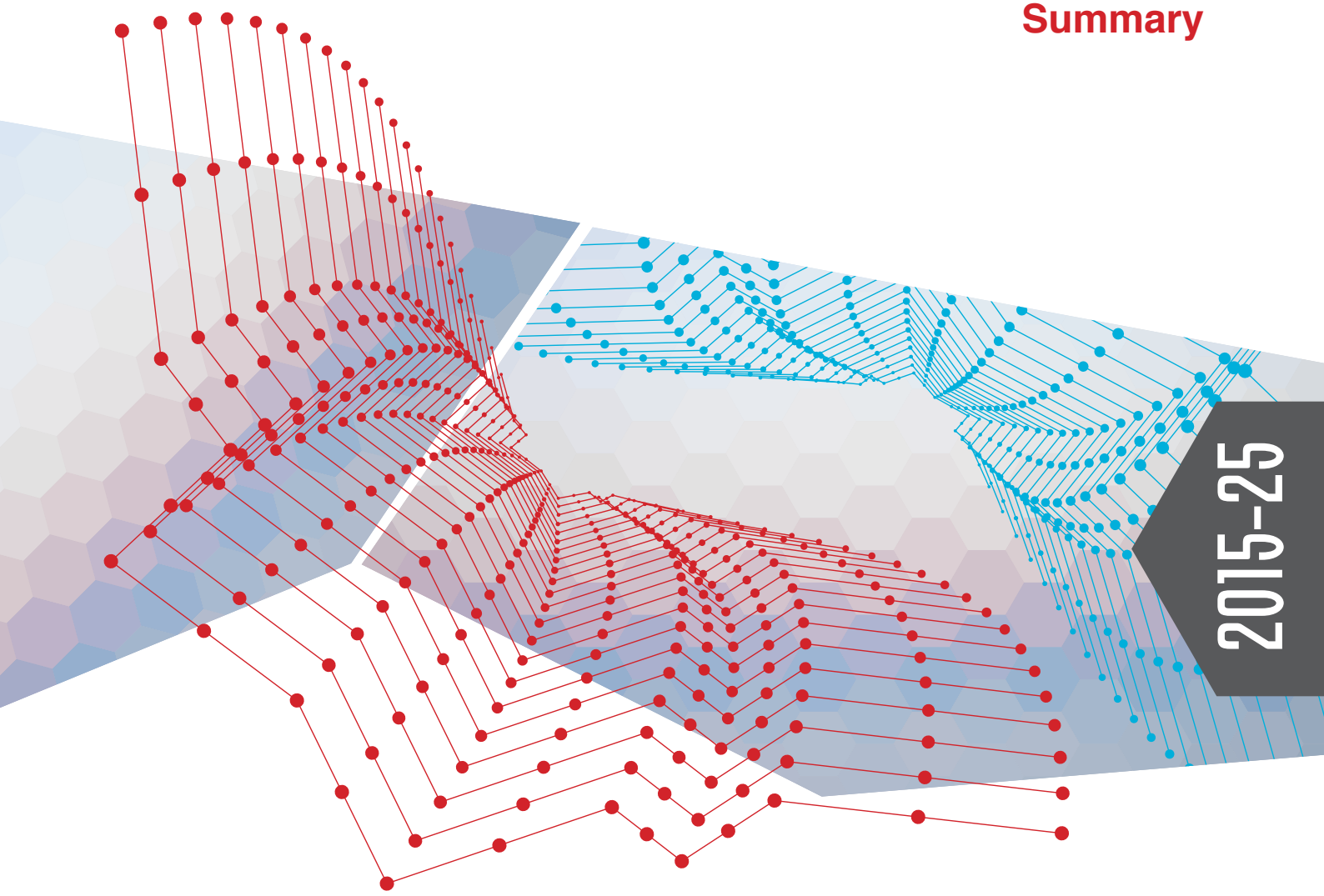
ELECTRICITY NETWORK TRANSFORMATION ROADMAP

Interim Program Report Summary



energy networks association

CSIRO

A partnership between ENA and CSIRO

Contact details

We value your feedback. Please provide feedback or raise any queries by emailing ntr@ena.asn.au

Citation

CSIRO and Energy Networks Association 2015, *Electricity Network Transformation Roadmap: Interim Program Report.*

Copyright

Important disclaimer

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.

