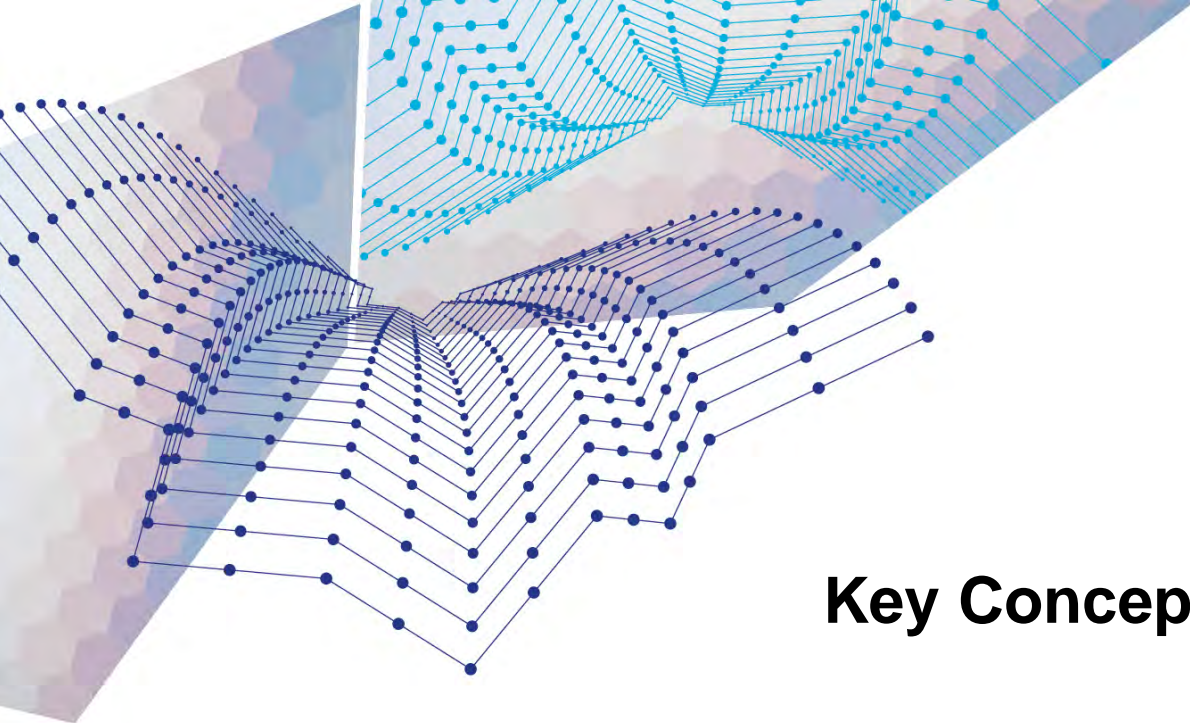




ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

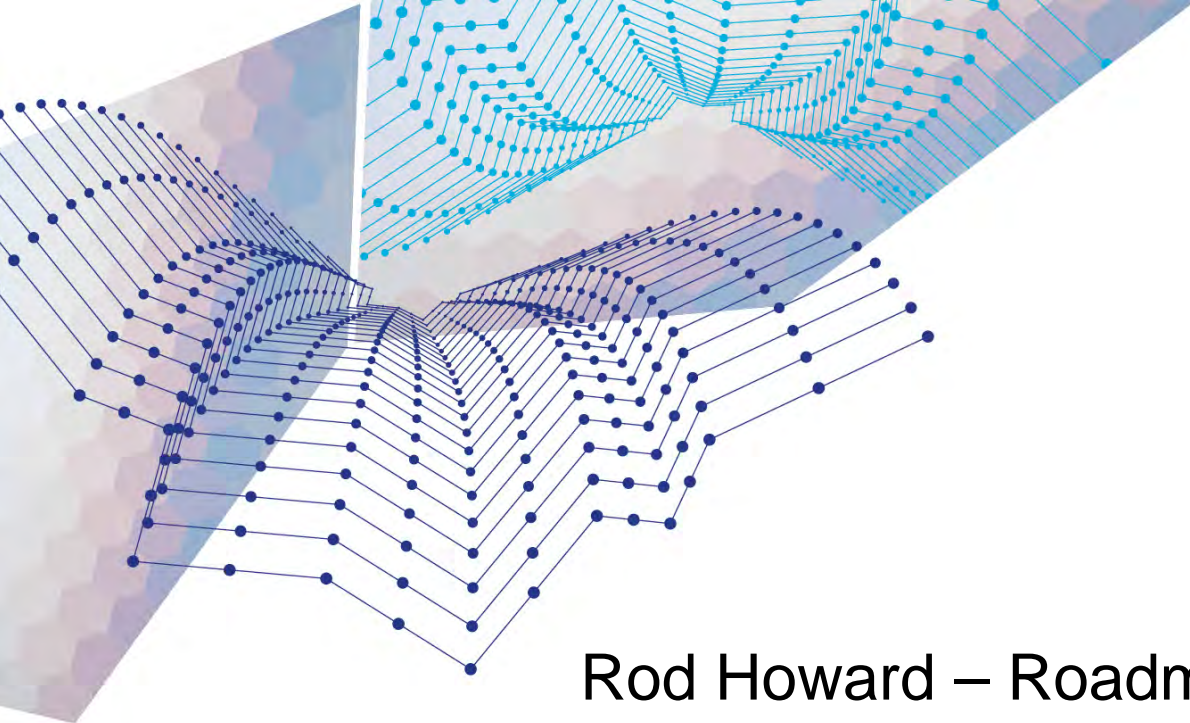


ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

Key Concepts Report Launch 6 December 2016



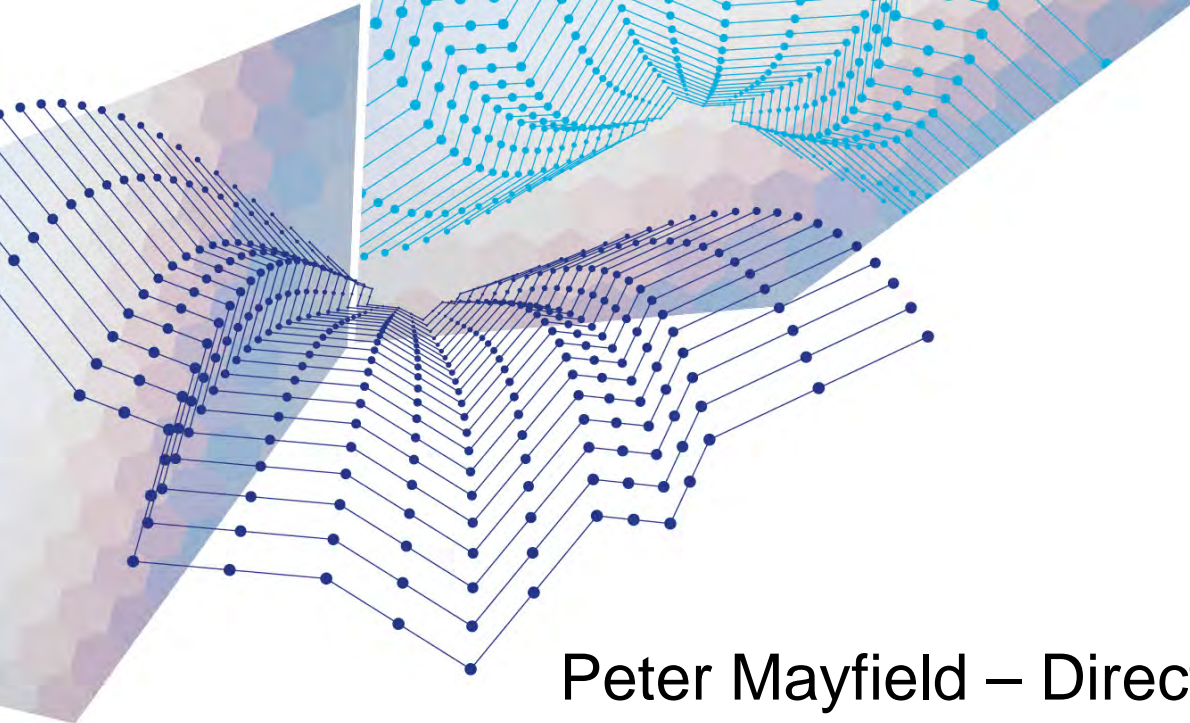


ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

Welcome:
Rod Howard – Roadmap Program Chair





ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

