored to an individual's needs. These demands require greater access to data, a more diverse energy technology mix, and greater interaction with customers.

» New energy technology breakthroughs are gradually reducing the cost of solar photovoltaic (PV) systems, storage and smart meters.[32]

The pace and depth of these changes vary widely, but Accenture noted:

> *Distributors are constrained by the nature of the traditional network business environment from responding effectively:*
>
> » *Regulated returns model favours heavy infrastructure investment in a traditional grid with limited incentive to adopt or integrate renewables;*
>
> » *[There is] risk aversion to deploying new technology in untested markets;*
>
> » *Grid technology does not allow for active management; [and]*
>
> » *Partnerships for technology/scale are not part of historic business models.*[33]

The challenge for electricity networks is to identify the specific issues most relevant to their operational circumstances and to ensure they have capacity and support to enable innovative responses in a timely manner.

The Accenture report concluded that shifts in regulatory policy and penetration of distributed energy resources are the two greatest influences on the pace and depth of network business model transformation. It noted that experience in European networks was dominated by government directives to incorporate renewables. For example, German Energiewende provides a regulatory framework that imposes ambitious renewables targets and provides significant subsidies to support distributed energy resources' proliferation. Similarly, while the United States of America lacks national renewables mandates, it is influenced by state-imposed approaches. For example, New York State's *Reforming the energy vision* defines a state-wide business model for the state's network distribution system.

Based on its reviews, Accenture considered that factors such as regulatory mandates, internal capabilities and a sense of urgency brought about by changing market conditions and competition will drive individual company responses. It believes these changes are evolutionary and represent the broader transition of the utilities industry to a more renewables dependent, digitally integrated operation. Accenture noted that the integration of distributed energy resources showed considerable value to traditional network businesses by providing greater network capacity and energy diversity to optimise grid performance for both supply and demand.

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32 Accenture 2015, *Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution*, Melbourne, p. 3.

33 Accenture 2015, *Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution*, Melbourne, p. 3.

Potential future distribution network business models

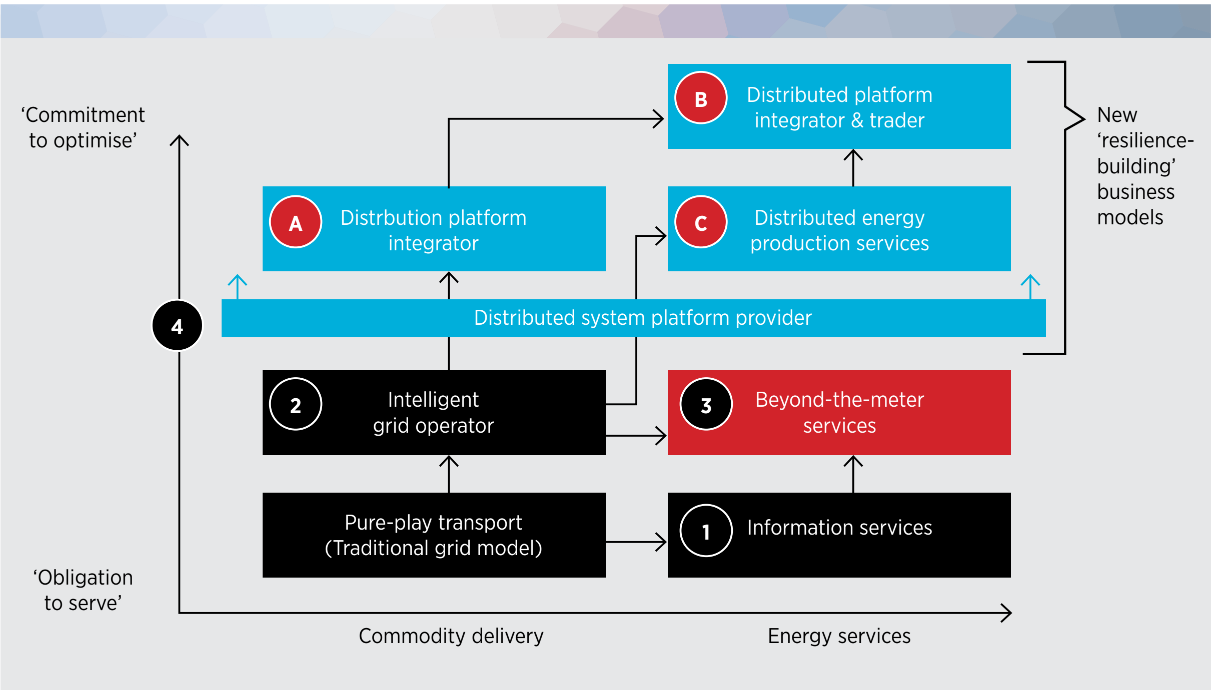
Accenture's analysis led it to identify four broad business model approaches:

- **Platform Enabled** – the establishment of a platform that enables optimum grid performance via real-time demand and supply management of distributed generation
- **Intelligent Grid** – advanced communications technology and automation that allows for real-time grid management
- **Beyond-the-Meter Services** – new service offerings that extend beyond traditional services, such as remote monitoring, smart metering and home energy management systems
- **Information Services** – monetising of data gathered from meters and other sources.[34]

Accenture does not see these models as exclusive or linear in developmental progression, but rather options that companies can select to address their particular circumstances at particular times. Accenture identified potential pathways between the models in its diagram reproduced in Figure 4.2.

In Figure 4.2, the traditional network business model is clearly identified as a valid option or choice in its own right, but only one of many business model approaches that may be appropriate or productive for effective network operations. The potential future operating models differ in their investment size and focus, risk parameters, and customer focus. Rather than focusing on just the perceived minimum functions that an energy network is required by regulation to perform, they focus on the potential additional values and services that may develop. The range of models reflects the very wide range of decision matrices for business operations in a complex and changing energy landscape.

Figure 4.2: Progressive electricity distribution network business model approaches



Source: Accenture 2015, *Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution*, Melbourne, p. 12.

34 Accenture 2015, *Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution*, Melbourne, p. 5.

Characteristics of progressive utilities

In its scan of global networks, Accenture identified some key initiatives common among all highly progressive utilities which are likely to be relevant to the Australian utilities industry.[35] These initiatives include:

- **Partnerships to build capabilities and accelerate pace of change** – Utilities should look externally to source expertise and technology, including how to incorporate or interact with renewable resources or distributed energy resources. Partnerships not only help to spread the risk of investment but can speed up deployment through use of existing best-in-breed products and services. Partnerships also provide access to a broader range of expertise than may be available within one company.
- **Establishment of a robust series of pilot programs that test a broad range of initiatives** – Companies should not choose a single initiative to respond to distributed energy resources' penetration and declining demand. By establishing a series of initiatives addressing efficiency, renewables and potential new products and services, companies can strengthen their core activities while developing new opportunities.
- **Investment in building an intelligent grid network** – Optimising demand and supply requires significant investment in the digitalisation of the traditional grid. Incorporating information and communications technology (ICT) and data analytics will improve the knowledge base and speed of response for networks. This includes real-time monitoring and communications as well as the ability to control the grid through automation.
- **Multi-phase business model planning** – Accenture noted that the most progressive utilities are those that are planning multiple evolutions of their business model. Some of these plans are driven by regulatory mandates (for example, the Office of Gas and Electricity Markets in the United Kingdom (Ofgem) and the California Public Utilities Commission). Others are driven by the company's understanding of future market conditions and competition (for example, Pacific Gas & Electric Company and E.ON Energy). The key point is that there will be no 'one size fits all' and no optimal 'final state' business model suitable for all networks at all times and in all circumstances. Future operational environments will require constant evolution.
- **Integration of distributed energy resources into the grid** – The proliferation of distributed energy resources is present to some degree in all jurisdictions that Accenture investigated. Most global network companies are looking into how to integrate and optimise distributed energy resources within a traditional grid network, but Accenture noted the most progressive networks are already rolling out targeted programs that incentivise producers to connect in parts of the grid where it would be of most value to grid operations.
- **Diversification of products and services** – Historically, because of their governing regulatory frameworks, network operators have relied on a regulated return model for most of their revenue generation. Moving forward, progressive companies are building capabilities with new products and services that will lead to a shift in their services and potential income sources. Non-regulated returns could come from smart metering services, and the provision and management of distributed energy resources such as virtual power plants, biomass or electric vehicles.

Accenture also highlighted some very new operating principles that progressive business models are adopting, including:

- being able to integrate all types of generation
- enabling consumers to provide services back to the grid
- offering enhanced or optional services, such as microgrid services and other distributed energy resources support services
- being agnostic about supply
- facilitating a retail market for consumers and third party providers to buy and sell services.

What the Roadmap needs to do

Accenture's detailed review for Stage 1 of the Roadmap program will inform the Stage 2 task of reviewing network business models for application in Australia. The Roadmap program wants to make sure Australian experience guides business model options in response to:

- the drivers of change in the Australian environment as outlined in the 2015 scenario set
- the penetration of distributed energy resources into Australian networks, and how to encourage and support further flexibility in energy generation and energy flow options

35 Accenture 2015, *Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution,* Melbourne, p. 8.

- the need to focus on customer service and changing energy customer wants and needs (Chapter 1). Reorienting the focus on to customers is a defining change in networks' operation.

Tasks going forward are to:

- identify the range of potential business models applicable to Australia, noting current barriers or constraints to their operation
- identify essential changes required to enable Australian network operations to evolve and to transition to business models suited to delivering the value that customers seek.

Analysis of these matters will need to determine:

- what operational flexibility may be available to networks within the current regulatory frameworks
- how to ensure the flexibility of regulatory frameworks is recognised and used to allow timely innovation in network service delivery and customer outcomes
- what (if any) major changes might be needed to allow Australian networks to operate most flexibly in delivering long term value to customers.

How you can help

Your feedback on the following questions is welcome. This feedback will be used during Stage 2:

4.1 Should networks play a broader role in servicing customers directly?

4.2 How can networks develop and implement a 'customer-oriented service' focus with limited direct customer relationships and links?

4.3 Who should be responsible for supporting individual customers or communities (microgrids) that independently decide to go off-grid? How would this support be funded and supported within regulatory and business model frameworks? Would it vary in emergencies and, if so, how?

4.4 To what extent should networks' operations remain delineated into regulated and unregulated services? Is the current regulatory framework still appropriate in the changing energy environment? Does it maximise benefits available to customers?

4.5 What roles could networks play in 2025 to support the delivery of maximum value to customers? What are the critical challenges to making this work?

4.6 How far should network business model flexibility interact with or impact on the operation of other energy industry companies and service providers?

KEY FINDINGS

F4.1 A review of international energy companies identified four broad business models: Platform Enabled, Intelligent Grid, Beyond-the-Meter Services and Information services.

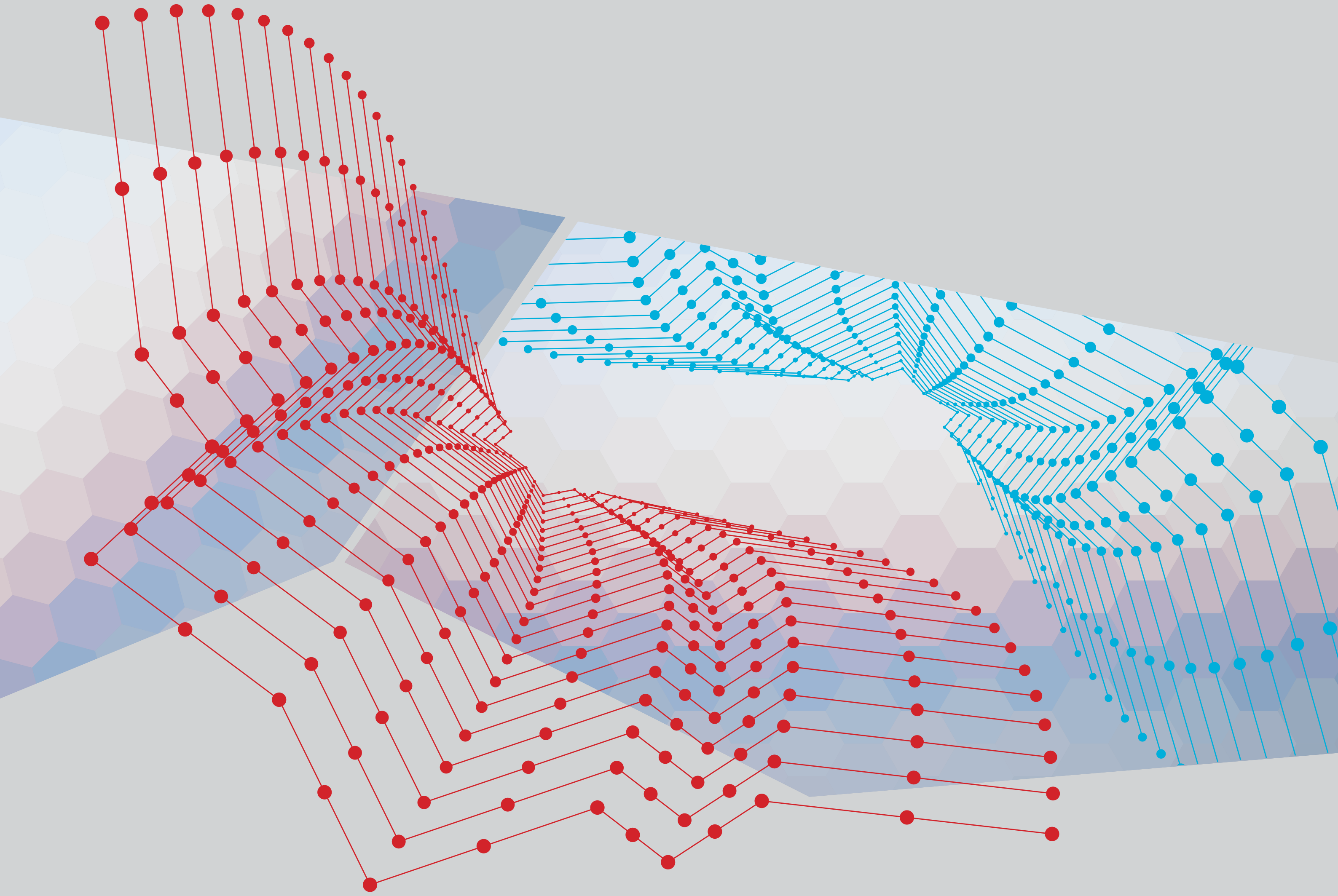
F4.2 Electricity network business models must evolve to deliver the future value desired by future customers and to ensure the economic and technical efficiency of networks as integrated and enabling platforms in their changing operational environments.