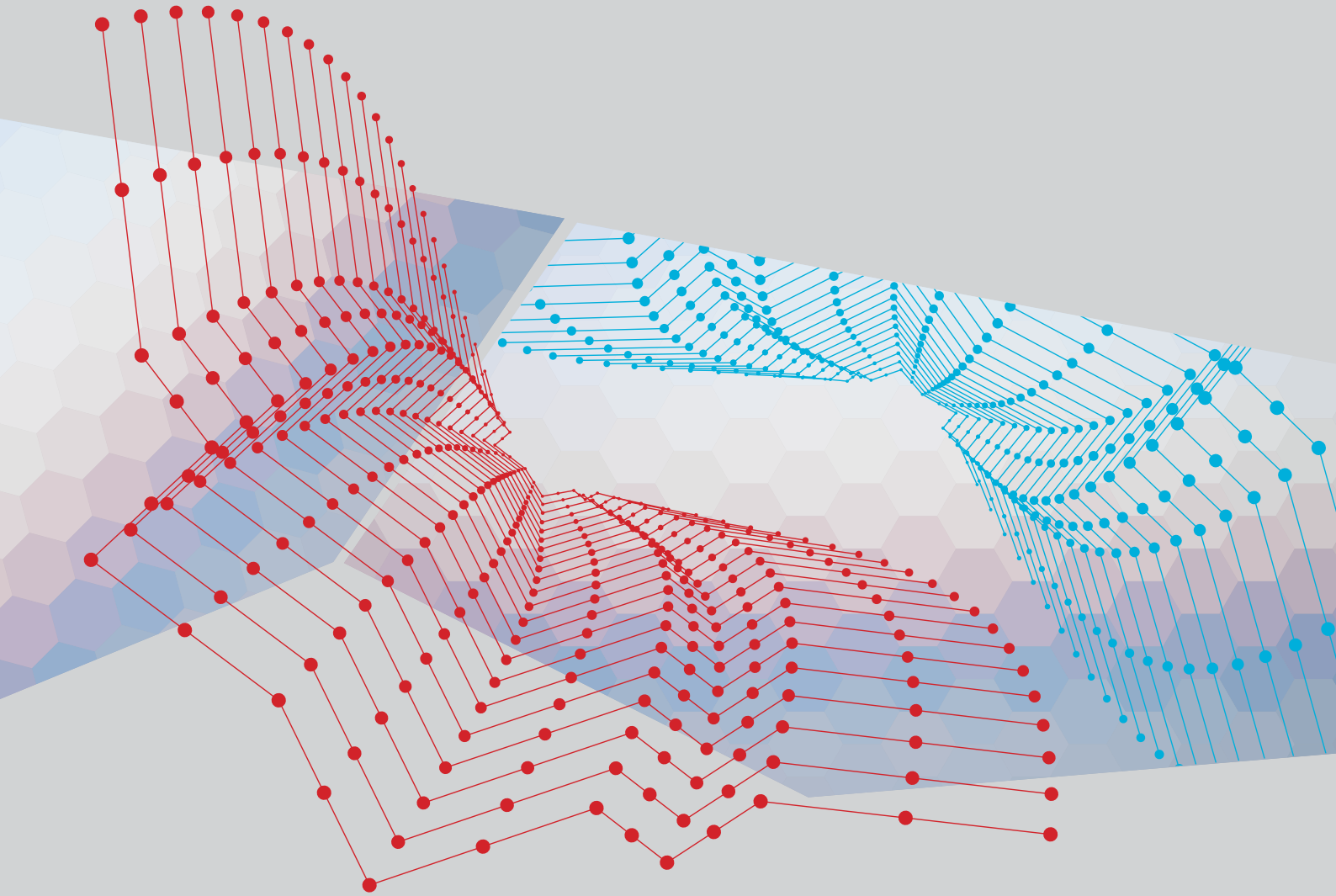
While the Roadmap program is a partnership between CSIRO and the Energy Networks Association (ENA), it relies on broad stakeholder collaboration to 'co-design' optimal pathways for this transition. Stage 1 of the program has already benefited from the valuable participation of almost 200 customer representatives,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

John Bradley
Chief Executive Officer,
Energy Networks Association

Peter Mayfield
Director, CSIRO Energy



INTERIM PROGRAM REPORT 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.