Introduction:
Peter Mayfield – Director, CSIRO Energy





ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

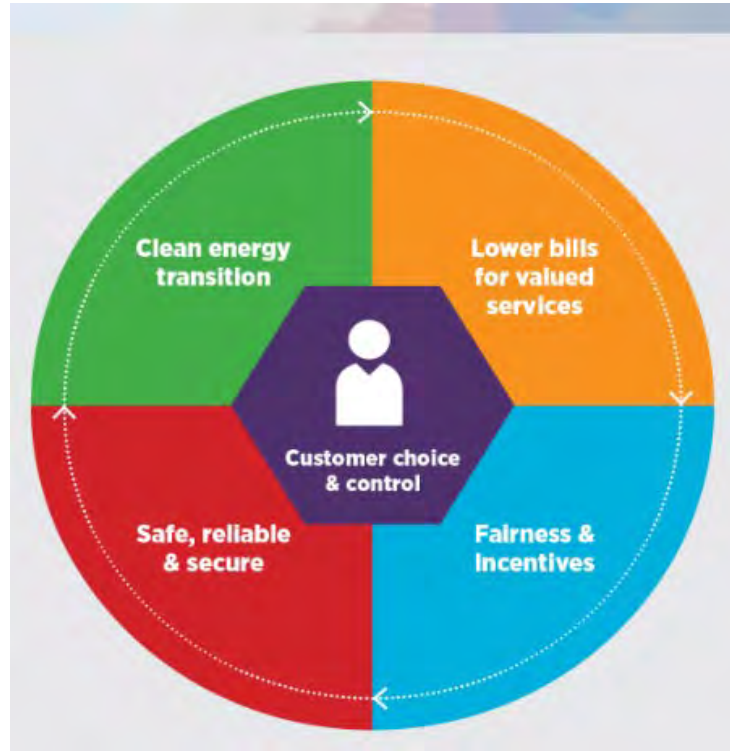
Launch of the Key Concepts Report

6 December 2016

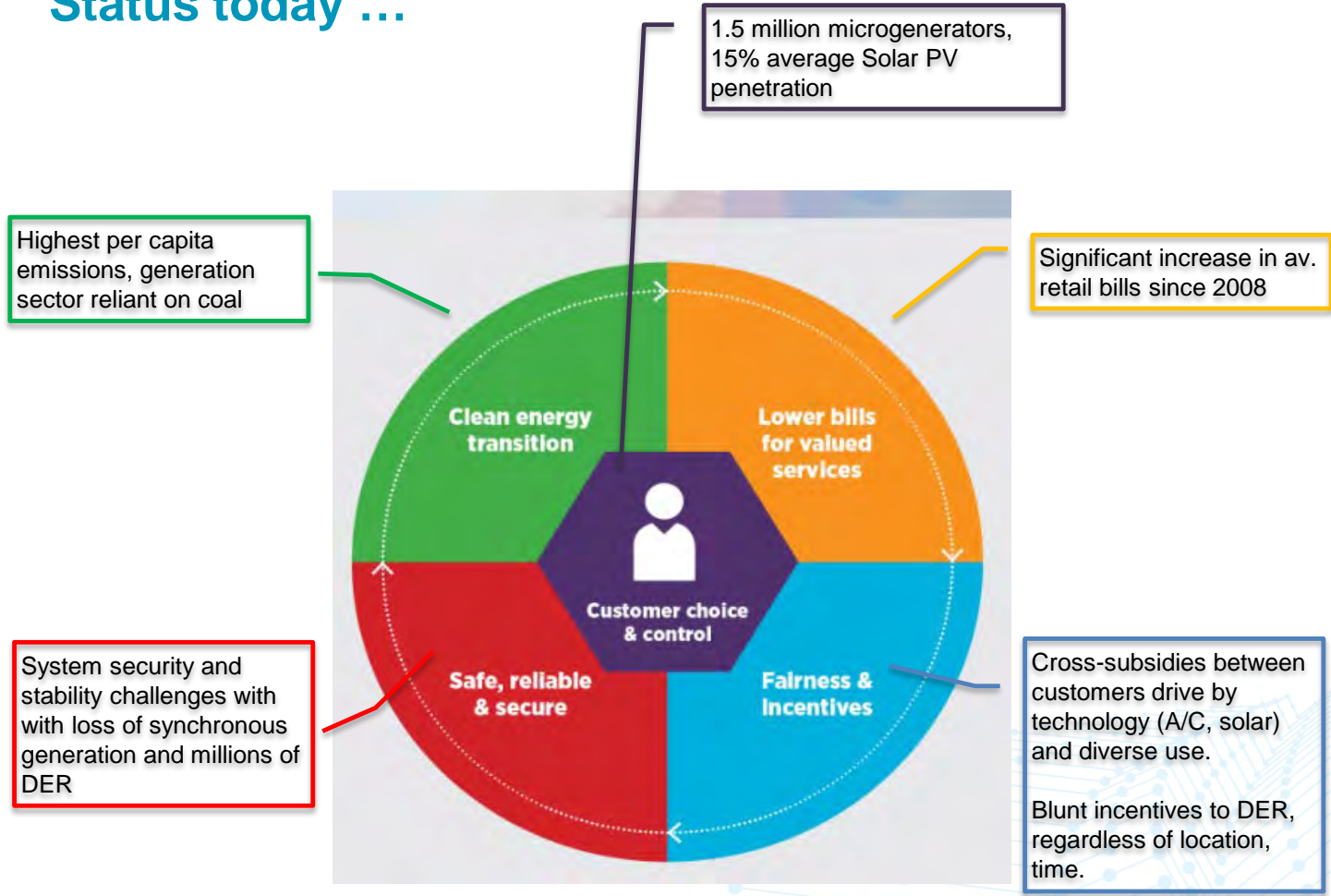


2027 Roadmap Vision

Australia's electricity systems in 2027 are resilient to divergent futures and are positioned to achieve balanced outcomes for customers:



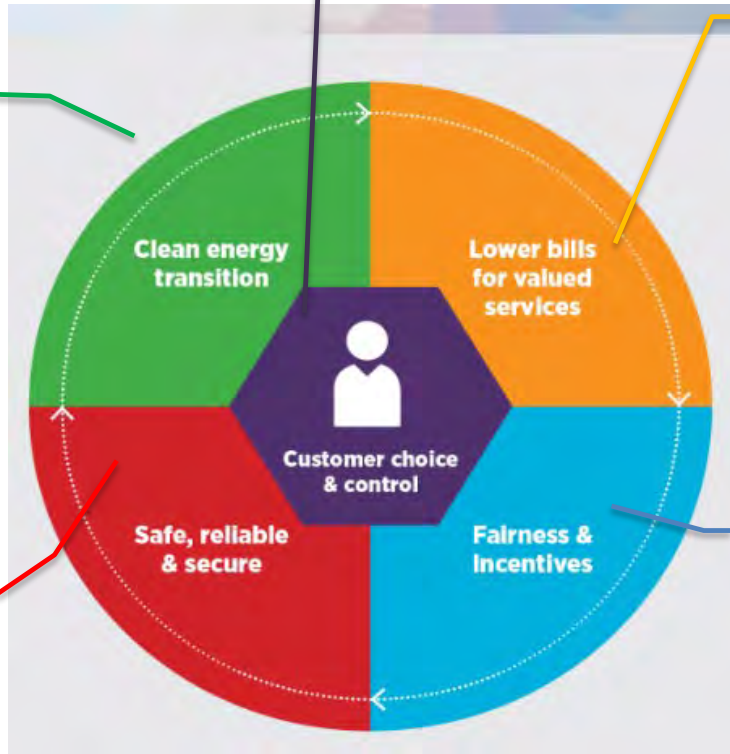
Status today ...



A better future...

- COP 21 aspiration of Zero Net Emissions by 2050 is met

- Efficient solutions for new NEM services avoid security & stability risks.
- Real time balancing, reliability & quality of supply with millions of DER participants



- Almost 2/3 of customers have DER
- 1/3 customers on 'stand alone power system' tariff
- Customer protection and concession schemes fit for purpose.

- Reduce total system spend by \$101 BN by 2050
- Save Households \$414 pa
- Network charges 30% lower than 2016

- Avoid over \$18 BN in cross subsidies
- Means \$600 pa. for mid size family without DER
- Networks pay over \$2.5 BN pa for DER services

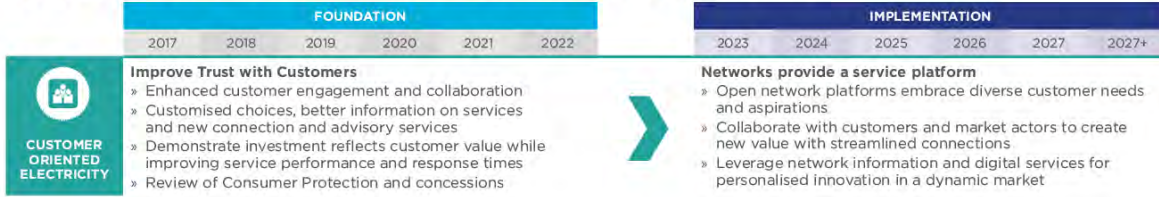
Overview of the Electricity Network Transformation Roadmap

Overview of the Electricity Network Transformation Roadmap





FOUNDATION					
2017	2018	2019	2020	2021	2022

IMPLEMENTATION					
2023	2024	2025	2026	2027	2027+




Overview of the Electricity Network Transformation Roadmap







Overview of the Electricity Network Transformation Roadmap

	FOUNDATION						IMPLEMENTATION						
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2027+	
 <p>CUSTOMER ORIENTED ELECTRICITY</p>	<p>Improve Trust with Customers</p> <ul style="list-style-type: none"> » Enhanced customer engagement and collaboration » Customised choices, better information on services and new connection and advisory services » Demonstrate investment reflects customer value while improving service performance and response times » Review of Consumer Protection and concessions 							<p>Networks provide a service platform</p> <ul style="list-style-type: none"> » Open network platforms embrace diverse customer needs and aspirations » Collaborate with customers and market actors to create new value with streamlined connections » Leverage network information and digital services for personalised innovation in a dynamic market 					
 <p>POWER SYSTEM SECURITY</p>	<p>New systems to support diverse generation</p> <ul style="list-style-type: none"> » Update Transmission Interconnection test » Review frameworks for protection systems, efficient capacity and balancing services » New market frameworks for ancillary services » Develop new power system forecasting and planning approaches to anticipate system constraints » Enhanced intelligence and decision making tools » Close focus on physical & cyber security 							<p>Harmonised System Operations at all levels</p> <ul style="list-style-type: none"> » Transmission networks support system stability with new services. » Distribution networks provide visibility of DER and potentially Frequency Control Ancillary Services (FCAS) and delegated balancing services. » Real-time communication and controls 					






Overview of the Electricity Network Transformation Roadmap

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 <p>INTELLIGENT NETWORKS & MARKETS</p>	<p>Essential information for an integrated grid</p> <ul style="list-style-type: none"> » Establish open standards and protocols to enable secure system operation, management and exchange of information and interoperability with distributed energy resources » Networks enhance current system monitoring and models to inform advanced system planning » Build distributed energy resource maps and feeder hosting analysis to support locational valuation of distributed energy based services 						<p>Networks optimised with distributed energy resources</p> <ul style="list-style-type: none"> » Active network management for technical stability, enabling distributed energy resource markets and efficient optimisation. » Networks provide a suite of grid intelligence and control architectures to animate distributed energy resource markets, as well as providing system security. » Establish a new network optimisation market to procure DER services for network support. » A flexible and agile workforce to support the new optimised energy system. 					

Overview of the Electricity Network Transformation Roadmap

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Overall Customer outcomes by	
2027	2050
<p>CUSTOMER CHOICE AND CONTROL</p> <ul style="list-style-type: none"> » Over 40% customers use onsite resources; 29 GW solar and 34 GWh of batteries. » Concessions to support those who need it most. » Almost 2/3 customers use onsite resources, including 1/3 customers on a new stand alone system tariff. 	
<p>LOWER BILLS FOR VALUED SERVICES</p> <ul style="list-style-type: none"> » Avoid over \$1.4 BN in network investment. » Average network bills 10% lower than 2016. » Total system spend is \$101BN lower to 2050. » Save households \$414 pa by 2050. » Network charges 30% lower than 2016. 	
<p>FAIRNESS & INCENTIVES</p> <ul style="list-style-type: none"> » Networks pay over \$1.1 BN pa for DER services. » Over \$1.4 BN in cross subsidies avoided, saving \$350 pa for med size family without DER. » Networks pay over \$2.5 BN pa for DER services. » Over \$18 BN in cross subsidies avoided, saving \$600 pa for med size family without DER. 	
<p>SAFETY, SECURITY, RELIABILITY</p> <ul style="list-style-type: none"> » Planned and efficient market response avoids security & stability risks. » Robust physical & cyber security management. » Real time balancing, reliability and quality of supply at small and large scale, with millions of market participants. 	
<p>CLEAN ENERGY TRANSITION</p> <ul style="list-style-type: none"> » Electricity sector carbon abatement to reach 40% by 2030 - greater than current national target of 26-28%. » Electricity sector achieves Zero Net Emissions by 2050. 	