F4.3 There is no 'one size fits all' approach to future network business models, and nor is there an 'optimal final state' business model for all networks. The most progressive utilities are planning multiple evolutions of their business model to address their particular and changing circumstances.

RECOMMENDATIONS

R4.1 Stage 2 of the Roadmap is expected to more closely consider the application of new business models in an Australian context and the required regulatory framework to deliver better outcomes for customers.

R4.2 Australian networks can learn from experiences and operations of overseas network businesses while remaining aware of critical differences in circumstances to address local key challenges.



CHAPTER 5
PRICE AND INCENTIVES FOR A TRANSFORMED ELECTRICITY SYSTEM

Quick look

- » Future electricity systems that empower diverse customer choice in a manner that is both equitable and highly efficient will require new approaches to electricity pricing.
- » Electricity pricing and incentives will be critical to delivering a balanced scorecard of societal benefits, not least because they will help customers optimise their own energy production and consumption for shared benefit.
- » For Australia's network businesses, network tariff reforms are revenue neutral – that is, they will govern how network costs are shared among customers, not alter the amount of regulated revenue.
- » The initial program of tariff reforms from 2017 can be thought of as a 'First Wave'. Under these reforms, network service providers will meet their *universal responsibility* to all customers to price network services and share cost recovery in a manner that is fair and efficient. However, while these reforms will provide improved signals for network service providers, the full optimisation of distributed energy resources is likely to require a 'Second Wave' of price and incentive reforms through to 2025. These reforms will involve offering customers the opportunity to participate in new pricing options or markets, which are likely to be location specific and dynamic in real time.

What we know

There is strong evidence that electricity pricing and incentives frameworks will critically influence the customer benefits sought in the industry's transition. This Chapter focuses on electricity network tariffs, which can represent approximately one third to one half of the customer electricity bill.

Efficient network pricing is needed to increase:

a. downward pressure on future network costs
b. the resilience of Australia's electricity system to step changes in technology and its use
c. price fairness among customers.[36]

Most Australian residential and small business customers may be unaware that their electricity distribution network tariff bears little relationship to the cost drivers of the network. While peak demand is the primary driver of long term distribution network costs, all Australian jurisdictions heavily rely on volumetric (c/kWh) charges for determining how network costs are shared among users. Volume (or the amount of electricity consumed) has little relation to peak demand, or the instantaneous coincidental demand, that customers can place on the network when using a range of appliances simultaneously at peak times.

36 ENA 2014, *Towards a national approach to electricity network tariff reform*, December, p. 5, available from http://www.ena.asn.au/sites/default/files/position-paper_towards-a-national-approach-to-electricity-network-tariff-reform_december-2014_1.pdf.

Australia's outdated distribution network tariff structures are not only undermining efficiency and equity in the short term, but are poorly placed in the longer term to reward efficient investment, behaviour and operations in the transformed energy system of the future.

Estimates commissioned by the Australian Energy Market Commission demonstrated that today's heavily volumetric tariffs result in unintended cross-subsidies among key customer groups. A customer using airconditioning at peak times, for example, may unintentionally receive a cross-subsidy equivalent to approximately $700 per year from customers that do not.[37] Similarly, a customer with north-facing solar panels in New South Wales may unintentionally receive a cross-subsidy of approximately $120 per year from other customers.[38]

As discussed in the scenario analysis in Chapter 2, significant investment in distributed energy resources will likely be justified by the economic value that it can create through efficiency and enhanced services. However, current electricity distribution network tariffs will also incentivise additional investment through cross-subsidies or cost transfers to other customers. In a comparative analysis of electricity network tariff options, Energeia estimated more efficient pricing of electricity network services will have the following benefits:[39]

» Customers could save up to $17.7 billion by 2034 from more efficient investment in networks and embedded generation capacity.
» Customers could avoid an increase from $120 per year today up to $655 per year in 2034 in unfair cross-subsidies to early adopters.
» Customers could save up to $250 per year on average residential electricity bills by 2034.

In a similar vein, the landmark *Smart grid smart city* study for the Australian Government found that cost reflective pricing reform with enabling technology could achieve an economic benefit of $10 billion by 2033.[40]

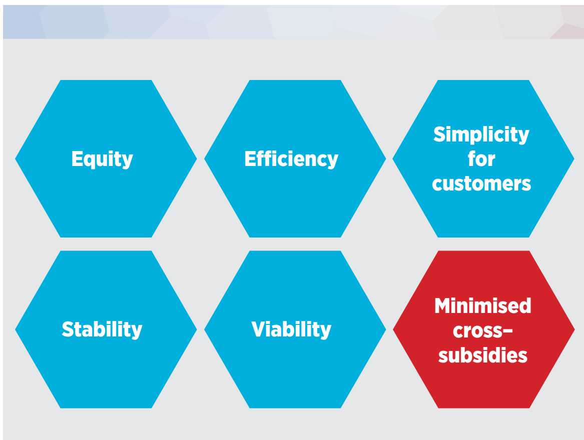
As discussed below, in addition to the initial network tariff reform measures, other pricing and incentive frameworks will also be necessary in the longer term to support the energy transformation.

What we're doing

Traditionally, network pricing has been designed to achieve a number of objectives, some of which may be in conflict and need to be balanced. Credit is given to James Bonbright for establishing key criteria that have served as the principles underpinning electricity pricing for the past half century.[41] The influence of Bonbright's principles is evident in the distribution network pricing principles recently introduced to the National Electricity Rules. Broadly, these principles can be collapsed into the five objectives of promoting economic efficiency, equity, simplicity of the customer experience, pricing stability, and viability of the network.

According to the Rocky Mountain Institute, the Bonbright principles remain largely relevant and appropriate for the transformational changes underway in electricity markets. However, the Institute also proposed improving the original principles by adding an objective: the minimisation of unintentional cross-subsidies (Figure 5.1).

Figure 5.1: Bonbright's principles (with an addition by the Rocky Mountain Institute)



37 NERA Economic Consulting 2014, *Efficiency of tariffs for current and emerging technologies*, Report for the Australian Energy Market Commission, 21 July, p. 20.
38 NERA Economic Consulting 2014, *Efficiency of tariffs for current and emerging technologies*, Report for the Australian Energy Market Commission, 21 July, p. 27.
39 Energeia 2014, *Network pricing and enabling metering analysis,* November, Sydney, available from http://www.ena.asn.au/network-pricing-and-enabling-metering-analysis-energeia.
40 SmartGrid 2014, *Smart City: Shaping Australia's energy future*, Executive report, July, p. 47.
41 The Brattle Group 2014, *Time-varying and dynamic rate design*, Global Power Best Practice Series, July, p. 4.

It considered this addition is critical in an environment where consumers may partly or fully substitute their own distributed generation.[42]

It is vital that electricity network tariff design, analysis and implementation are informed by a realistic understanding of the customer response and interaction with the tariff and the service. The CSIRO and others have applied behavioural economics to assess potential customer responses to cost reflective pricing. A range of known customer preferences can inform tariff reform and engagement, including the following:

» Customers will weigh losses more heavily and discount future (uncertain) benefits.
» Customers are risk averse and prefer certainty.
» Customer behaviour is highly inert. As information increases, people tend to 'stick to defaults'.
» Customer decision making will generally deteriorate as information or options increase.
» Message framing should be attentive to community norms and interests.[43]

Electricity network providers are progressing tariff reform proposals in close consultation with their customers and retailers. Recent changes in the Rules include a shift to cost reflective pricing of network services to customers. By 2017, electricity distribution networks will set the distribution network tariff structures to apply for the remainder of the five year regulatory period for each business. Under a new network pricing objective, 'network prices should reflect the efficient costs of providing services to each consumer'.

Distribution network tariffs must also comply with the following principles:

» Each network tariff must be based on long run marginal cost.
» The total revenue must be recovered in a way that minimises distortions to price signals.
» In developing tariffs, distribution network businesses must consider a consumer impact principle.
» Network tariffs must be reasonably capable of being understood by consumers.
» Network tariffs must comply with any jurisdictional obligations.

For Australia's network businesses, network tariff reforms are **revenue neutral** – that is, they will govern how network costs are shared among customers, not alter the amount of regulated revenue. In other words, the introduction of new tariff structures has no inherent profit objective; rather, the objective is to increase the efficiency, fairness and long term sustainability of the shared network infrastructure required by consumers.

Networks will develop tariff reform proposals in consultation with their customers and retailers under the oversight of the Australian Energy Regulator. In some cases, the proposed tariff design and its implementation will vary, based on locational circumstances, enabling technology such as metering, and the views of customers on a particular network.

What we're learning

Many electricity distribution networks favour a transition to demand based network tariffs, to signal the future costs of expanding the distribution network to meet peak demand and to incentivise the efficient size, location and operations of distributed generation. Over time, an increasing portion of the network cost will be recovered through a demand charge that is based on the customer's maximum demand. Network tariffs will be fairer because consumers who use proportionately less electricity at peak times of the day (generally early evenings for residential customers) will have lower electricity bills. That is, those customers will pay cheaper rates than peakier users.

Such tariffs also incentivise the timely use of distributed resources such as solar and storage, whereby customers can help mitigate network peak demand. This incentive will help customers to choose efficient technology and control options to modify their energy use to reduce not only their costs but also the costs of networks.

42 Rocky Mountain Institute 2014, *Rate design for the distribution edge*, August, p. 38.
43 Fredericks, E, Stenner, K and Hobman, E 2015, 'Household energy use: applying behavioural economics to understand consumer decision-making and behaviour', *Renewable and Sustainable Energy Reviews*, January.

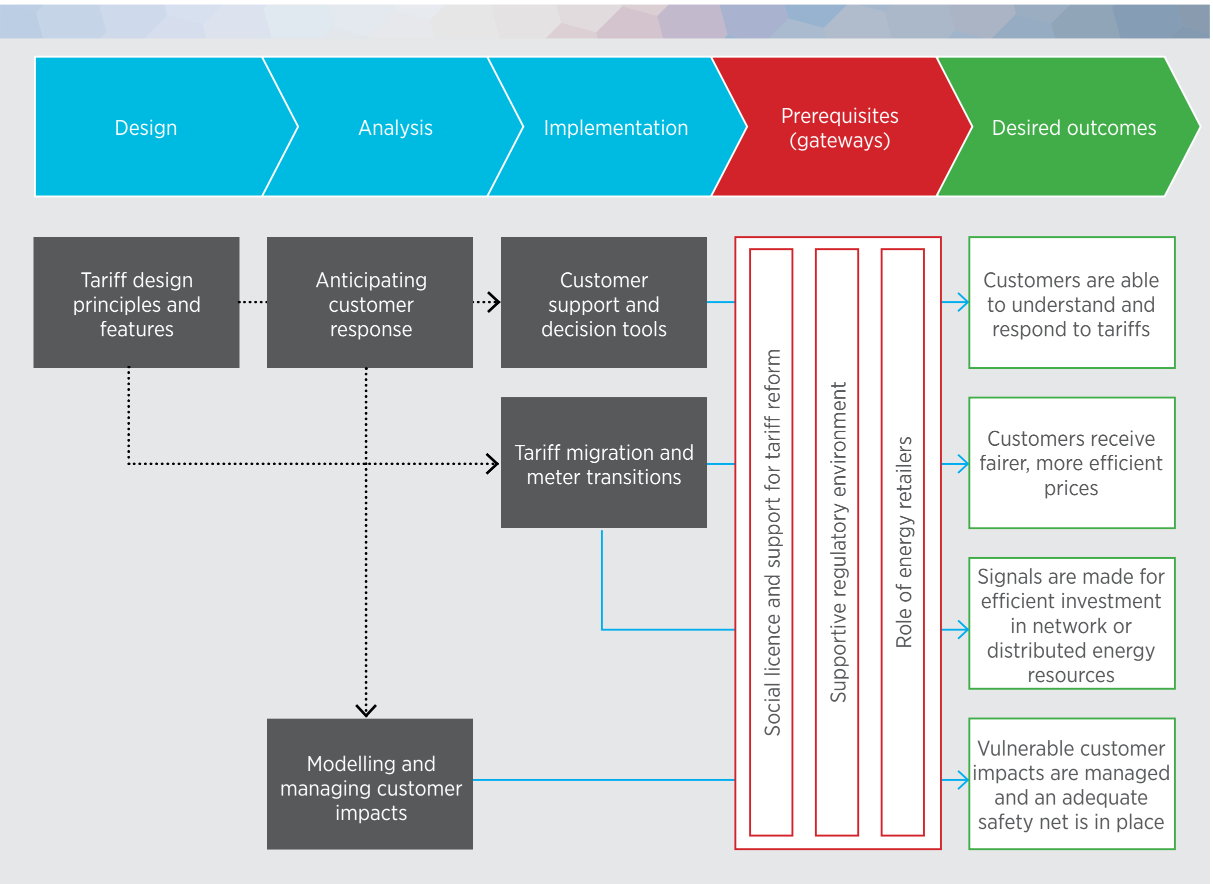
The successful implementation of these initial network tariff reforms will require an integrated, national approach by distribution network businesses working together with retailers, third party service providers, governments, consumers and their advocates (Figure 5.2). This approach reflects the shared benefits of achieving a sustainable, efficient and equitable electricity system for customers.