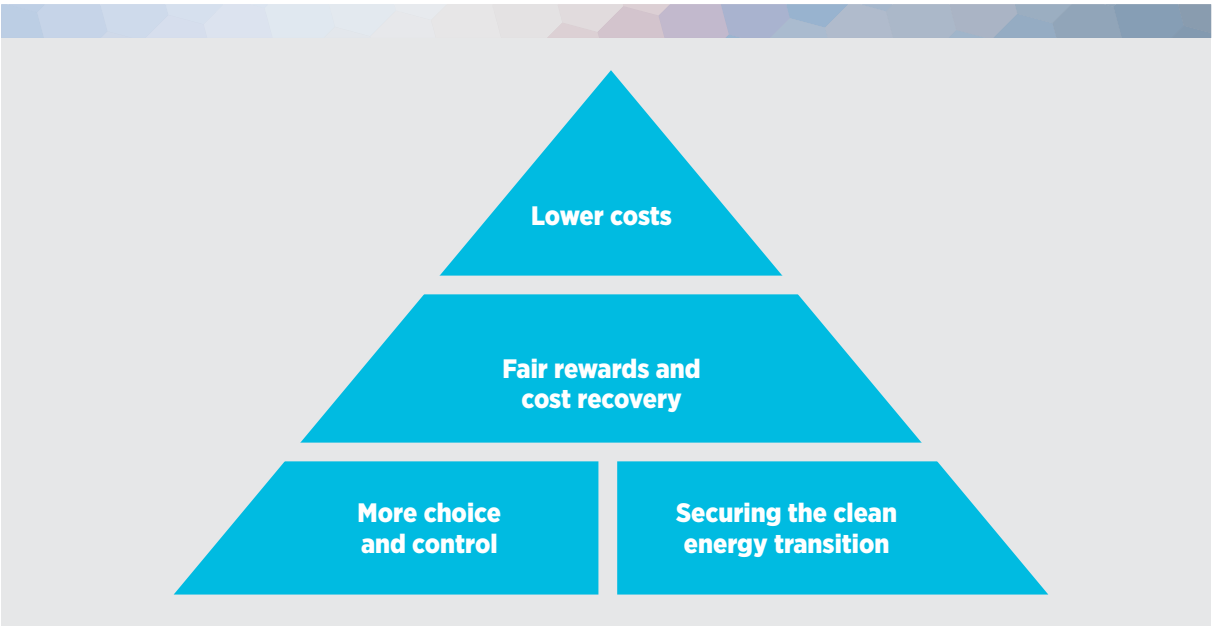
The supporting Chapters are:

» 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.