ENTR Supporting Report Library

Program Quantification

- *Economic benefits of the Electricity Network Transformation Roadmap: Technical report.* (Forthcoming - 2017)

Customer-oriented Networks

- Electricity Network Transformation Roadmap: Interim Program Report (2015)
- *Electricity Network Transformation Roadmap: Customer Engagement Handbook* (2016)
- Network business model evolution
 - Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution. Accenture (2015)
 - Insights from Global Jurisdictions, New Market Actors & Evolving Business Models, Accenture (2016)

Customer Safety Net

- External: Consumer Action Law Centre, *Power Transformed* (2016)

Carbon & Renewable Policy Options

- *Enabling Australia's Cleaner Energy Transition*, Energy Networks Association (2016)
- *Australia's Climate Policy Options – Modelling of Alternate Policy Scenarios.* Jacobs (2016)

Efficient Capacity Utilisation

- *Efficient capacity utilisation: transport and building services electrification.* (2016)
- *Gas-electricity substitution projections to 2050.* ClimateWorks Australia (2016)

Pricing & Incentives

- Energeia, *Price and Incentives Report.* (2016)
- *Energeia Stand Alone Power Systems and Microgrids Report* (2016)

Regulatory & Policy Frameworks

- Cambridge Economic Policy Associates *Future Regulatory Options for Electricity Networks*, 3 August 2016

Power System Security

- *Embedded Generation Report.* Marchmont Hill Consulting (2015)
- *Grid Design, Operation, Platform & Telecoms Report.* EA Technology (2016)

Intelligent Networks

- *Network Transformation Roadmap: Innovation Gap Analysis and Plan.* EA Technology (2016)

DER Markets & Orchestration

- *Grid Design, Operation, Platform & Telecoms Report.* EA Technology (2016)
- *Distribution Systems in a High DER Future: Planning, Market Design, Operation and Oversight.* Lawrence Berkeley (2015)

Future Workforce Requirements

- *Changing Industry, A Changing Workforce: Electricity National Transformation Roadmap Workforce Skilling Impacts* (Energy Skills Queensland), October 2016.

Technical Standards and Regulations

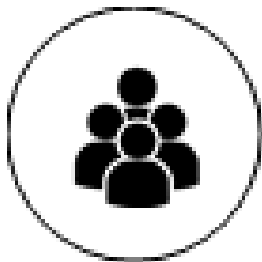
- *Standards and the Future of Distributed Electricity (Standards Australia)*, November 2016.



ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-21

Customer-oriented electricity



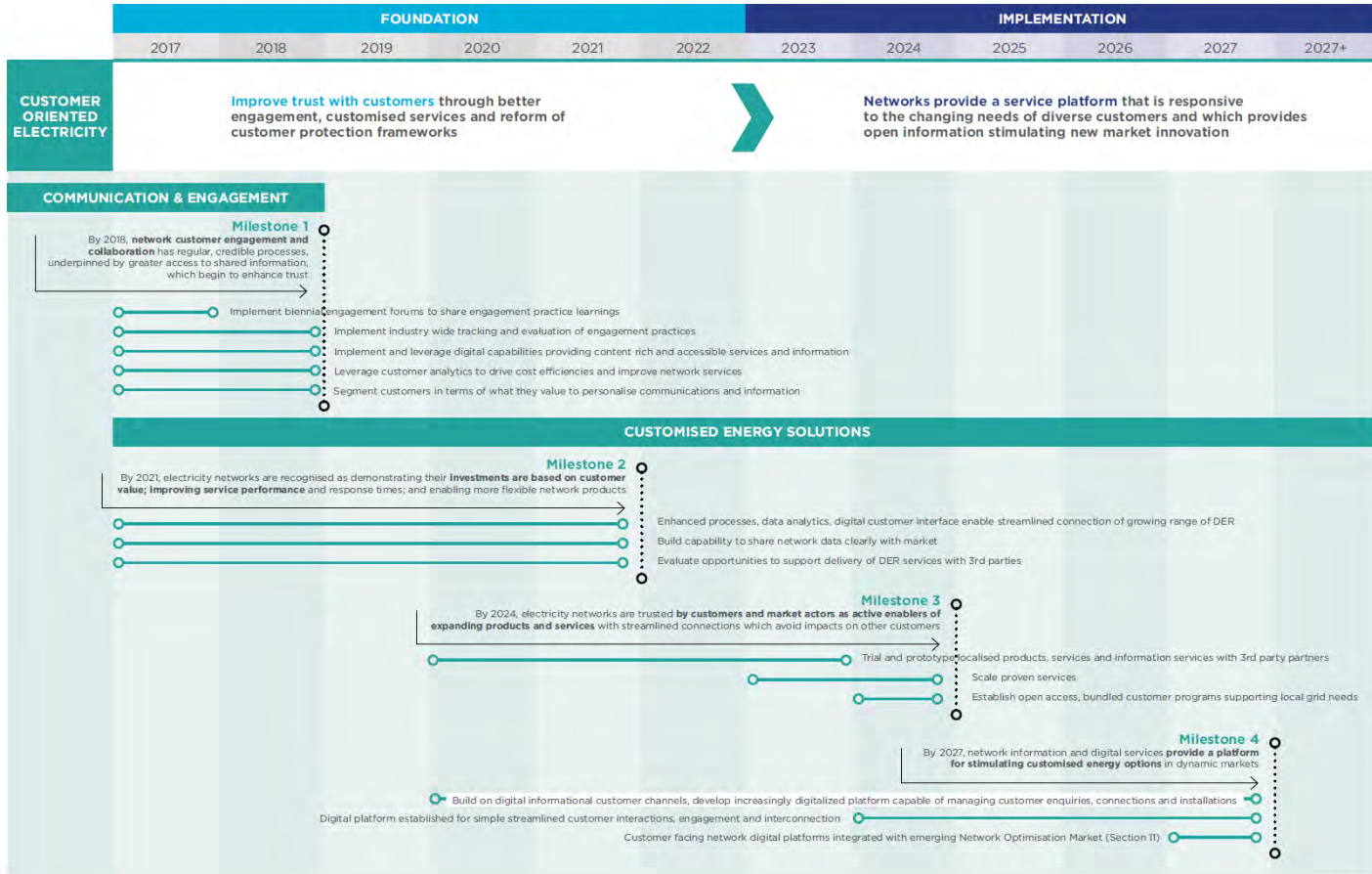
Customers are placed at the centre of Australia's future electricity system and empowered with greater choice, control and autonomy while enjoying the security and benefits of a grid-connection. Transformed electricity networks actively connect customers with a growing range of market actors and customised electricity solutions that are supported by a modernized customer safety net designed for the 21st century energy system.

Key Findings



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.