Since December 2013, when the current distribution network tariff reform process was initiated, ENA has worked closely with consumers and stakeholders on the following five key enabling measures as part of the ENA Roadmap for Tariff Reform:

- a balanced framework for smart meters that achieves the fastest economic roll-out in jurisdictions outside Victoria, including a national new and replacement meter policy
- a national approach to introducing flexible pricing, including mandatory assignment of customers to cost reflective network tariffs when the customer has a smart meter or exceeds certain thresholds (energy or demand)
- better information and decision tools for consumers through a joint initiative of electricity networks, retailers and governments
- a review of customer hardship programs, to support vulnerable customers during the transition to more cost reflective pricing
- the deregulation of retail prices, when markets are sufficiently competitive.

To support the implementation of this initial network tariff reform, during the first part of the critical decade for the Roadmap, ENA is developing a network tariff reform guideline. The forthcoming guideline will seek to help implement network tariff reform in a collaborative and aligned manner, considering a range of stakeholder inputs. It will highlight the desired outcomes of this initial tariff reform, and their reliance on how distribution network service providers design, analyse and implement tariff structures. It will also recognise the prerequisites or gateways to enable tariff reform, including the social licence for reform, a supportive regulatory environment and the role of energy retailers.

Figure 5.2: Achieving successful electricity network tariff reform



Two waves of network pricing and incentive reforms?

This initial program of tariff reforms can be thought of as a ‘First Wave’ (Figure 5.3). Under these reforms, network service providers will meet their universal responsibility to all customers to price network services and share cost recovery in a manner that is fair and efficient. The transition to demand based network tariffs for residential customers and small businesses, for example, would provide significant progress towards removing cross-subsidies, incentivising efficient investment in the network and in distributed energy resources, and putting downward pressure on future network costs.

The specific demand based tariff structures, and the rate at which the demand component will be phased in, are being determined in consultation with consumers and retailers as networks develop their Tariff Structures Statements (required under new pricing Rules). Additionally, while there are options for migrating network customers to cost reflective prices, the migration is inherently a universal reform process that seeks to minimise the cross-subsidies between customers. (The First Wave of tariff reforms focuses on recent changes in the rules that require distribution network business to develop prices that better reflect the costs of providing services to individual customers. These changes help individuals make more informed decisions about how they use electricity. However, it is also important to recognise the need to improve the signals and incentives that larger customers receive directly through transmission pricing structures.)

Figure 5.3: Two ‘Waves’ of tariff reform to 2025

First Wave			Second Wave
Highly volumetric tariffs	Improved fixed cost recovery	Demand based tariffs	First Wave reform PLUS
FIXED / USAGE (c/kWh)	FIXED / USAGE (c/kWh)	FIXED / USAGE / DEMAND (c/kW)	Voluntary, localised pricing options: » Demand management storage tariff » Back-up supply charges » Critical peak pricing » Peak time rebates Voluntary incentive (payment) options: » Embedded generation incentives, credits or feed-in tariffs » Ancillary services payments
− Significant cross-subsidies between consumers	+ Reduced cross-subsidies between consumers	+ Minimised cross-subsidies based on customer use of the network	+ Minimised cross-subsidies based on customer use of the network
− Technology adoption (airconditioning, solar, storage) driven partly by cost shifting	+ Reduced incentive for technology adoption (airconditioning, solar, storage) to be driven by cost shifting	+ Economic incentives for technology adoption based on contribution to avoided network costs	+ Economic incentives for technology adoption based on contribution to avoided network costs
− No reward to shift consumption off-peak	− No reward to shift consumption off-peak	+ Reward to shift consumption off-peak	+ Reward to shift consumption off-peak
− No ‘locational’ reward to customers to reduce network costs (through demand management or embedded generation)	− No ‘locational’ reward to customers to reduce network costs (through demand management or embedded generation)	− No ‘locational’ reward to customers to reduce network costs (through demand management or embedded generation)	+ ‘Locational’ reward to customers to reduce network costs (through demand management or embedded generation)
− No incentive for new energy markets and services	− No incentive for new energy markets and services	■ Some incentive for new energy markets and services	+ Incentives for new energy markets and services

In the longer term, there are opportunities for a 'Second Wave' of tariff reforms. The reforms may include the subsequent introduction of other pricing and incentive structures, including ones at the transmission network level. Together with developments in intermediaries and third party service providers, they could further benefit consumers through more targeted incentives that address the particular needs of diverse customer groups in their use of, and support for, network services.

In 2025 Australians could have a choice of more complex tariffs. Over the medium to longer term, network pricing could be increasingly dynamic (reflecting real time events such as critical peak rebates and critical peak pricing) and more locational (reflecting local network capacity constraints). Distribution network businesses are likely to pay a range of incentive payments to the customer, such as demand management tariffs for storage devices, network support payments and ancillary benefit payments. Further, consumers who are largely or wholly self-reliant on distributed generation may contract with a network and pay a back-up supply charge or an on-demand reconnection charge to restore supply when the customer's supply fails or is unavailable.

Third party service providers and other intermediaries may increasingly manage tariff complexity and unfamiliarity, and simplify tariffs for the end customer, who ultimately benefits from being able to access a range of price signals and opportunities to participate in more dynamic energy markets.

Further, the 'Second Wave' of network pricing and incentives could include greater use of demand management tariffs and introduce new network tariffs and incentives for small customers, including:

» locational tariffs and nodal pricing for distribution and transmission networks
» critical peak pricing or peak time rebates
» embedded generation incentives, credits or feed-in tariffs
» transactive energy markets for services (for example, ancillary services).

Without prejudging future network considerations, these 'Second Wave' pricing and incentive reforms may more likely occur through consumers' *voluntary participation* and *experimentation* by networks and other service providers.

What the Roadmap needs to do

The Stage 1 work program has focused on the near to longer term options for network pricing reform to help transform the electricity network industry. It has also considered how electricity network pricing could evolve over the next decade to more fully reflect a two-way exchange of value and services between electricity networks and customers. Further, it has considered the overall structure of future price signals, to understand how more effective network price signals can be reliably transmitted to customers. In particular, it has aimed to understand and assess the drivers and enablers that could affect pricing reform, including:

» the customer orientation of networks
» changes in technology choices, whereby consumer investment in distributed energy resources could vary significantly across jurisdictions
» the roll-out of metering and other enabling technologies (such as in-home displays) to support time varying pricing
» customers' ability to understand and respond to time varying pricing and demand management incentives
» the nature of the social licence for customer-oriented network service providers.

In the medium to longer term, as more customers increasingly either acquire distributed energy resources or access them through community schemes, further pricing innovations will be required to ensure fair and efficient operation of electricity networks as integrated enabling platforms. The more effective the integration of distributed energy resources into the network, the greater will be the opportunity to reduce future network costs while maintaining or increasing grid resilience and reliability.

This integration and optimisation of distributed energy resources adoption will be enhanced by future price signals that clearly reflect the value of two-way electricity services exchanged between end-users and the electricity system. Stage 2 of the Roadmap will examine how price signals can evolve over the next decade to deliver efficient outcomes for customers and the grid alike. It will need to identify the essential features and characteristics of the potential 'no regrets' network pricing reform priorities for the decade to 2025, accounting for the costs and benefits of these options. It will need to also identify and assess the key enablers of and barriers to successful implementation of more dynamic price signals, including advanced metering and customer preferences.

Stage 2 is expected to:

» leverage ENA's forthcoming network tariff reform guideline, including opportunities and challenges in distribution and transmission network pricing over the medium to longer term
» further evaluate 'Second Wave' pricing and incentive reform measures such as locational tariffs and nodal pricing; critical peak pricing or peak time rebates; embedded generation incentives, credits or feed-in tariffs; and transactive energy markets for services (for example, ancillary services)
» explore further opportunities to use behavioural economics techniques to enhance network tariff reform implementation, to practically help consumers understand and respond to network tariffs that reflect the drivers of network costs.

How you can help

Your feedback on the following questions is welcome. This feedback will be used during Stage 2.

After each question, please note initial observations on 'no regrets' network tariff reform priorities to 2025. Stage 2 will test those observations against international experience and stakeholders' views (including your feedback).

5.1 What is most important for helping residential and small business customers to understand cost reflective network pricing?

In 2025 electricity network service providers will likely have a universal network tariff for small customers that is fairer and more reflective of the costs of network use for each customer. Customers will understand and accept the principle that *unintended* cross-subsidies between one customer and another should be minimised.

5.2 How could technology create more choices and enhance reasonable consumer ability to understand and respond to more complex tariffs?

In addition to having a universal cost reflective network tariff in 2025, networks will also likely have efficient network price and other incentive options that reward customers for voluntarily shifting their load and deploying distributed energy resources to provide capacity or ancillary services to the network.

These options are likely to arise from advances in technology, including intelligent appliances, cost effective customer owned storage, and a platform to support dynamic (real time) trading in energy services. In other words, customer acceptance of more complex cost reflective tariffs will likely depend on breakthrough technologies.

5.3 What synergistic benefits and changes in business models could make energy services bundling more likely?

In 2025 services and products offered by industry may be bundled in such a way that network pricing will be only one element of a bundled energy service. These services could include bundled distributed energy resource solutions.

KEY FINDINGS

F5.1 Fairer, more efficient electricity network prices could provide significant benefits in lower electricity bills, avoided cross-subsidies, and incentives for efficient investment in network infrastructure and distributed energy resources. For Australia's network businesses, network tariff reforms are **revenue neutral.**

F5.2 Recent studies estimated tariff reform could save customers up to $17.7 billion by 2034 from more efficient investment in networks and embedded generation capacity; avoid growth of widespread cross-subsidies of up to $655 per year by 2034; and save up to $250 per year on average residential electricity bills by 2034.

F5.3 The initial program of tariff reforms from 2017 can be thought of as a 'First Wave'. Under these reforms, network service providers will meet their universal responsibility to all customers to price network services and share cost recovery in a manner that is fair and efficient.

RECOMMENDATIONS

R5.1 ENA's forthcoming network tariff reform guideline should help bring about a national, collaborative and integrated approach to reform, with a range of stakeholder engagement.

R5.2 Stage 2 of the Roadmap is expected to include:

- leveraging ENA's forthcoming network tariff guideline, including opportunities and challenges for distribution and transmission network pricing over the medium to longer term
- further evaluating 'Second Wave' pricing and incentive reform measures such as locational tariffs and nodal pricing; critical peak pricing or peak time rebates; embedded generation incentives, credits or feed-in tariffs; and transactive energy markets for services (for example, ancillary services)
- looking for further opportunities to use behavioural economics techniques to enhance network tariff reform implementation, to practically help consumers understand and respond to network tariffs that reflect the drivers of network costs.

CHAPTER 6
PRIORITY DIRECTIONS FOR ELECTRICITY POLICY AND REGULATION

Quick look

- Electricity markets, consumer technologies, network business models and energy resources are changing, so it is necessary to think differently about the traditional regulatory framework for electricity networks in Australia.
- The Stage 1 work program has developed guiding principles for regulatory evolution over the 2015–25 decade and identified some important issues that need further consideration, rather than setting out prescriptive 'answers'.
- This Chapter identifies that some elements of the current regulatory framework are robust and will remain relevant. However, others are not 'fit for purpose' in the range of expected future scenarios, and they risk delivering poor customer and societal outcomes. The Chapter also notes that a regulatory regime that is outpaced by technology and market developments cannot protect consumers or deliver a balanced scorecard of societal outcomes.
- Australia needs a clear conversation about the purpose and expectations of economic regulation. It must articulate a coherent framework for defining what is regulated and why, and providing well-defined options for regulating services at different stages of contestability.
- Economic regulation can also be considered as a tool for allocating risk. In this case, we need to consider how network transformation could fundamentally change possible risk allocations. It is in the interests of electricity customers that the regulatory framework for future network services enables investor confidence to efficiently finance long-lived infrastructure.
- Different transition pathways and destinations for regulatory frameworks are viable but it is important to define our expectations and set the processes upfront.