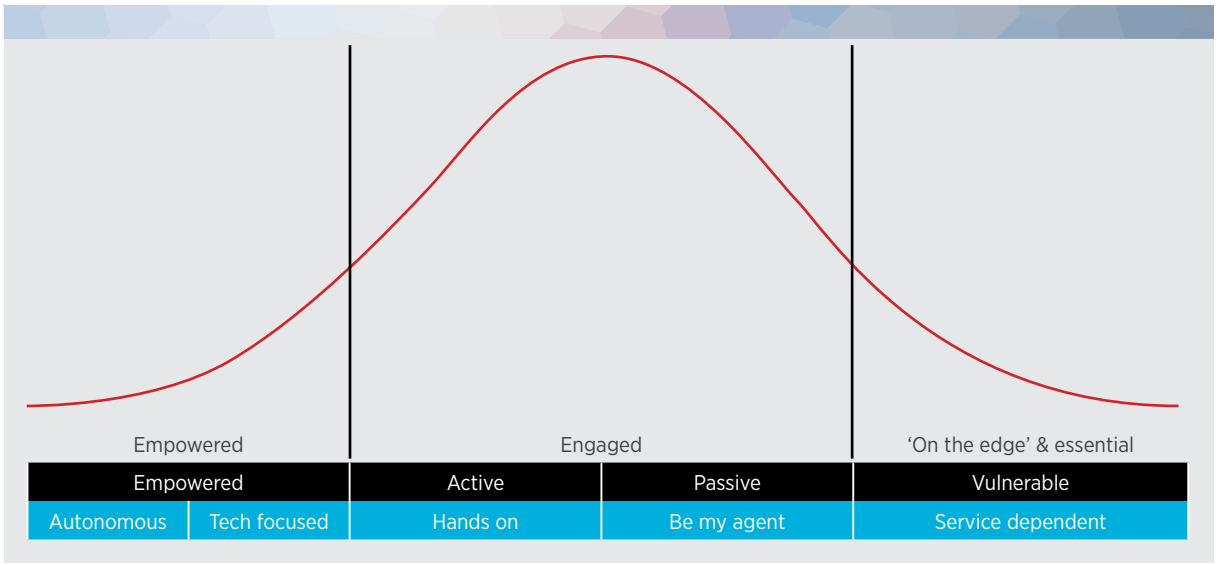
The resulting customer-oriented perspectives will inform all other parts of the Roadmap program.