Customer Oriented Electricity – Engagement and Customised Solutions



Customer Oriented Electricity – Engagement and Customised Solutions



CUSTOMER ORIENTED ELECTRICITY

Improve trust with customers through better engagement, customised services and reform of customer protection frameworks



Networks provide a service platform that is responsive to the changing needs of diverse customers and which provides open information stimulating new market innovation

COMMUNICATION & ENGAGEMENT

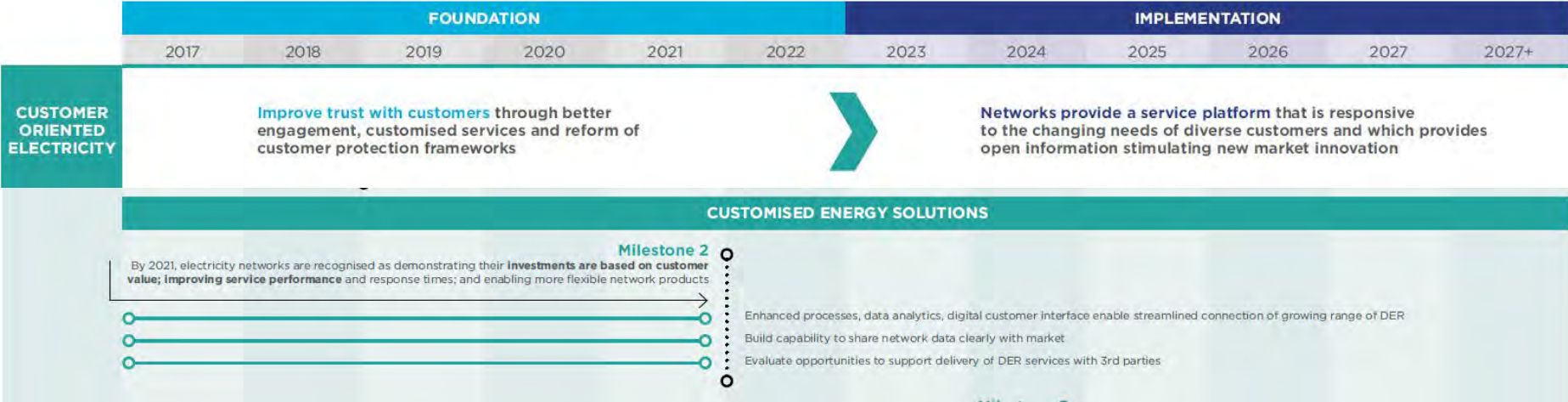
Milestone 1

By 2018, network customer engagement and collaboration has regular, credible processes, underpinned by greater access to shared information, which begin to enhance trust

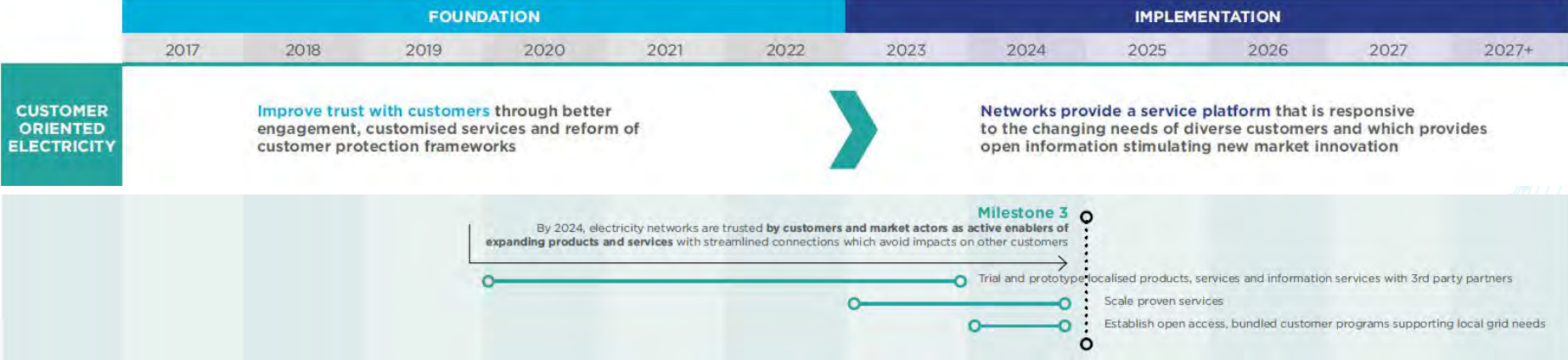
- Implement biennial engagement forums to share engagement practice learnings
- Implement industry wide tracking and evaluation of engagement practices
- Implement and leverage digital capabilities providing content rich and accessible services and information
- Leverage customer analytics to drive cost efficiencies and improve network services
- Segment customers in terms of what they value to personalise communications and information



Customer Oriented Electricity – Engagement and Customised Solutions



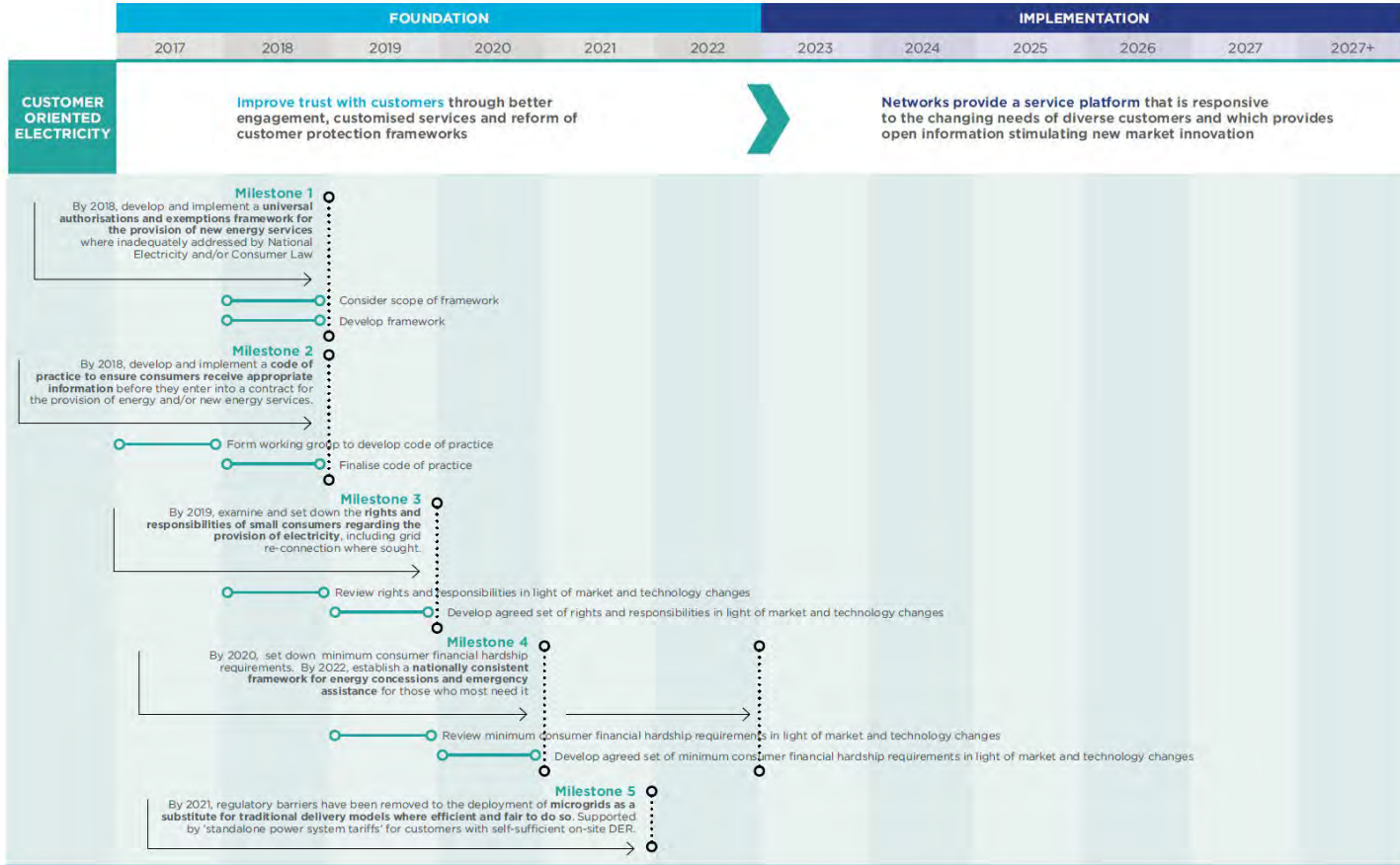
Customer Oriented Electricity – Engagement and Customised Solutions