What we know

Australia's current regulatory model for electricity networks is based on forms of utility regulation developed in the United Kingdom over 30 years ago. It also includes features of US style 'rate of return' regulation, which has a history stretching back to the early 1900s. It requires the network service providers to prepare and consult on detailed regulatory proposals that forecast the networks' operating and capital costs, electricity demand, network charges and investment plans for the next five year regulatory period.

This regulatory model has evolved, with tweaks and innovations. An example is the progressive introduction of incentives and reward/penalty schemes. These schemes encourage network service providers to achieve capital and operating expenditure efficiencies in their service delivery, and to maintain or enhance their service quality.

Alongside these amendments, the regulatory framework has retained three core presumptions:

- the existence of a centralised, one-way electricity network
- a persistent natural monopoly over critical network services
- limited potential emergence of competition over time.

For these reasons, it is a relatively intrusive framework that seeks to ensure charges for a narrow and defined set of services reflect efficient costs. It also aims to make network businesses' cost recovery more predictable, so network investors have the confidence to make substantial ongoing investments in long-lived capital intensive network assets such as poles and wires.

This traditional regulatory framework is not necessarily the best way to promote the long term interests of consumers, or to protect the medium term commercial interests of the network sector in the future. In particular, it does not have all the answers for the electricity grid's transformation into a system that integrates a complex and evolving mix of distributed energy resources.

The widespread diffusion of distributed energy resources – in the form of large scale embedded generation, solar photovoltaic penetration, and the potential emergence of mass scale battery storage technologies – is the single most important change to grid architecture over the past century. It also has significant implications for how to regulate the sector.

The Roadmap program is not suggesting the existing framework will become inappropriate in its entirety. The framework contains some flexibility that may be useful – for example, network service providers have the theoretical capacity to seek long regulatory periods, and the regulator may trial and experiment with small scale incentive schemes. In some scenarios, these features could help support the energy transformation affecting the energy market and consumers. Yet, some features and application of the current regulatory regime unintentionally limit how well it can respond to market circumstances. They constrain networks' ability to innovate, apply normal commercial options to achieve efficient customer based solutions, and manage evolving demand and technology related risks.

The 2013 Future Grid Forum report recommended establishing processes to identify whether and how market frameworks need to respond to market and technology megashifts.[44] The Roadmap's scenarios provide a 'technical' view of potential futures, and of the changes that may occur in each energy sector. However, processes are needed for considering whether the current market and regulatory frameworks will be consistent with these futures, and how to make the transition to any new arrangements. It would be sensible to start thinking about the regulatory pathway now, at least at a high level. In particular, the Roadmap program should look to understand the feasibility of the options.

In short, Australia's electricity networks are subject to significant economic regulation, and that regulation is premised historically on network service providers being natural monopoly businesses. However, the significant market and technological changes underway mean network service providers are increasingly exposed to competitive forces, so this long standing premise is no longer universally valid. In other words, a new regulatory mindset may be needed.

44 CSIRO 2013, *Change and choice: the Future Grid Forum's analysis of Australia's potential electricity pathways to 2050,* Canberra.

What we're doing

Roadmap Stage 1

Stage 1 of the Roadmap has focused on analysing and describing likely developments in the Australian energy market to 2025 (based on different scenarios), and emergent business models for energy market players. The Roadmap's scenarios encompass a range of alternative future states. The challenge is to develop the economic regulatory regime that can robustly respond to the widest range of these scenarios. Most importantly, all the scenarios include the increased penetration of distributed energy resources, and any new regulatory framework must account for that change.

So, rather than setting out prescriptive 'answers', the Stage 1 work program focused on developing high level principles to guide how the broad economic regulatory framework may evolve over 2015–25 to provide appropriate outcomes across different scenarios. These principles are designed to account for the potential revenue, business model, technological and other changes expected over the decade to 2025 and beyond (changes that are explored in the broader Roadmap program).

Roadmap Stage 2

In Stage 2, the Roadmap work program will identify future regulatory and institutional framework options that are aligned to the future scenarios, customer centred and suitable for increased competition and contestability. It will also identify potential ways to better support network innovation – for example, by designing a more flexible regulatory framework that promotes innovation and the delivery of new services valued by consumers. This exploration will account for the appropriate ongoing role of current guiding principles for regulation – namely, the principles of competitive neutrality, appropriate risk sharing, investment cost recovery, and ensuring the scope and type of economic regulation are proportional to the long term benefits to consumers.

What we're learning

Some elements of the current regulatory framework are robust, and will remain relevant. Others may not be 'fit for purpose' in the range of expected future scenarios, and could risk delivering poor consumer outcomes. To establish why this might be the case, the Stage 1 work program involved:

- reviewing the original policy drivers for existing regulation
- examining the risks of regulation being outpaced by market and technology developments
- reviewing other regulatory jurisdictions' approaches to address developments in the electricity sector
- questioning whether the role of regulation should be redefined
- considering how society can use regulation as a tool for risk allocation.

Reviewing policy drivers of the current regulatory regime

The current regulatory regime for electricity and gas networks is a product of successive governments' public policy objectives. Understanding these objectives (listed below) is important for understanding how energy market transformation will affect future regulatory approaches:

- **Having a safe and reliable universal service** – The primary policy objective of governments has always been to provide a universal service that is safe and reliable.
- **Protecting consumers from monopoly power** – The electricity network infrastructure has traditionally had natural monopoly characteristics, so policy makers have designed regulation to remove the potential risks of network owners extracting 'monopoly rent' via their control of pricing and access to critical 'bottleneck' infrastructure. The regulatory regime has focused on the potential for monopoly infrastructure owners to deny access or provide it on commercially unreasonable terms and conditions (including high prices).
- **Minimising the cost of delivering energy to consumers** – Policy makers have sought to minimise network service providers' cost of serving residential, commercial and industry customers. Their goal has been to promote electricity affordability and competitiveness.

» **Promoting innovation and competition** – Over the past two decades, governments and policymakers have sought to promote contestability and competition in the market, to achieve innovation and greater customer choice in energy services.

How the current regulatory framework addresses the policy drivers

The current regulatory framework is a product of different policy and regulatory approaches adopted over time to meet the above objectives.

To have a safe and reliable universal service, governments have used a mix of measures. These include minimum obligations to serve and offer connections, and control of entry through defined monopoly franchise areas. Reliability obligations are included in legislative and regulatory instruments, and are conditions of exclusive licences. Over time, regulatory mechanisms to promote reliability have evolved to focus on financial incentives to maintain or improve service. An example is the service target performance incentive scheme (STPIS), which seeks to better link reliability targets to customer willingness to pay for reliability.

The current regulatory model presumes a persistent natural monopoly over network services. So, to protect energy users from the potential exploitation of monopoly power, the regulatory regime has primarily focused on infrastructure access. Current network regulation provides a 'right of access' to monopoly infrastructure. It seeks to ensure charges for the services delivered via monopoly infrastructure reflect the efficient costs of that service provision.

This goal is critical for two main reasons. First, electricity is an essential input into broader economic activities. Second, a stable and efficiently priced electricity service is important to Australia's economic competitiveness in export markets and as an attractive investment location.

To minimise the cost of delivering energy, the regulatory framework provides a predictable cost recovery framework so network investors have sufficient confidence to make ongoing investments in long-lived capital intensive network assets such as poles and wires. Australia's transparent, independent, rules based regulation, with its avenues for independent review of regulatory determinations, has been crucial to the long term commitment of capital (particularly low cost private capital) to sunk infrastructure assets.[45]

Even with significant use of distributed energy resources, the evidence suggests timely and efficient investment in energy infrastructure will be important to support the reliability and quality of electricity services for residential, commercial and industrial customers. Such network investment will also support the integration of renewable and non-dispatchable energy sources at all scales, and enable emerging energy markets for distributed energy resources.

Some commentators have suggested the regulatory compact around past investment cost recovery should be breached, in the public interest. However, even they acknowledge this approach would increase financing costs, which consumers would ultimately bear.[46]

To promote innovation and competition across the energy chain, policy makers have historically encouraged or required the separation of contestable components of the supply chain from natural monopoly components. Examples include the creation of eastern Australia's wholesale electricity market, whereby governments sought to establish a national electricity market in which interconnection between significant electricity transmission networks enables competition between significant generation facilities, and thus facilitates efficient outcomes. Similarly, the introduction of retail competition was achieved by the unbundling of network charges and the introduction of contestability, to allow consumers to choose their retail supplier.

45 Lord Deighton, Commercial Secretary to HM Treasury, 2014, Speech to Annual Conference of Association of Consultancy and Engineering, London, 21 May 2014.

46 For a summary of the proposals and an initial assessment of these potential impacts, see ENA 2014, *Written-down value? Assessing proposals for electricity network write-downs*, Research paper, Canberra.

Additionally, to promote competitive market outcomes and to stop regulated network providers from leveraging monopoly power into retail or generation markets, policy makers and regulators developed ring fencing and cost allocation rules that effectively restrict regulated networks from participating in those markets. Examples are the current prohibitions on network service providers owning large scale generation facilities, and requirements for networks to deal at 'arm's length' with commonly owned energy retail businesses.

How energy market transformation will affect the policy drivers

The energy market transformation represented in the updated 2015 scenarios set will affect each of the traditional four policy drivers. In particular, in all the CSIRO's scenarios (although on differing levels and timescales), the energy regulatory regime will need to accommodate – and even facilitate – the efficient development and diffusion of distributed energy resources, including embedded generation, widespread solar panel penetration and energy storage technologies. That is, it will need to adapt to a significant change from the one-way, centralised pattern of grid development and operation of much of the past century.

A safe and reliable universal service will remain a critical priority for governments, the community and the energy sector. Changing energy markets may affect how this goal is delivered, including the technology sets used, the community's ability to sustainably fund the goal, and the ultimate nature of the universally available service.

As an example, changing technologies and capabilities could mean:

- universal service in regional or remote areas increasingly relies on stand-alone power systems or microgrids
- reliability levels become more amenable to customer and community level decision making, allowing tailored price–service offerings that reflect local conditions (for example, the use of microgrids or the use of the network as a back-up supply service)
- the funding of universal service provision via implicit cross-subsidies between network connected consumers becomes unfeasible as consumers have more opportunities to cost effectively self-supply.

The impact of future energy scenarios on the second major driver – the protection of consumers from monopoly power – is less clear. Overall, an increasing capacity for consumers or communities to employ distributed generation, store energy and manage their electricity demand is likely to reduce network service providers' ability to exercise significant monopoly power. The availability of either partial or full grid substitutes, for example, means traditional monopoly regulation may be not be required. That is, regulation may no longer be a cost effective or proportionate policy response to this driver.

Electricity grids could move from market circumstances that a decade ago were like those of water distribution networks, to a position more similar to that of fixed line telecommunication providers after the emergence of mobile phone technologies. In the telecommunications case, traditional monopoly regulation is retained for only a (shrinking) set of specific 'bottleneck' services. In the electricity sector, as consumers enjoy greater choice in how their electricity is supplied, and alternatives to core grid services, the regulatory regime may no longer need to focus so heavily on controlling monopoly power.

The goal of minimising the cost of electricity supply will probably continue to underpin regulatory and policy concern. However, evolving market and technology developments are likely to mean Australia will not need as much regulatory focus on limiting network prices to prevent high prices to customers. Instead, the focus will shift to ensuring prices are as consistent with as many consumers and communities as possible accessing the benefits of new energy technologies that are falling in cost.

As a result, policy measures may be needed to ensure the efficient, dispersed access to new energy technologies and the services that they enable.

Finally, the goal of promoting competition and innovation will remain highly relevant in the transforming energy market. Traditional monopoly regulatory frameworks have been consistently criticised for providing weaker incentives for innovation than competitive markets do. Energy storage, advances in small scale distributed generation, and growing technology capabilities are allowing customers to control their energy use decisions.

These innovations have major implications for the business model and efficiencies of electricity networks. To an extent, therefore, competition and innovation have flourished at the 'edge' of the electricity grid. However, the critical societal question is whether the existing regulatory framework ensures the efficient deployment of such technologies in the energy supply chain, including within the grid.

Understanding the consumer risks if market developments outpace regulation

Consumers and the community face significant risks and costs if the traditional regulatory framework fails to adapt to evolving market and technology conditions. A regulatory regime that is predicated on business models that no longer exist will waste limited regulatory resources. It will also fail to address emergent consumer protection or economic efficiency issues that arise from the new or changed business models. Governments and policy makers are already grappling with such issues in other competitive markets. As an example, the business models and technology capabilities underpinning the rise of 'sharing economy' entrants Uber and Airbnb are posing significant challenges to traditional regulatory approaches in the transport and accommodation sectors.

Consumers face the following risks, among others:

- Regulatory barriers to parties participating in rapidly emerging new energy service markets may constrain competition, the pace and scale of technology deployment, service innovation and cost efficient service delivery.
- If a regulatory regime fails to provide network service providers with a reasonable expectation of recovering their efficient costs, then inefficient underinvestment may occur. As a result, the community may lose service quality and reliability that it values.[47]
- A regulatory regime that promotes inefficient bypass of the network may result in significant inequities if some communities or individuals have the financial capacity to disconnect, and subsequently a smaller number of network users have to bear common network costs.
- If a regulatory regime fails to balance (a) providing consistent and appropriate levels of consumer protection, with (b) providing for customers to make their own choices around price-service options, then it will undermine competition, innovation and service delivery options for consumers.
- When promoting the efficient commercial use of customer data to deliver value to those customers, a regulatory regime must provide the right customer protections. If it does not, then the outcomes may be higher costs, unrealised consumer gains, and a loss of synergies along the energy delivery chain.