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

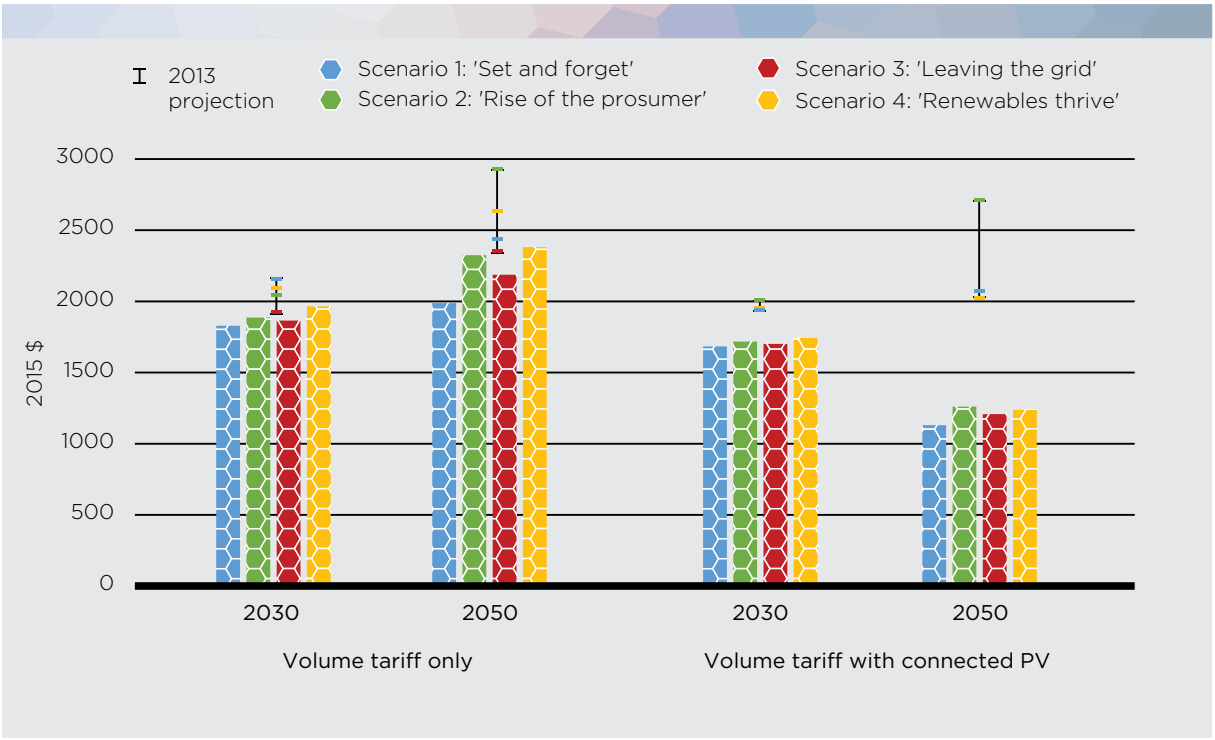
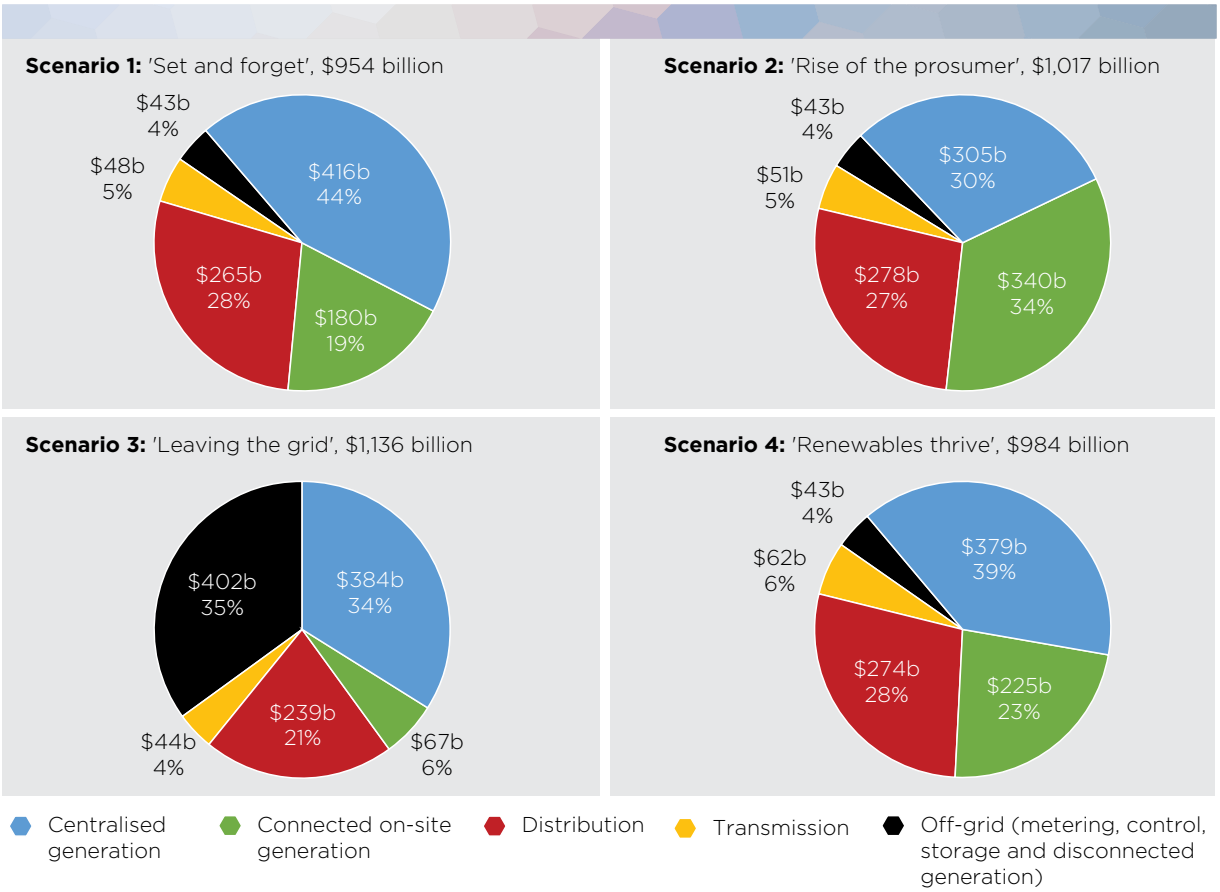


Figure 4: Projected cumulative electricity sector investment and operating expenditure to 2050 (including percentage contribution of each supply chain component), by scenario