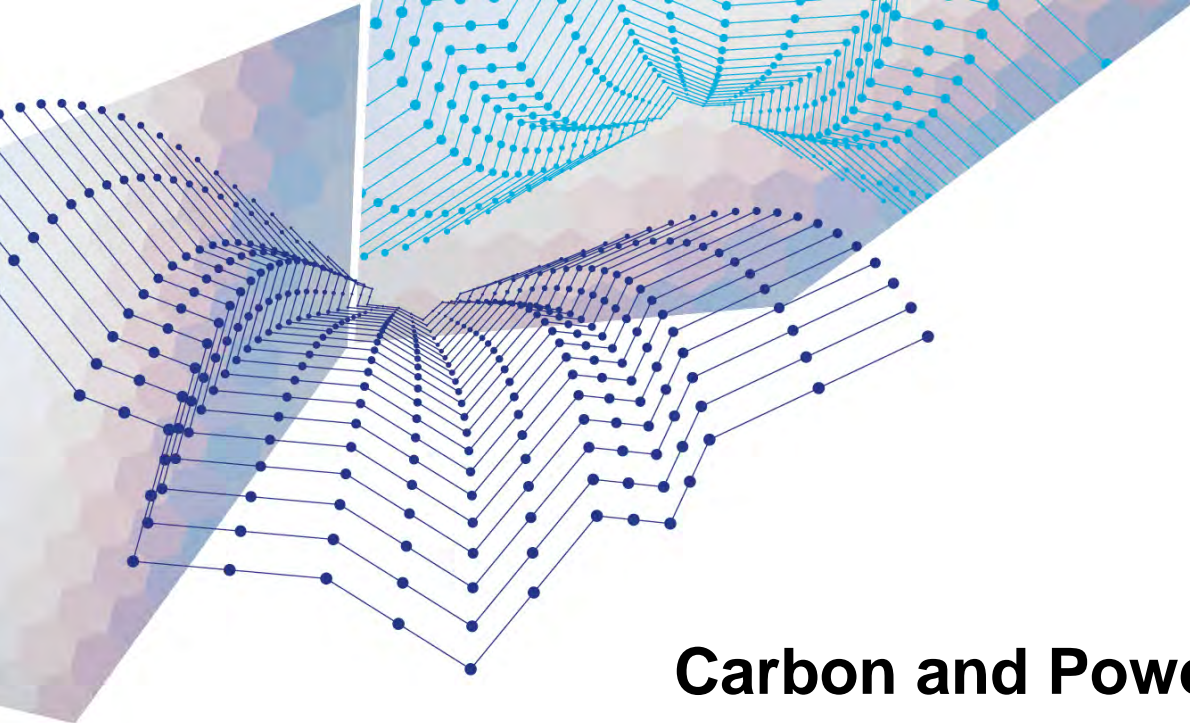


Customer Oriented Electricity – Engagement and Customised Solutions



Customer Oriented Electricity – Customer Protection

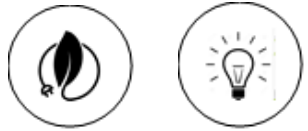




ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

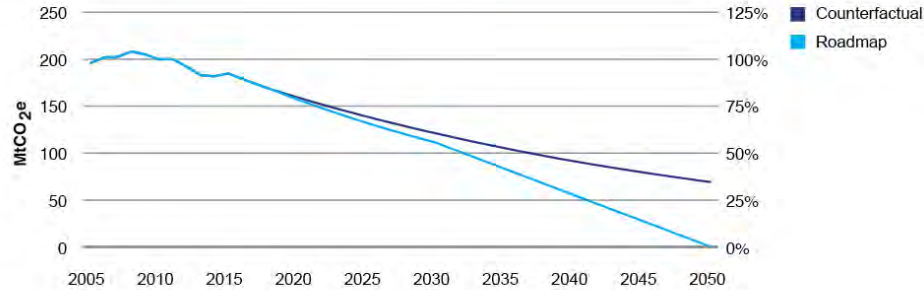
Carbon and Power System Security



Carbon abatement



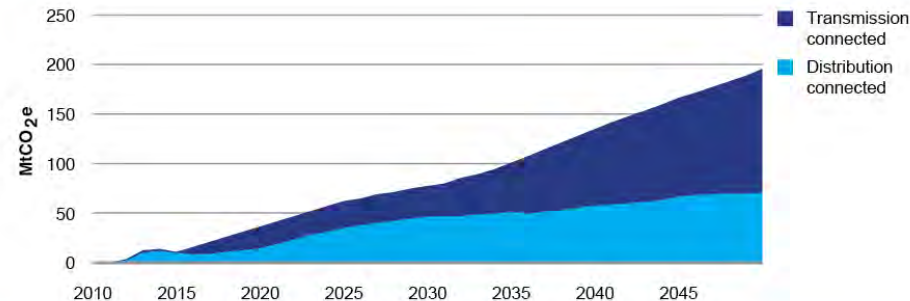
Assumed greenhouse gas pathways under the Roadmap & counterfactual scenarios



Incentive-based policy options capable of enabling least-cost carbon abatement are supported by options for maximising capacity utilisation. The transformed electricity system is positioned to efficiently maintain system reliability, support renewable energy growth and achieve zero net carbon emissions by 2050.

Distribution connected devices will lead to 2030 with transmission connected devices doing the heavy lifting 2030-2050

Historical and projected quantify of electricity sector abatement by network location



Key Findings: Carbon Policy

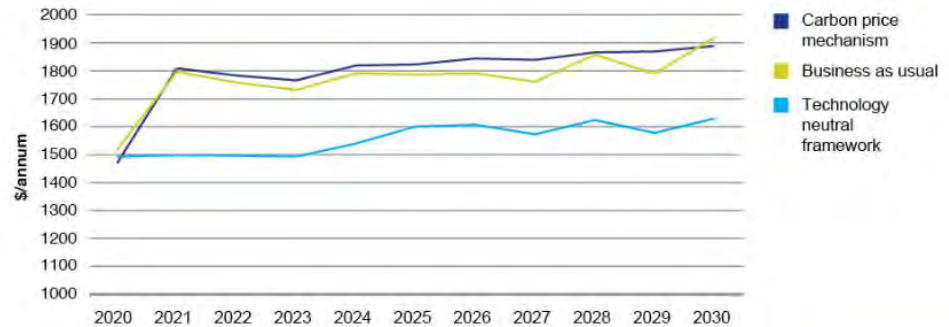


Finding 1: Emission reductions of 26 to 28% from the stationary energy sector can be achieved with any of the selected policy scenarios

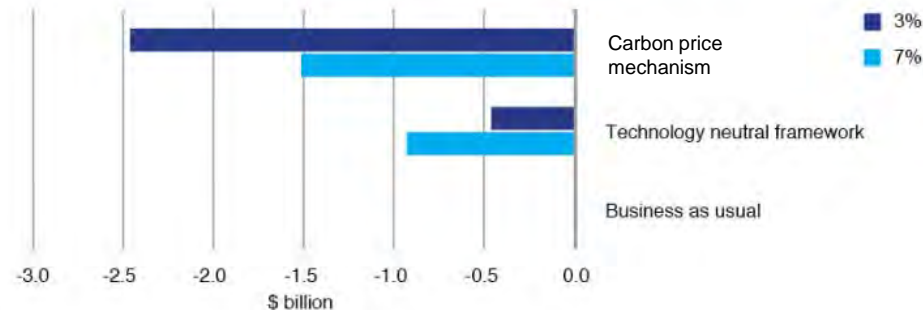
Finding 2: Household bills are lower under an emission intensity baseline and credit scheme.