These types of potential harm mean the Roadmap process will need to identify learnings from the experience of other regulatory regimes that have faced market transition and increasing competition.

Exploring how other regulators are tackling network transformation

This section contains three case studies (Boxes 6.1–6.3) of regulatory change in other jurisdictions that have responded to energy industry transformation.

47 These issues are discussed in ENA 2015, *Future network cost recovery and depreciation: regulatory and policy options*, Research paper, Sydney.

Box 6.1: New Zealand Commerce Commission's 'problem identification' process

The New Zealand Commerce Commission recently commenced a forward looking 'problem identification' policy review process, examining the market and technology changes affecting the country's energy supply chain. The review raises a range of issues with the robustness of existing regulatory rules and practices, in the light of emerging market developments and technologies. It is a collaborative and open process, through which energy market stakeholders are encouraged to identify emerging issues for investigation and potential regulatory changes by the Commerce Commission.

Source: New Zealand Commerce Commission 2015, *Input Methodology Review invitation to contribute to problem definitions*, 16 June.

Box 6.2: New York's *Reforming the Energy Vision*

Through its *Reforming the energy vision* proceeding, the New York Public Utilities Commission set out a future of the electricity industry in New York that is customer centric, focuses on reducing the total energy bill to customers, and is fully integrated to ensure optimal resource choices. Among other components, this vision will require New York's electric utilities to provide Distributed System Platform services to enable third party providers of distributed energy resources to create value for both customers and the system.

The Framework Order under *Reforming the energy vision* recognised utilities must retain their universal service obligations to maintain a delivery system that provides reliable, resilient power at just and reasonable rates. The Commission was also clear that the changes contemplated in *Reforming the energy vision* must ensure New York State can achieve or exceed its goals to protect the environment through the increased use of (1) energy efficiency and renewable energy and (2) market enabling measures that integrate those resources to achieve both economic and environmental sustainability.

The Commission further recognised that simply ordering utilities to make distributed energy resources integral to their operations would not be sufficient. The intent of *Reforming the energy vision* is to harness markets to achieve innovative and cost effective solutions, with utilities facilitating those markets both in their system planning and in day-to-day operations. Financial incentives and economic signals will be designed to align with this goal.

While the Commission has wide latitude to determine compensation schemes to ensure fair and reasonable prices for customers, it signalled it must provide utilities with an opportunity to earn a fair return on their investments. In doing so, it recognised utilities continue to need to raise large amounts of capital, and it is in the interests of customers and shareholders that investors retain high confidence in how the State oversees the risks and rewards of the regulated business.

Reforming the energy vision is also based on a reformed rate making paradigm. The idea is to encourage, not deter or delay, the realisation of customer benefits through optimal investment in (and management of) the system, including the deployment and use of distributed energy resources. *Reforming the energy vision* recognises customer benefits are at risk if utilities' financial interests do not align with operational changes or transactive obligations that improve economic and efficient energy delivery. Such changes include the continued and growing penetration of distributed energy resources.

Source: New York State Department of Public Service, *Staff report and proposal: case 14-M-0101*, New York.

Box 6.3: California Public Utilities Commission

In California, the Advanced Energy Economy Institute, private utilities, energy market service providers and the California ISO recently concluded an initial research process that culminated in publication of *Towards a 21st century electricity system in California*. Part of this study examined the regulatory framework, incentives and revenue mechanisms that will be needed to support a reformed energy grid in 2030. This work stressed the importance of regulatory agility and flexibility in the treatment of new services, capacity to allow innovation (and failure), the modernisation of rate structures, and potential alternative business models. It highlighted the potential need for the regulatory framework to accommodate multiple models, such as a Distribution System Platform model or an Independent System Operator model.

The California Public Utilities Commission has already embarked on several parallel paths to address changes taking place in the electricity sector. In August 2014, for example, it instituted a rule that requires the utilities to file distribution resources plans (DRPs). Related efforts are already underway. Southern California Edison, for example, initiated a Preferred Resources Pilot to measure the impact on the grid of using 'preferred resources' instead of building new gas fired plants.

As a result, California is on the path to achieving important state policy objectives. It has also set the stage for the sector to evolve to a new structure. As the changes become more profound, the State will need to consider more fundamental changes, particularly for restructuring/aligning incentives to achieve the desired outcomes while maintaining a utility's long term viability. This consideration should be transparent and look at all the options available, including:

» identifying the regulatory issues that currently impede – or could enable – the evolution from existing business models to new ones
» assessing what is most appropriate for the regulated market versus the competitive market, and how the two would interact as the market evolves
» focusing on regulatory process, and assessing how to best integrate/coordinate the various regulatory proceedings that address different aspects of the sectoral evolution. This work could help reduce the effort and time required to run all these proceedings. It could also lead to better results, by considering issues more holistically.

Sources: Advanced Energy Economy Institute, *Towards a 21st century electricity system in California,* San Francisco.

Redefining the role of economic regulation

The vulnerability of different regulatory approaches

The existing economic regulatory model is based on relatively clear 'boundaries'. Examples of boundaries are:

1. the status of services as regulated or unregulated
2. the restricted capacity of network service providers to enter adjacent markets
3. the concept of expenditure being funded either by common user charges, or by limited participation in markets that are related to the network services market but deemed to be competitive and unregulated.

Australia's regulatory model has precedents both across network infrastructure generally and in energy regulation internationally. Comparable elements of this approach are used in postal, water, airport and telecommunications infrastructure across the world. Common elements include defining a set of regulated services, estimating the efficient costs of delivering these services, and summing those costs to define a stream of annual regulated revenue that the business recovers through regulated charges or levies. The extent and reach of each regulatory framework may differ, and the means of establishing appropriate maximum allowed revenue may differ, but the principles remain the same.

One issue to consider later in the Roadmap process is whether such 'boundary setting' regulatory models are susceptible to market changes. This vulnerability can occur in a number of ways. For example, regulation that too narrowly defines the set of regulated services (in effect creating a new 'regulated service provider') can end up creating a highly artificial business that can only use its scale and scope economies to deliver a limited set of services. It may also create a highly unstable outcome in a period of significantly changing consumer preferences, new and emerging services, a blurring of traditional service definitions, and changes to what economies of scale and scope are commercially achievable.

Boundary setting regulation is thus uniquely vulnerable to embedding a market structure and definition of services that do not necessarily result in the efficient delivery of consumer value. The collision of Uber and Airbnb with traditional regulatory models in the taxi and accommodation markets are examples of this issue.

The transformation of existing risk allocations

Economic regulation can also be considered as a societal risk allocation 'bargain' – that is, regulation as a tool for allocating risk. So, how could network transformation fundamentally change possible risk allocations?

The current economic regulatory framework sets out implicit and explicit risk allocations affecting consumers. Below are some of the most significant risks in electricity markets:

- **Demand risk** – Depending on the form of regulation, demand risk is typically shared by network service providers and their customers over time. Under price capping, the networks bear a greater proportion of demand risk within the regulatory period. By contrast, under revenue cap arrangements, networks' revenue outcomes are less (or not) subject to demand variations.[48]
- **Risks of changes in operating and capital costs** – Typically, the risks of unanticipated costs are borne in the first instance by the network service provider. In cases of major unanticipated changes in costs that meet a materiality threshold, a limited re-opening and cost pass through provision may allow a network to meet unanticipated costs deemed prudent by the regulator.[49]
- **Risks of changes in financing costs** - The risk allocation for changes in financing costs differs for debt and equity. Under the new trailing cost of debt approach, consumers and the network service providers share (over time) most of the risk of changing debt costs. However, changes in the cost of equity finance are borne entirely by the network within each regulatory period, and equity cost estimates are reset for each new regulatory period.

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48 Under revenue cap regulation, a pre-established target revenue reflects the efficient required revenue to deliver the services, with tariffs being adjusted over time (based on demand variations) to ensure target revenue recovery. Under price cap arrangements, fixed tariffs are based on a once-off demand forecast, such that achievement of the demand forecast will allow the business to achieve its target revenue. The two approaches differ mainly in how they allocate demand risk.

49 Pass throughs, or 're-openers', provide a mechanism by which unanticipated or unforeseeable changes in costs (arising from new regulatory or reliability obligations, for example) may be approved for recovery over time.

- **Price variation risk** – The regulatory regime generally features mechanisms or scope to minimise the risk of year-on-year price variation. These mechanisms include side constraints, tariff variation approval processes, and 'sculpting' of the time profile of revenue recovery.
- **Risk of stranding** – The current regulatory regime deliberately limits the exposure of network businesses to asset stranding following regulatory and policy determinations that aim to minimise risk, uncertainty and price shocks to consumers. Consumers' own 'sunk' investments in electricity connection assets are also protected over time by regulatory oversight designed to avoid charging of monopoly rents to users that depend on network access.
- **Risk of services not being provided to low or no profit customers** – The current regulatory regime removes this risk for individual customers, either through implicit or explicit cross-subsidies across users, or through direct government funding of non-commercial community service obligations.

The energy market transformation underway could shift the nature of risk allocation, or make different allocations more feasible than in the past. Customer choices and emerging mass technologies may undermine existing 'settled' allocations, requiring the community to reach a consensus on a new, rebalanced set of risk allocations.

Aspects of the Future Grid Forum's Scenario 3 ('Leaving the grid') highlighted the potential existing risk allocations to be called into question. In this scenario, disconnected customers effectively choose to internalise demand risk and assume the risk of changes in the performance and the future operating costs of their stand-alone power system. In return, they may minimise the price variation risks of participating in the wholesale market and network delivery chain. The scenario raises questions about the consequential change in the risk profile of customers that remain connected to the grid. Could existing universal service obligations to those customers become unsustainable on a purely commercial basis enabled by customer cross-subsidies? Do grid connected customers risk an impact on their costs if disconnected customers seek future re-connection?

Managing contestability, competition and regulation

The future regulatory framework must be flexible and agile enough to support increasing contestability and competition across the existing and new energy delivery chain. But it must also be stable enough to enable network owners and operators to make efficient long term investments in network infrastructure that will:

1. provide the essential backbone to link customers and communities to renewable energy sources
2. allow for the efficient integration and use of distributed energy resources.

In this environment, the need for economic regulation of some network services may diminish. It will be replaced by strong competitive and commercial incentives to provide low cost, non-discriminatory grid access, and to maximise grid use. This scenario could emerge, for example, in point-to-point electricity transmission services that connect large decommissioned generators with areas of urban demand. Alternatively, elements of distribution grids, particularly at the grid edge or in other areas that are high cost to serve, will face strong countervailing competition from emergent distributed energy resources and microgrids.

Considering these examples, the Roadmap program needs to examine how to redefine the boundaries of the 'regulated service' to ensure costly legacy regulation does not distort competitive outcomes or impose other perverse costs or effects on consumers or market participants. In doing so, it should consider the regulatory 'gateway' (that is, how services should become regulated), the differing levels of economic regulation that may be appropriate, and the governance and institutional roles that should support this framework.

What the Roadmap needs to do

Stage 1 of the Roadmap has focused on mapping and understanding current and expected market changes, emergent business models, and how technological changes may deliver valued services to consumers. Stage 2 will continue to assess the appropriate role of policy and evolving regulatory frameworks.

Proposed design principles to develop in Stage 2

Acknowledging that policy and regulation should be as robust as possible in dealing with multiple potential energy futures, this Chapter proposes a set of design principles for the economic regulatory framework (Box 6.4). These principles are based on Stage 1 analysis and will guide Stage 2 work to develop regulatory and policy options in more detail.

Box 6.4: Proposed design principles for regulatory framework

- **a** **Focused on the long term interests of customers** – Regulatory decisions on remaining regulated services should account for the perspectives and priorities of both current and future customers. They should focus on providing a stable framework for investments that deliver the connectivity and access to bi-directional electricity services that customers value.
- **b** **Flexible and enabling for emerging technology, technology diffusion, new competition and marketplaces** – Efficient competition should be allowed to emerge, with flexible and dedicated processes to recalibrate or remove regulation where appropriate. Rules should be nimble and facilitative, enabling prompt market action.
- **c** **Able to align network incentives with long term customer value** – The regulatory framework should provide clear revenue and profit opportunities for delivering services that create value for customers and market actors.
- **d** **Proportional and bounded** – In an environment of increasing contestability and competition, regulatory intervention needs to be well justified and proportional to the risks of a clearly identified problem. Further, its application should account for the costs and benefits of intervention. Robust independent processes are needed for regularly evaluating the boundaries of competition, considering the full range of costs and benefits.
- **e** **Non-discriminatory** – Network service providers should be free to deliver valued, efficient energy service solutions to each customer. The framework should not be reactive or 'permission' based. It should provide a competitively neutral platform that does not pre-define a single 'ideal' network business model.
- **f** **Consistent, coherent and knowable for all participants** – Regulatory rules should continue to be consistent across Australia, and they should be predictable, simple, precise and knowable in advance, to facilitate least cost market participation and efficient investment. Regulatory decisions that share risks across networks, debt and equity providers, and customers need to be conscious, consistent with the risk compensation provided in the framework, and predictably implemented. Similarly, cost recovery should align with those customers that initiate the system cost.
- **g** **Independent and accountable** – Regulatory rules should be applied and enforced independently, commonly, transparently and accountably, including the rights to reasons and appeal for consumers and businesses whose interests are materially affected.