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:

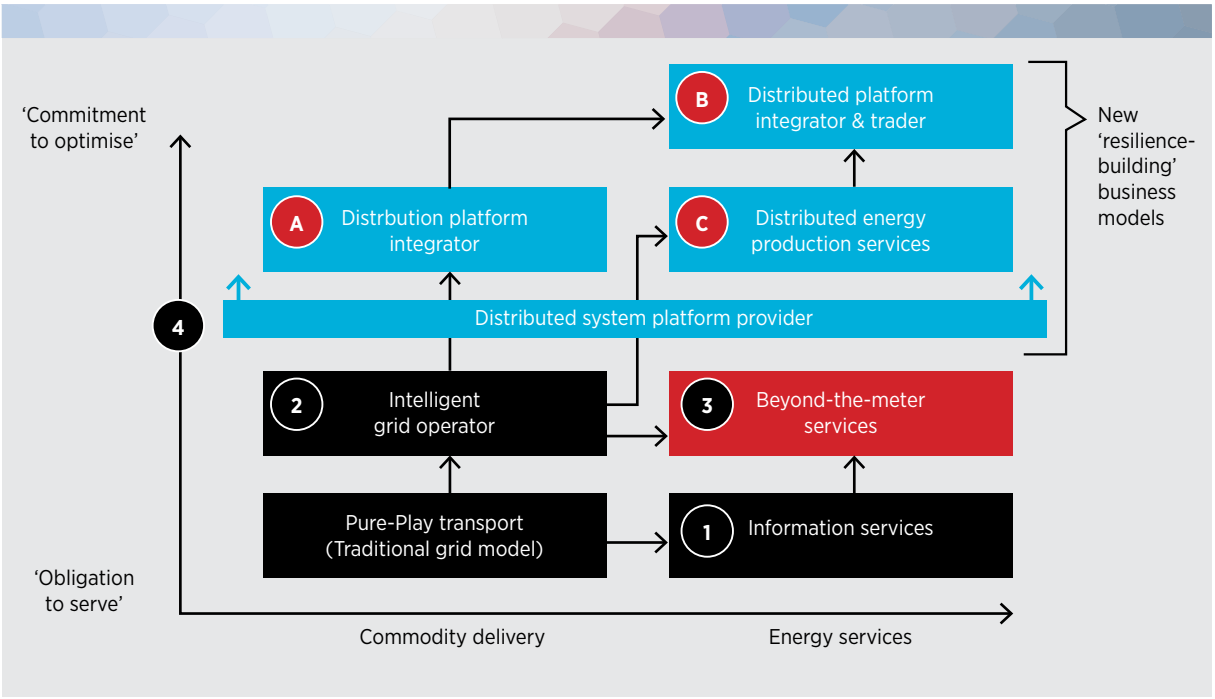
- four broad business model approaches are emerging: Platform Enabled, Intelligent Grid, Beyond-the-Meter Services, and Information Services (Figure 5)
- the most progressive utilities are those planning multiple evolutions of their business model
- there is no 'one size fits all' approach to future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