Finding 3: Policy settings impact the economic cost of emissions reductions

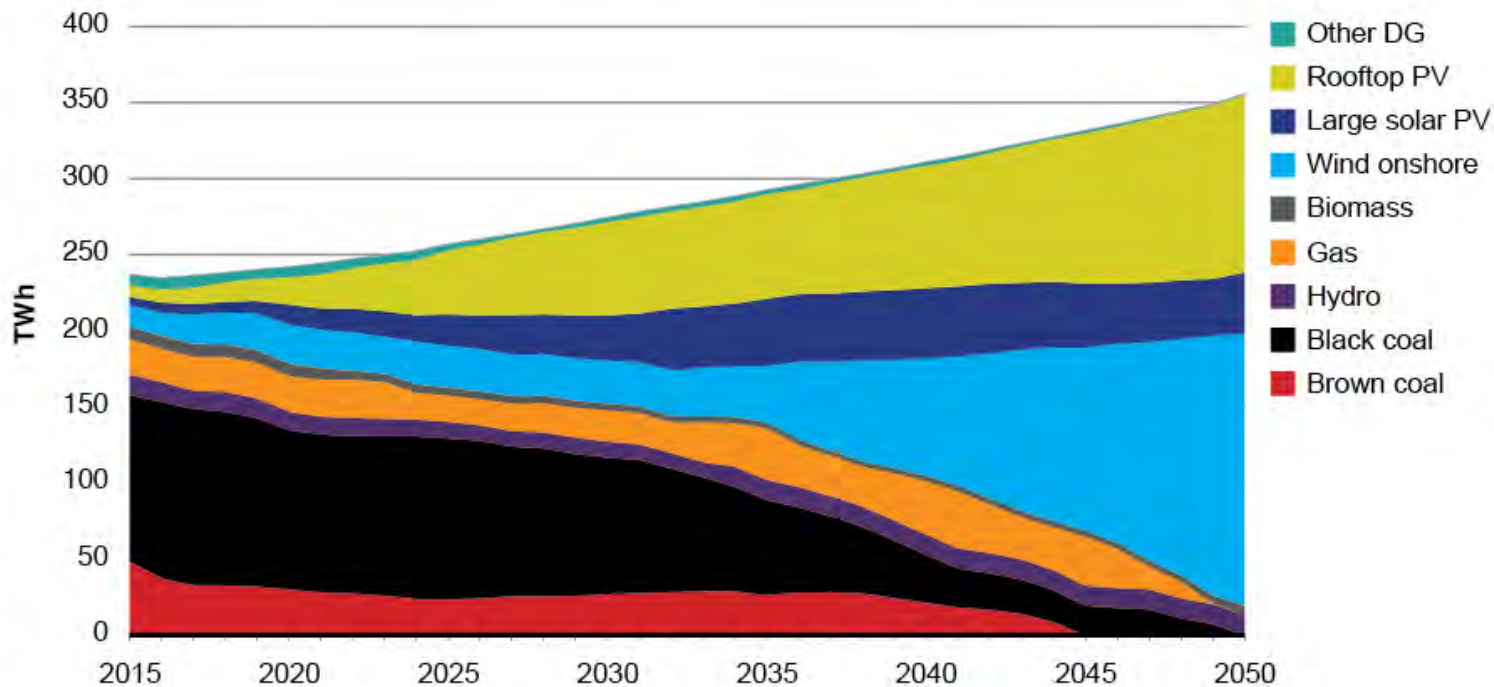
Impact of policy settings on household electricity bills



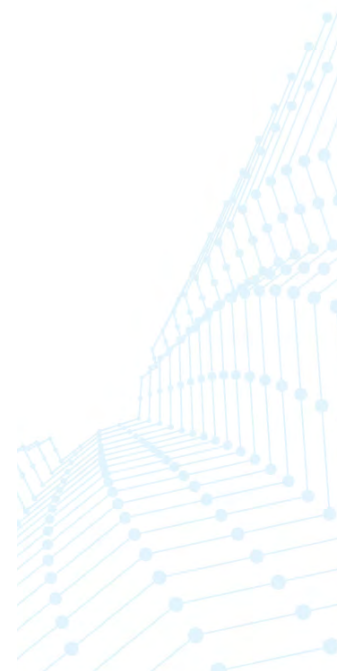
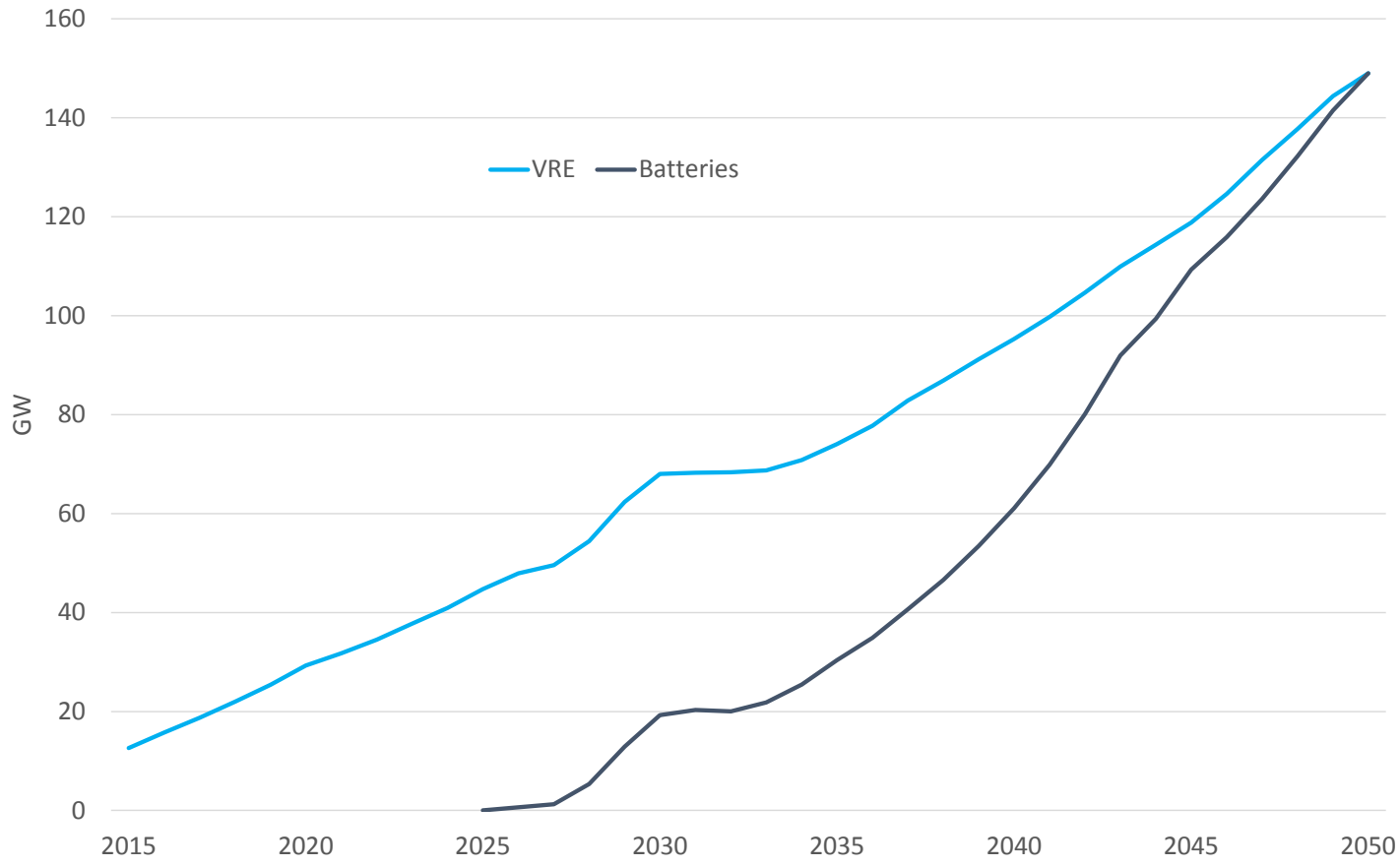
Impact of policy settings on total economic costs