Some early thoughts on transition pathways

The current economic regulatory framework will likely have to adapt in some way to the changing market, technology and business model factors discussed in this report. So, how can it transition to new regulatory approaches? Different transition pathways and destination are viable, but it is important to define expectations and set the processes upfront.

A series of interrelated issues are connected to this question. For example, what future regulatory models might be more 'fit for purpose' in the regulated remaining monopoly services? And how should areas of emergent or full competition be treated? In short, how does the pathway from regulation under the 'old world' to the 'new world' look? Embedded in this question is a range of options for investigation.

Transition might be viewed as a gradual movement along the regulatory spectrum from intrusive, prescriptive and business-specific models to lighter handed models based on external competitive benchmarks. A variety of potential models are available for discussion, including innovative 'regulatory settlement' approaches trialled in the United Kingdom and the United States, and price monitoring approaches used in other infrastructure sectors that face emergent or workable competitive forces. A further question, on which current frameworks are blurry, is whether economic regulation attaches to the individual service offering or to the regulated business.

Linked to these issues is the question of how the economic regulatory framework should interact with consumer objectives and existing consumer protection mechanisms.

Suggestions for priority work

Given the above discussion, Stage 2 needs to examine aspects of the current regulatory framework. These aspects include:

- the nature of the universal service obligation, and how this obligation is met on a sustainable communitywide basis in the face of new technologies, network configurations, and grid substitutes
- how to ensure economic regulation of monopoly power is responsive to the erosion or disappearance of such power, and serves to promote efficient market participation and service delivery in new markets for the benefit of consumers
- how to protect consumer interests while minimising the cost to finance significant network infrastructure investments in the grid, given the grid's continuing role in delivering essential services, and its emerging role as an active platform for market participation and exchange
- how to best ensure innovation and efficient integration of new technology throughout the electricity delivery chain
- how to adequately protect consumers through the energy market transformation.

How you can help

Your feedback on the following questions is welcome. This feedback will be used during Stage 2:

6.1 Are there material risks to maintaining a sustainable universal service in a transformed energy market? Are there appropriate options to vary the risk over time or to manage the risk allocation between customers?

6.2 How should economic regulation respond to emerging competition in and contestability for grid services?

6.3 Do you have additional critical regulatory and policy questions that should be a focus of the Roadmap's future work?

6.4 What is your view on the regulatory design principles proposed in this Chapter?

6.5 What issues will affect the successful transition of economic regulation over time to the transforming electricity market?

KEY FINDINGS

F6.1 Allowing economic regulation to be outpaced by market development presents risks to consumers and the broader community

F6.2 There are key strengths in the existing system that should be preserved. Consumers today benefit from the relatively high level of regulatory predictability and certainty, because it allows the low cost financing of long term network infrastructure that provides a ubiquitous platform for the collection, trading and delivery of electricity.

F6.3 The changing markets, technologies and potential emerging business models require a renewed community discussion and agreement on the purpose and scope of regulation, and the best way to allocate a range of risks into the future.

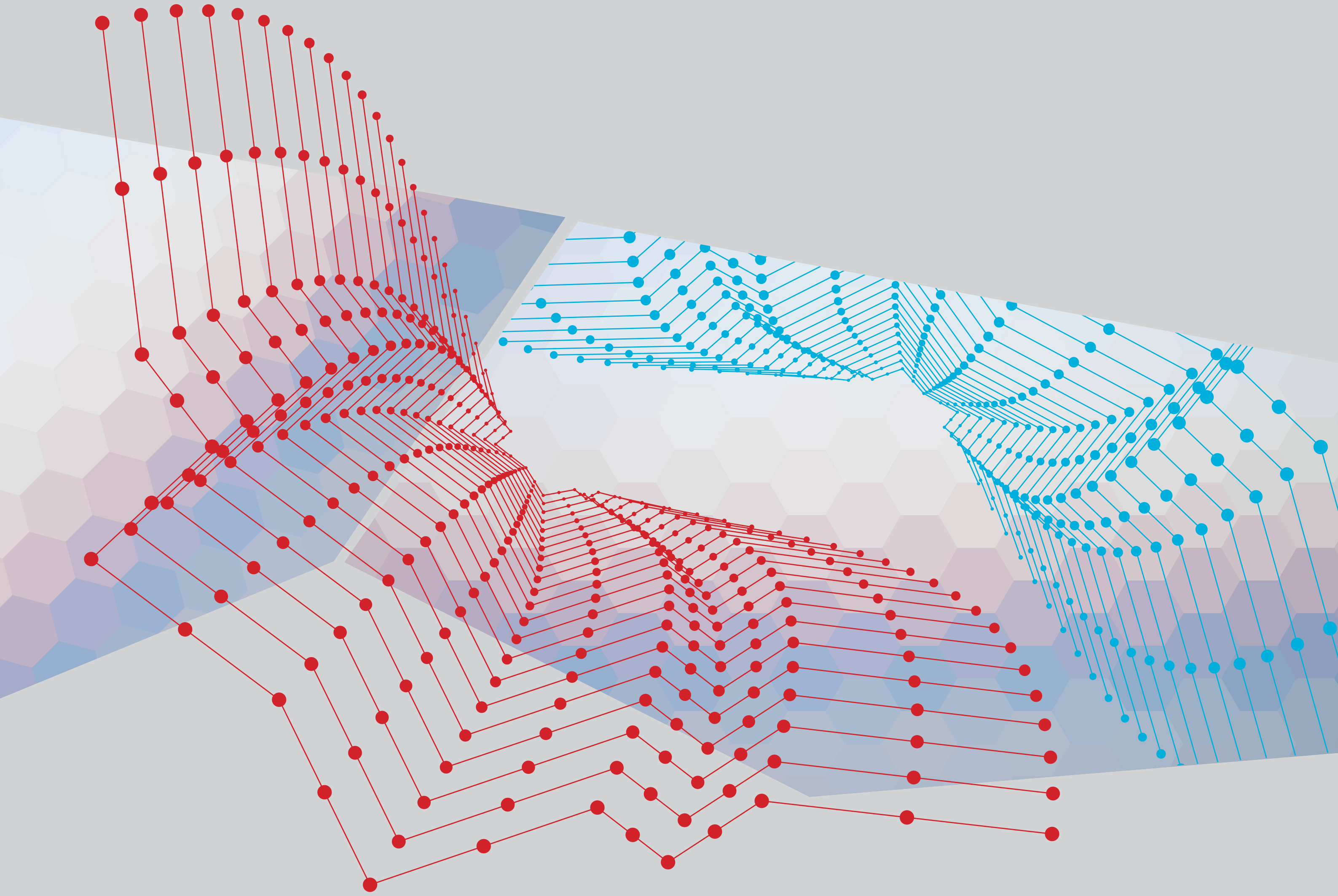
F6.4 Best practice design principles for the regulatory framework represent a way to start this discussion in a way that is robust in a wide set of scenarios.

RECOMMENDATIONS

R6.1 Potential new models of regulation need to be reviewed and tested against the outlined design principles, with the objective of reaching broad agreement on an optimum approach.

R6.2 Stage 2 of the Roadmap is expected to include:

- exploring how best to structure and deliver universal service obligations in a disrupted or transformed energy market
- detailing ways to transition to new forms of regulation, and move to a reliance on greater competition for network and energy services
- evaluating regulatory approaches to drive innovation and new technologies through the grid.



CONCLUSION AND RECOMMENDATIONS

As Australians continue to embrace new approaches to electricity, the electricity system will continue to evolve rapidly. Customers are likely to be highly diverse but to seek new levels of empowerment and control, demonstrated by the rapid and ongoing uptake of distributed energy resources.

Following are recommendations that inform the future direction of Australia's electricity systems and Stage 2 of the Roadmap.

Recommendations:

Chapter 1: Customers at the centre of Australia's future grid

R1.1 The detailed appreciation of future residential, commercial and industrial customer segments developed in Stage 1 should:

- be applied across the entire Roadmap program, to ensure all elements focus on a customer-oriented electricity future that benefits Australian households and enterprises
- inform CSIRO's quantitative modelling, to compare the 'balanced scorecard' outcomes of alternative transition options for distinct customer segments
- be updated periodically, as additional information becomes available during the Roadmap program.

R1.2 This expanded view of what future end-users are likely to value from electricity solutions will enable Stage 2 of the Roadmap to explore:

- Which market actors individually and/or in combination will be well-positioned to create and deliver the value that future end-users will expect?
- How might network businesses and other market actors work together as a value network?
- How can network businesses continually identify commercial opportunities and evolve as organisations to successfully meet customer needs?

Chapter 2: What's driving Australia's electricity sector transformation

Stage 2 of the Roadmap can use 2015 Future Grid Forum scenarios as a baseline set of assumptions and projected outcomes for Australia's electricity sector transformation.

R2.1 Stage 2 of the Roadmap is expected to include:

- expanding the representation of customer segments and how they are impacted by the sector's transformation
- identifying and, where possible, quantifying counterfactual cases for 'no regrets' Roadmap options
- developing a preferred end state for the Roadmap, combining priority 'no regrets' options.

Chapter 3: Technical challenges and opportunities of distributed energy resources

R3.1 The successful integration of distributed energy resources into existing grid systems will involve engaging and empowering new participants in electricity services and building network efficiency and resilience.

R3.2 Stage 2 of the Roadmap is expected to include:

- modelling the impact of distributed energy resources on Australia's LV and MV networks
- quantifying the operational and maintenance issues and performance of grid-connected energy storage
- identifying critical gaps in the current and future skills and training requirements for electricity supply industry workers
- identifying potential solutions for delivering the new technologies, protocols and business models needed to facilitate the new Smart Grid and network businesses for 2025 and beyond
- looking at network segment and microgrid emulation for embedded generation / distributed energy resources integration and performance testing
- identifying opportunities for electric vehicle and other volume growth opportunities.

Chapter 4: Business models for an evolving electricity future

R4.1 Stage 2 of the Roadmap is expected to more closely consider the application of new business models in an Australian context and the required regulatory framework to deliver better outcomes for customers.

R4.2 Australian networks can learn from experiences and operations of overseas network businesses while remaining aware of critical differences in circumstances to address local key challenges.

Chapter 5: Price and incentives for a transformed electricity system

R5.1 ENA's forthcoming network tariff reform guideline should help bring about a national, collaborative and integrated approach to reform, with a range of stakeholder engagement.

R5.2 Stage 2 of the Roadmap is expected to include:

- leveraging ENA's forthcoming network tariff guideline, including opportunities and challenges for distribution and transmission network pricing over the medium to longer term
- further evaluating 'Second Wave' pricing and incentive reform measures such as locational tariffs and nodal pricing; critical peak pricing or peak time rebates; embedded generation incentives, credits or feed-in tariffs; and transactive energy markets for services (for example, ancillary services)
- looking for further opportunities to use behavioural economics techniques to enhance network tariff reform implementation, to practically help consumers understand and respond to network tariffs that reflect the drivers of network costs.

Chapter 6: Priority directions for electricity policy and regulation

R6.1 Potential new models of regulation need to be reviewed and tested against the outlined design principles, with the objective of reaching broad agreement on an optimum approach.

R6.2 Stage 2 of the Roadmap is expected to include:

- exploring how best to structure and deliver universal service obligations in a disrupted or transformed energy market
- detailing ways to transition to new forms of regulation, and move to a reliance on greater competition for network and energy services
- evaluating regulatory approaches to drive innovation and new technologies through the grid.