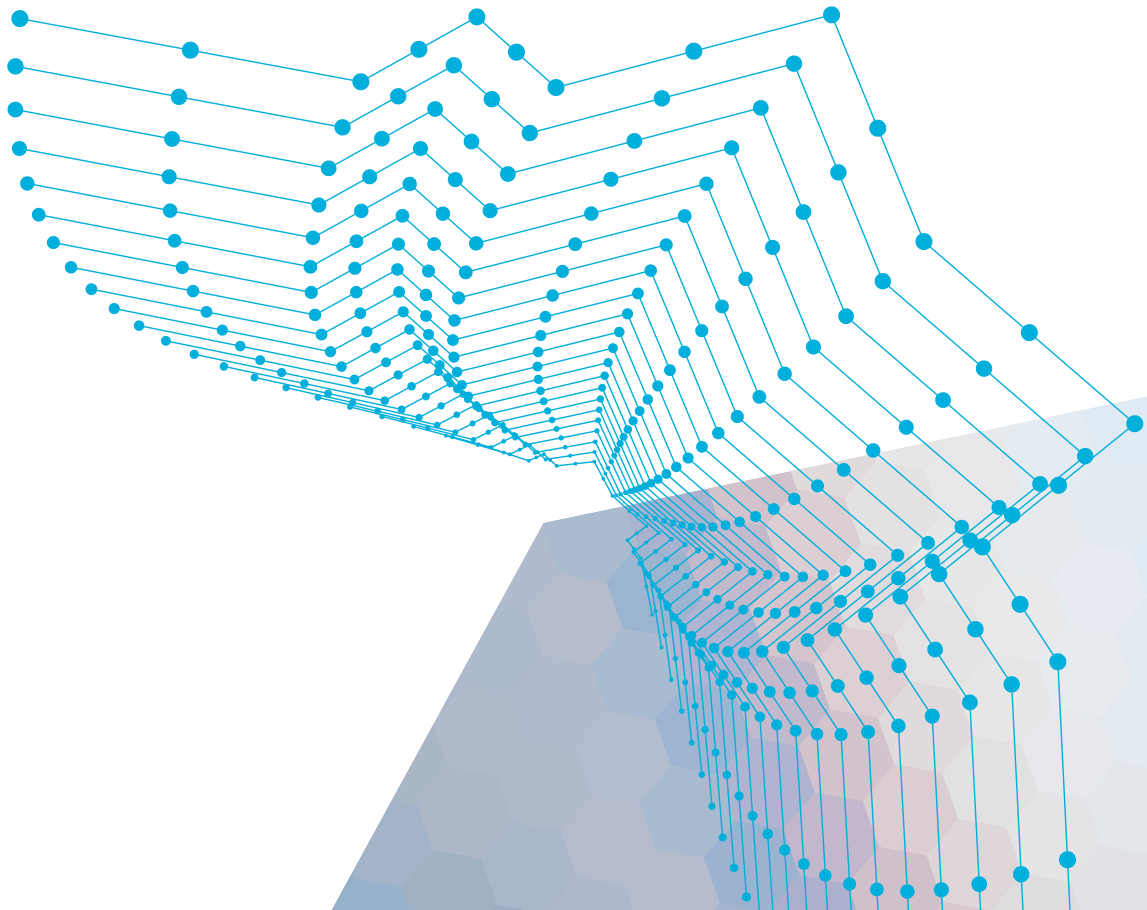
Further business model analysis in Stage 2 will consider:

- 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.