FURTHER READING

Understanding the context of Australia's electricity transformation

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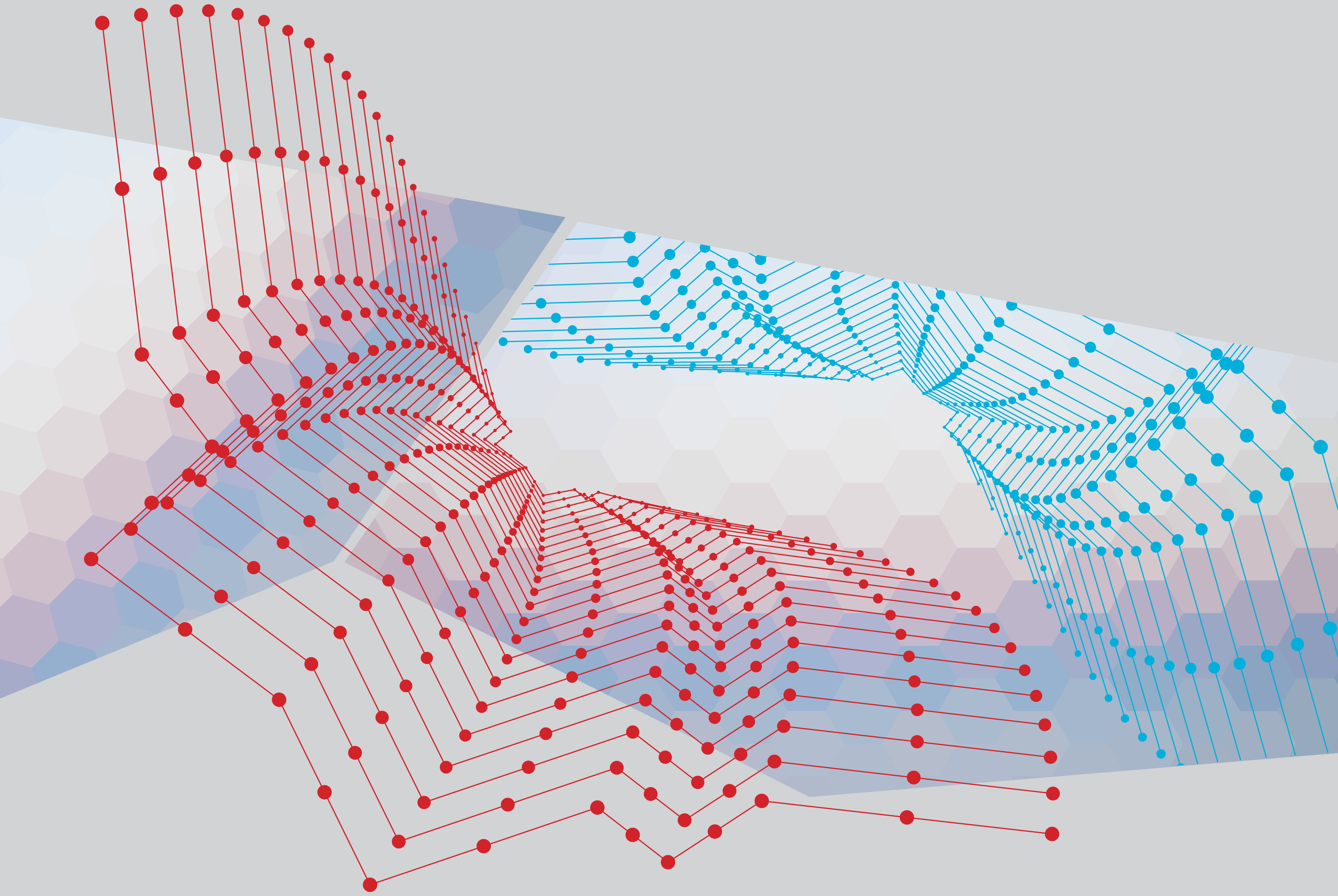


APPENDIX A
AUSTRALIAN ELECTRICITY NETWORKS

Electricity networks transport power from generators to customers. Transmission networks transport power over long distances, linking generators with load centres. Distribution networks transport electricity from points along the transmission network and through urban and regional areas to provide electricity to customers.

The National Electricity Market (NEM) in eastern and southern Australia provides a fully interconnected transmission network from Queensland through to New South Wales (NSW), the Australian Capital Territory (ACT), Victoria, South Australia and Tasmania (Figure A.1). The NEM transmission network has a long, thin, low density structure, reflecting the location of, and distance between, major demand centres. It comprises five state-based transmission networks, with cross-border interconnectors linking the grid (Table A.1).

The Australian electricity system was originally based on independent, self-supporting state systems. The NEM was then developed in the 1990s, and now includes transmission system connections between states to manage power delivery more efficiently overall. It also has 13 major electricity distribution networks (Table A.2). Queensland, NSW and Victoria each have multiple networks that are monopoly providers in designated areas (Table A.2). The ACT, South Australia and Tasmania each have one major network. Some jurisdictions also have small regional networks with separate ownership. The total length of distribution infrastructure in the NEM is around 735,000 kilometres – 17 times longer than transmission infrastructure.

Table A.1: NEM region transmission networks

Network	Location	Line length (km)	Electricity transmitted (GWh), 2012-13	Maximum demand (MW), 2012-13	Asset base ($ million)
Powerlink	Qld	14,310	49,334	10,956	6,035
TransGrid	NSW	12,893	65,200	17,100	5,289
AusNet Services	Vic	6,573	49,056	9,342	2,414
ElectraNet	SA	5,527	14,284	4,136	1,786
TasNetworks	Tas	3,503	12,866	2,483	1,236
NEM totals		**42,806**	**190,740**		**16,760**

Source: Australian Energy Regulator 2014, *State of the energy market 2014*, Australian Competition and Consumer Commission, Melbourne, p. 66.

Table A.2: NEM region distribution networks

Company	Location	Customer numbers	Line length (km)	Electricity delivered (GWh)	Maximum demand (MW)	Assets ($ million)
Energex	Qld	1,359,712	51,781	21,055	5,029	10,197
Ergon Energy	Qld	710,431	160,110	13,496	3,420	8,837
AusGrid	NSW	1,635,053	40,964	26,338	5,570	13,613
Endeavour Energy	NSW	919,385	35,029	16,001	4,156	5,344
Essential Energy	NSW	844,244	191,107	12,291	2,294	6,518
ActewAGL	ACT	177,255	5,088	2,903	698	790
Powercor	Vic	753,913	73,889	10,556	2,396	2,869
AusNet Services	Vic	681,299	43,822	7,501	1,877	2,809
United Energy	Vic	656,516	12,837	7,856	2,077	1,789
CitiPower	Vic	322,736	4,318	5,981	1,493	1,601
Jemena	Vic	318,830	6,135	4,254	986	1,031
SA Power Networks	SA	847,766	87,883	11,008	2,915	3,469
TasNetworks	Tas	279,868	22,336	4,248	239	1,455
NEM totals		**9,507,007**	**735,298**	**143,488**		**60,322**

Source: Australian Energy Regulator 2014, *State of the energy market 2014*, Australian Competition and Consumer Commission, Melbourne, p. 67.

Figure A.1: Electricity transmission and distribution networks in the NEM

Source: Australian Energy Regulator 2014, *State of the energy market 2014*, Australian Competition and Consumer Commission, Melbourne, p. 65.

Western Australia and Northern Territory electricity systems

Western Australia

Unlike within the NEM, electricity services in Western Australia operate as multiple standalone systems. There are two major electricity system suppliers: Western Power and Horizon Power (Figure A.2).

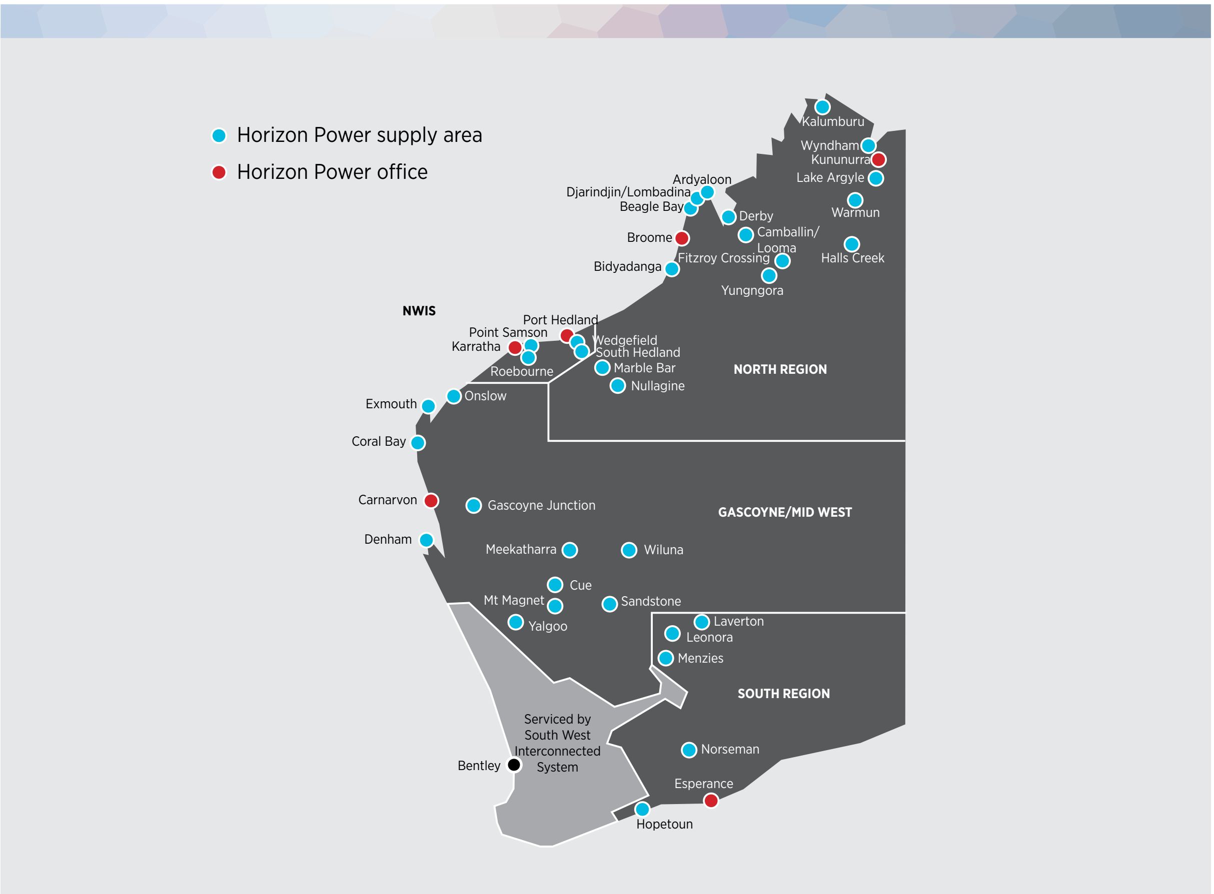
Western Power is a Western Australia state government-owned corporation that builds, maintains and operates the electricity network in the south west corner of Western Australia. The Western Power Network forms the vast majority of the South West Interconnected Network (SWIN). The SWIN, together with all of the electricity generators, comprises the South West Interconnected System (SWIS). Western Power does not generate or retail electricity or operate in non-SWIS areas of Western Australia (see Horizon Power below).

The SWIN covers 261,000 square kilometres and includes over one million customers. Unlike all other major urban areas of Australia, which are covered by the NEM, the SWIN is an isolated, self-contained network. The SWIS must deliver the electricity needs of consumers within the SWIS at all times, without any outside support or back-up.

Horizon Power is also state government-owned and provides power to about 100,000 residents and 10,000 businesses, including major industry, across regional and remote Western Australia. It generates, procures, distributes and retails electricity supplies.

Horizon Power services 46,187 customer connections (June 2014) in the Pilbara, Kimberley, Gascoyne, mid west and southern Goldfields (Esperance) regions, dispersed across an area of approximately 2.3 million square kilometres – about 10 times the size of Victoria. Horizon Power manages 38 systems: the North West Interconnected System (NWIS) in the Pilbara and the connected network between Kununurra, Wyndham and Lake Argyle, and 34 standalone systems in regional towns and remote communities.

Figure A.2: Horizon Power systems and the Western Power South West Integrated System



Source: Horizon Power, http://horizonpower.com.au/about-us/overview/our-service-area/, accessed 19 October 2015.

Northern Territory

Power and Water Corporation is responsible for electricity transmission and distribution, and also provides water and sewerage services across the Northern Territory. On 1 July 2014 the electricity generation part and the electricity retail part of Power and Water were separated to form two new government-owned corporations: Territory Generation and Jacana Energy.

Power and Water Corporation distributes electricity across the Northern Territory to an estimated 243,700 people spread across an area of 1.3 million square kilometres (Figure A.3). To do this, it maintains more than 5,600 kilometres of overhead lines, 1,690 kilometres of underground cable and 37,500 poles and towers. A 400 kilometre high voltage line delivers electricity from the Top End's major power stations, managed by Territory Generation, to Darwin and Katherine.

The environmental challenges faced in maintaining the network include cyclones, severe storms, and damage from trees and wildlife, especially flying foxes (bats).

Power and Water's not-for-profit subsidiary Indigenous Essential Services provides electricity, water and sewerage services to 72 Indigenous communities, including 20 major remote towns. These communities are geographically isolated, in both tropical and arid environments, yet require service levels equal to those needed for similar sized urban centres, from infrastructure that is resilient and adapts to the changing climate.

Rapid development in these regions requires a commitment to working with communities towards sustainable electricity and water use to meet future needs and aspirations. Power and Water contracts and trains Essential Services Operators through local councils, Indigenous enterprises and private contractors to run facilities day to day.

Infrastructure includes solar powered water pumps, highly efficient diesel, low emission gas and renewable power stations. Many remote power stations are now controlled by fully automated systems, requiring a high degree of staff expertise.

Figure A.3: Northern Territory electricity systems

Source: Based on Power and Water, www.powerwater.com.au/community_and_education/student_resources/maps/electricity_map, accessed 19 October 2015.

- Power station – Power and Water Corporation
- Power station – power purchase agreement
- Retail agreement only
- Transmission lines
- Distribution lines

APPENDIX B
ROADMAP PROGRAM ARCHITECTURE

The Roadmap program is tackling complex and multifaceted subject matter. At a broad level, Roadmap participants will:

» update and build on the CSIRO Future Grid Forum work completed in 2013, focusing on the 2015–25 decade of industry transformation
» identify the new services and technologies that future residential, commercial and industrial customers will value
» identify the options for regulation, business models and electricity pricing that can best support delivery of the future services that customers want, while ensuring an efficient, competitive and economically robust value chain.

At a lower level, the varied but interrelated bodies of work are structured to simplify this complex subject matter.

Content domains

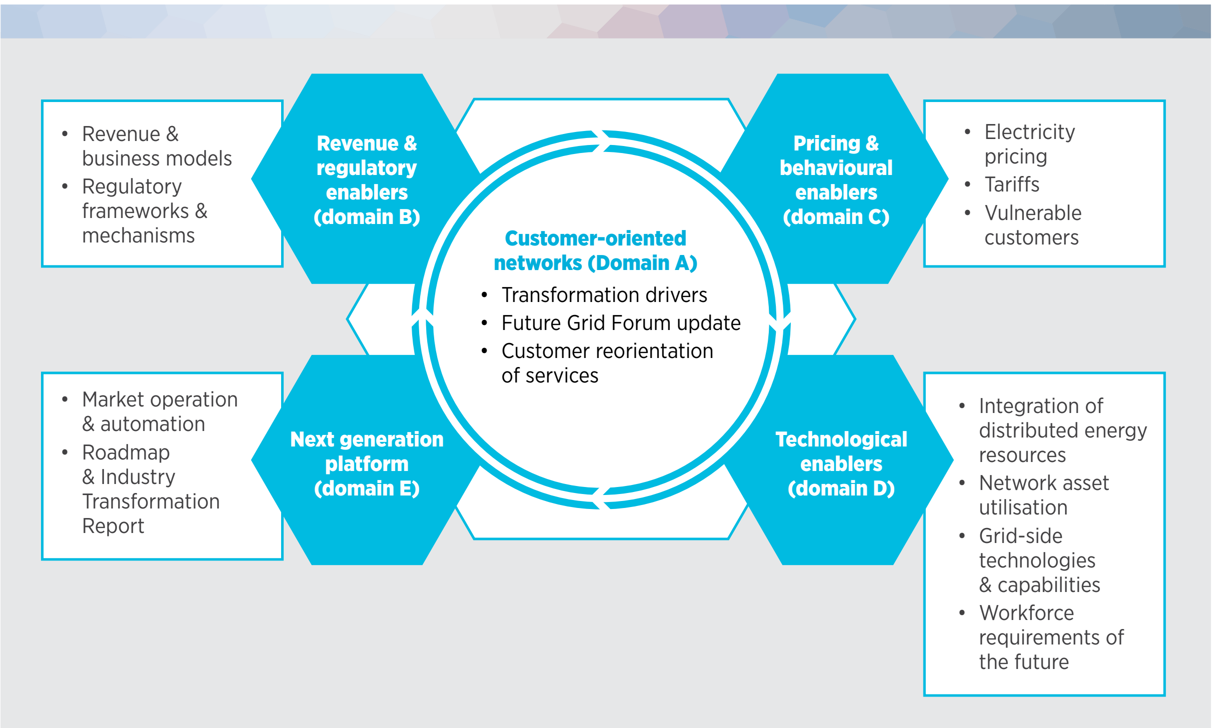
The Roadmap architecture comprises five content domains (A–E), each of which includes work packages (Figure B.1). Domain A: Customer-oriented networks is the central hub of the program, because customers are driving the transformation.

Domains B–D deal with the critical enablers of a customer-oriented electricity future:

» Domain B: Revenue and regulatory enablers
» Domain C: Pricing and behavioural enablers
» Domain D: Technological enablers.

Domain E: Next generation platform examines how these diverse elements of future electricity systems and markets may interconnect to deliver customer-oriented outcomes for Australia.

Figure B1: Roadmap domain and work package architecture



Work packages

Each domain has distinct projects or 'work packages' to construct specialist inputs for the Roadmap. These 10 work packages, which focus on the dominant features, barriers and enablers of the transformation, are structured as follows.

- Domain A: Customer-oriented networks
  - WP1: Transformation drivers and Future Grid Forum refresh
  - WP2: Customer reorientation of services
- Domain B: Revenue and regulatory enablers
  - WP3: Revenue and business models
  - WP4: Regulatory frameworks and mechanisms
- Domain C: Pricing and behavioural enablers
  - WP5: Electricity pricing, tariff mechanisms (import and export) and social safety net
- Domain D: Technological enablers
  - WP6: Beneficial system integration of distributed energy resources
  - WP7: Opportunities for efficient energy network volume growth and improved asset utilisation
  - WP8: Critical grid-side technologies and capabilities
- Domain E: Next generation platform
  - WP9: Market operation and automation
  - WP10: 2015–25 Network Transformation Roadmap and 2015–25 Industry Transformation Report.

Program sequence

The five domains are highly interrelated, so Roadmap progress will be iterative. Nevertheless, to ensure timely progression from commencement through to the final 2015–25 Roadmap, the delivery of the five domains is structured into three sequential phases:

- Foundation phase (July – November 2015)
  - Domain A: Customer-oriented networks
  - Domains B–E: Selected initial activities
- Future enabler phase (December 2015 – August 2016)
  - Domain B: Revenue and regulatory enablers
  - Domain C: Pricing and behavioural enablers
  - Domain D: Technological enablers
- Capstone phase (April 2016 – December 2016)
  - Domain E: Next generation platform

For simplicity, this report describes the Roadmap program as consisting of two stages. Stage 1 covers the Foundation phase only, while Stage 2 comprises both the Future enabler and Capstone phases.

APPENDIX C
CUSTOMER-ORIENTED SEGMENTATION

Segmentation approach

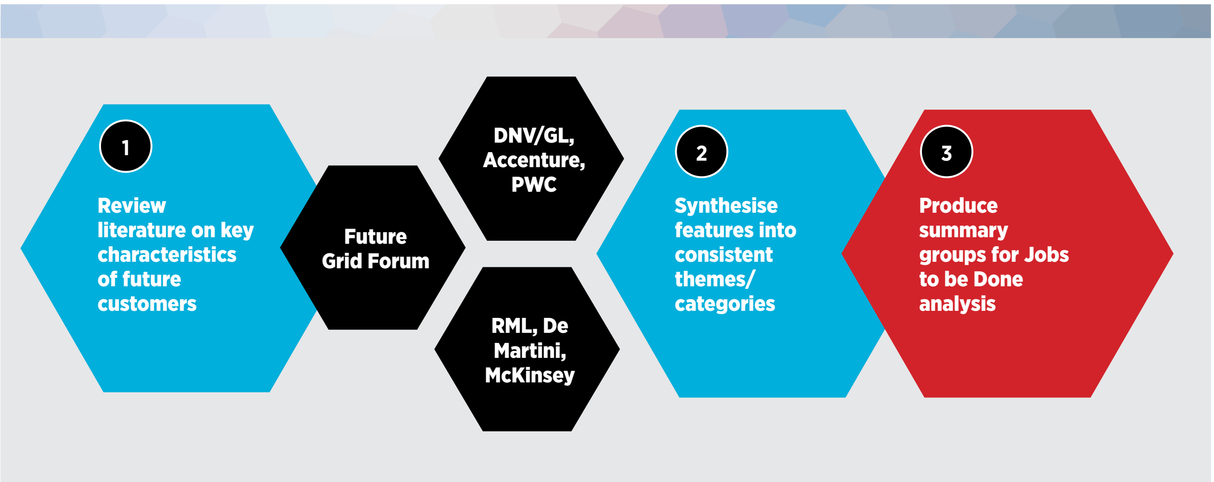
The segmentation synthesis that informed the development of Chapter 1 draws on a wide range of global sources. It was also extensively workshopped and reviewed by industry stakeholders, particularly the SME and C&I customers (Figure C.1).[50]

'Jobs to be Done' method: a fictional residential energy management illustration

Harvard's Professor Ted Levitt famously asserted that 'People don't want to buy a quarter-inch drill. They want a quarter-inch hole!'.

When designing and field testing innovative product and service ideas, businesses must focus on what the customer wants (the hole), and not the process or means (the drill). A set of tools – known as the 'Jobs to be Done' method – has proved useful for developing successful innovations. Applying the method to residential energy management, as done below, is illustrative only.

Figure C.1: Process to create a first iteration of 2025 customer segments



50 Based on characteristics drawn from: Accenture 2014, *New energy consumer: architecting for the future*; Accenture 2013, *The new energy consumer handbook;* De Jong, M & Van Dijk, M 2015, 'Disrupting beliefs: a new approach to business model innovation', *McKinsey Quarterly*, July; De Martini, P 2015, *Customer oriented networks – a North American perspective*, Newport Consulting; De Martini, P 2013, *The evolving distribution grid*, Newport Consulting; DNV GL 2015, Webinar: aligning strategy with customer wants planning for new electricity products, www.dnvgl.com/events/aligning-strategy-with-customer-wants-planning-for-new-electricity-products-and-services-28034, 21 July; Graham, P and Bartley, N 2013, *Change and choice: the Future Grid Forum's analysis of Australia's potential electricity pathways to 2050*, CSIRO, Canberra; Lacey, S 2015, 'Concern about grid defection are overblown, says Moody's', Greentech Media, in http://reneweconomy.com.au/2015/concern-grid-defection-overblown-say-moodys-62942, 13 January; Paterson, M 2011, *Two radically different approaches to HANs*; Rocky Mountain Institute 2013, *New business models for the distribution edge*, Colorado; PWC 2013, *Energy transformation: the impact on the power sector business model*.

Thinking about emerging markets

There are varied opinions about which energy management systems have the greatest appeal for residential customers. Some researchers consider customers will want appliances and devices that are largely automated, while others consider customers will prefer a low technology approach.

Without substantive data (given market immaturity), the Roadmap program used the Jobs to be Done method to examine the technological offerings that may be received and by whom. Market analysis should be based on the job that a product or service's end-user wants performed, not other factors (such as end-user demographics, psychographics, income etc.).

The 'job' that residential energy management will perform

The job of residential energy management is to make it easy and painless for householders to manage their energy consumption and to take advantage of new electricity pricing incentives. To illustrate the Jobs to be Done method, assume two distinct customer segments. Both segments are interested in residential energy management (the drill). However, each group has a different 'job statement' about what they want to achieve (their 'hole').

Segment 1 – 'Make it simple'

These householders want a complex energy situation simplified. They are not interested in the 'ins and outs' of electricity pricing. Nor are they interested in investing in a high-end home automation system, playing with gadgets or spending time customising operation. Their job statement is:

You manage my home's electricity profile for me to take best advantage of lower electricity price periods; just make sure I don't experience any real inconvenience.

For these householders, the job is primarily functional, although it may also include an emotional dimension about feeling good about 'helping to be part of the energy solution'.

Segment 2 – 'Defender of freedom'

These householders have a deep sense of autonomy and self-determination. Their home is their castle. They worked hard to accrue their comforts, love technology and distrust 'Big Brother' managing their energy. They want lower energy bills, but primarily they want to feel in control. Their job statement is:

Give me the tools to better manage my home's electricity profile; I'll make sure that I never suffer any inconvenience or discomfort, and I'll maximise my savings in the process.

Their job has a functional dimension, but often, it also involves strong emotional drivers. At a personal level, it emphasises being in control. At a social level, it demonstrates their position as early adopters of new energy solutions.

One job, multiple objectives

Within each segment illustrated above, customers will have a range of objectives that they want residential energy management to achieve. These objectives are loosely grouped under functional and emotional headings, with sample weightings indicating their relative importance (Table C.1).

Tools for developing future value propositions

The Jobs to be Done method aims to understand the jobs that customers will want to get done in the future. It is based on network businesses understanding who customers are likely to be, and their likely expectations, needs and demands.[51] The analysis considers the pains that customers want minimised and the gains that they want maximised. Network businesses use this information to create a bundle of products and services that match the each customer type's distinct needs.

The value proposition design canvas developed by Osterwalder *et al.* (2014) comprises two key sections: (1) a customer profile; and (2) a matched value proposition. The Roadmap program used this framework to develop a customer profile design, exploring customer jobs, pains and gains. It then developed a customer value proposition design, creating products and services, gain creators and pain relievers to address the customer profiles for each segment.

51 Osterwalder, A *et al.* 2014, *Value proposition design*, Wiley, New York.

Table C.1: Residential energy management objectives

	Make it simple	Defender of freedom
Functional objectives		
Minimise installation cost	Very high	Low
Reduce ongoing energy bills	Very high	Medium
Simplify complexity	Very high	Low
Ensure uninterrupted convenience and comfort	Medium/High	Very high
Help me understand energy	Medium	Medium
Allow me to personalise/customise	Low	Very high
Integrate seamlessly with home automation system	Low	Very high
Emotional objectives: personal/social		
Environmental concerns	Low/Medium	Medium
Maintained autonomy	Low/Medium	Very High
Social prestige	Low	High
Green appearances	Medium	High

Step 1: Customer profile design

Understanding customer Jobs to be Done relates to three core aspects:

- First, identify the outcomes or needs that customers are trying to satisfy (jobs).
- Second, identify the problems or obstacles (pains) that these customers will encounter when trying to satisfy these needs.
- Finally, identify the advantages and benefits (gains) that customers will aspire to achieve in fulfilling their functional needs. Increasingly, customers will want solutions that combine tangible and intangible benefits. A customer may install an energy storage device to fulfil an intangible desire for autonomy, for example, as well as to receive a tangible return on investment.

Step 2: Value proposition design

Developing a value proposition involves identifying how the products and services address the needs and aspirations of customers. Value propositions often combine many elements – tangible (for example, goods), digital or virtual, intangible (for example, quality assurance) and/ or financial. A competitive value proposition simultaneously alleviates key customer pains (such as negative emotions, undesired complexity or cost, or risk), and accentuates gain creators (such as functional utility, social gains, positive emotions or cost savings).