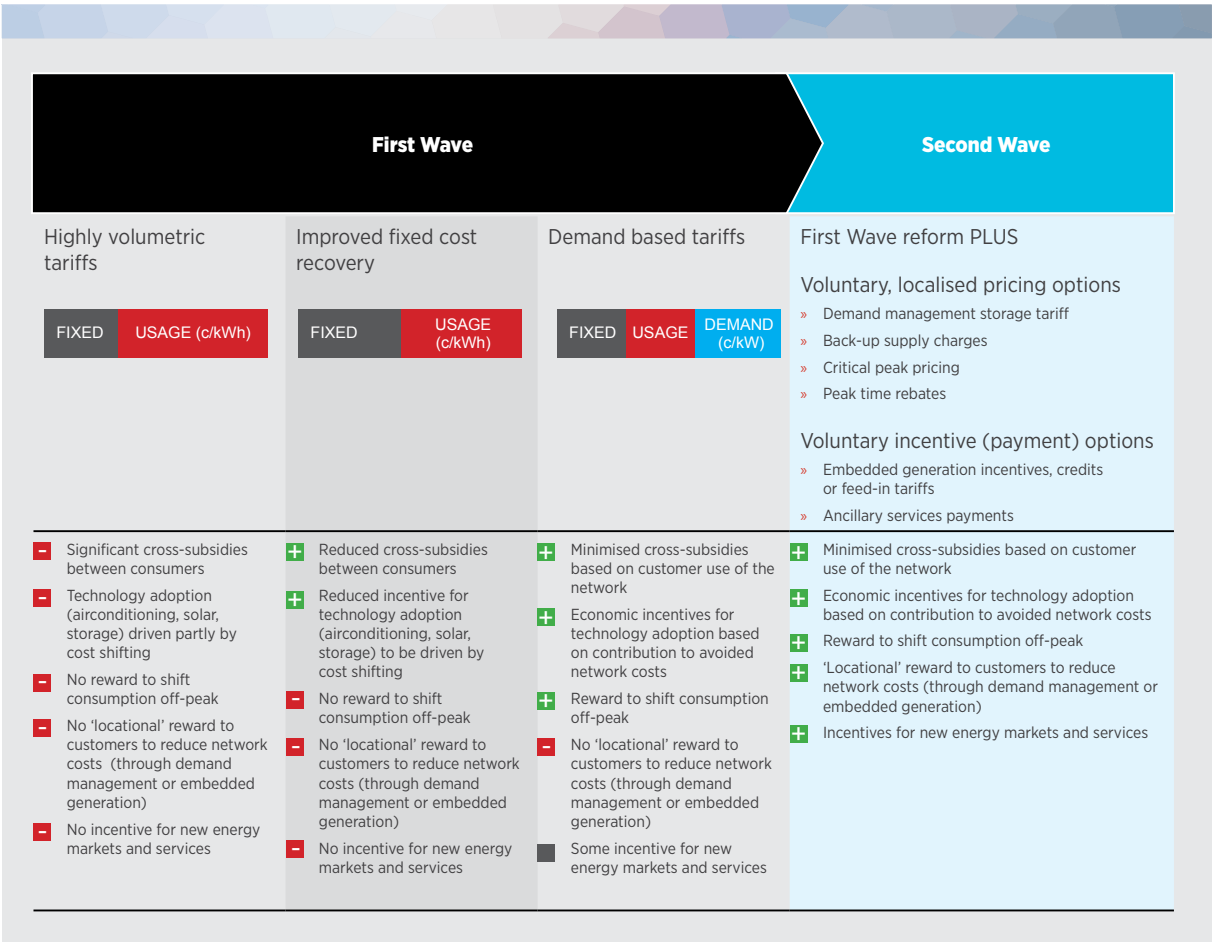
This 'Second Wave' of tariff reform will be critical to ensure the fair and efficient operation of electricity networks as integrated enabling platforms, as Australian customers either acquire distributed energy resources or access them through community schemes. The more effective the integration of 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



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.

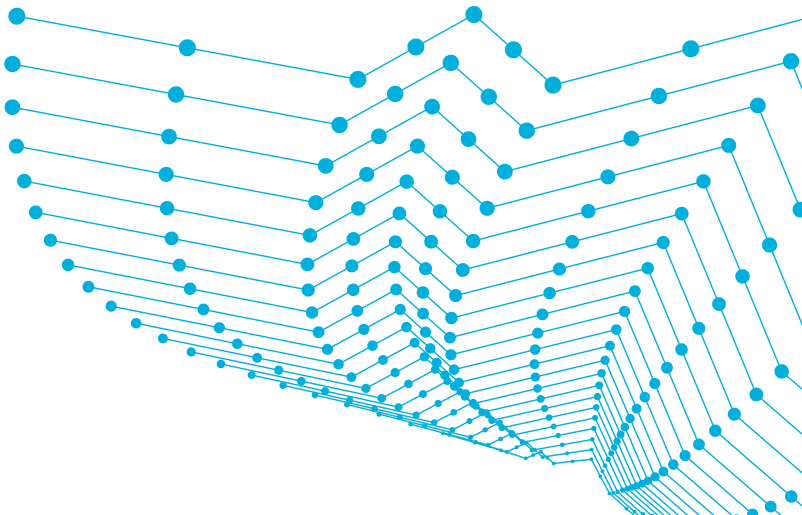
Given the pace and scale of change occurring across electricity systems in the developed world, many jurisdictions are reconsidering historical approaches to economic regulation. As a leader in aspects of this global transformation, Australia needs a clear conversation about the purpose and expectations 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.