Electricity generation by technology



Total battery storage requirements

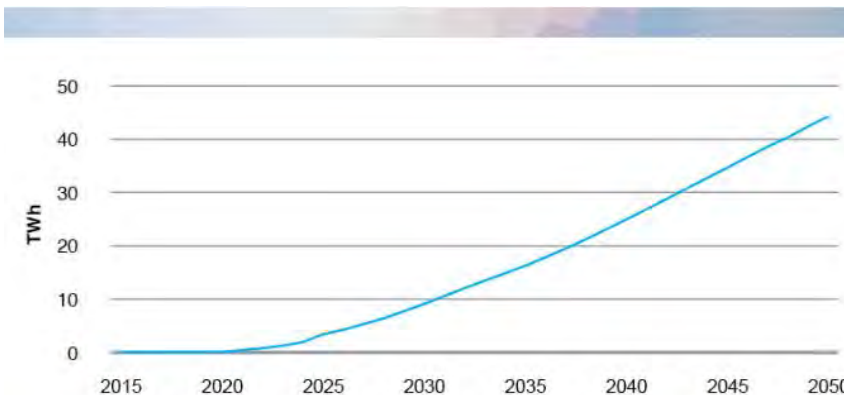


Efficient capacity utilization – electric vehicles

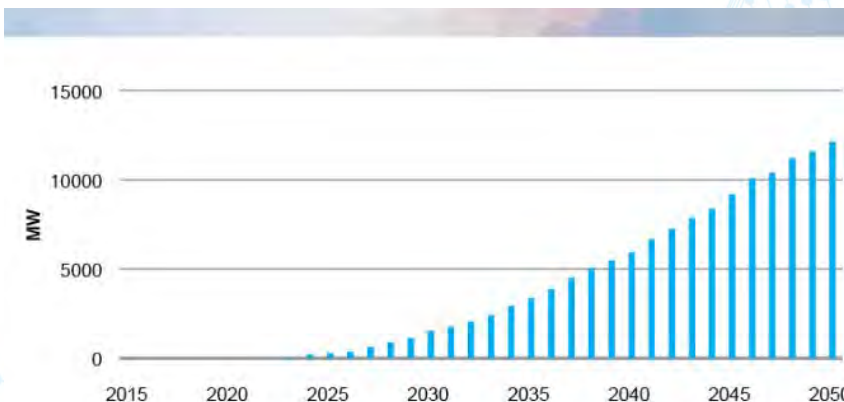
Finding 1: Electrification of transport could make a substantial contribution to efficient capacity utilisation

Finding 2: Orchestration maximises electric vehicle contribution to decarbonisation and efficient capacity utilisation

Projected additional national electricity consumption from electric vehicles



Projected additional national aggregate non-coincidental zone substation load



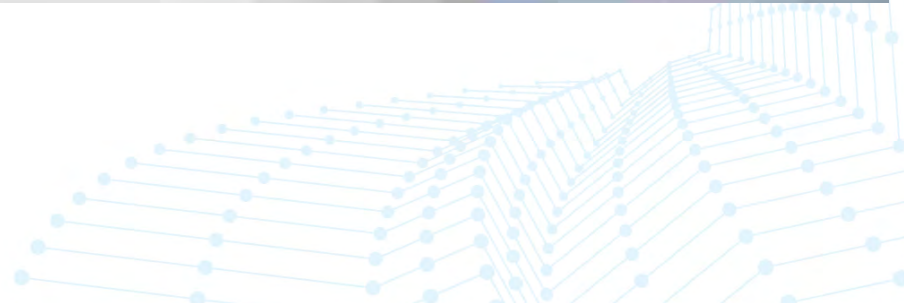
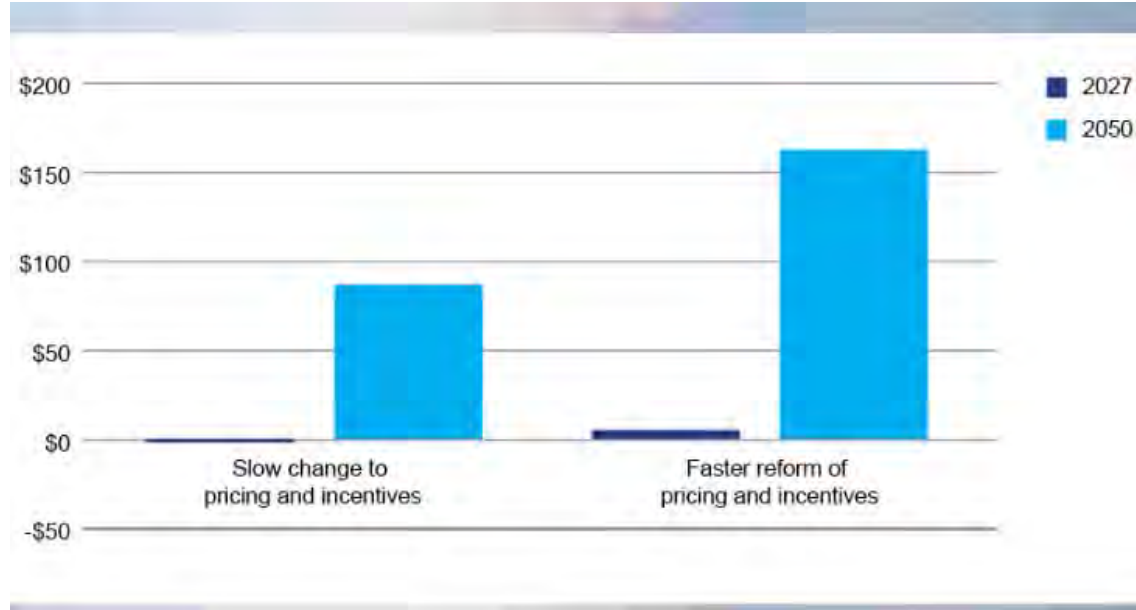
Efficient capacity utilization – electric vehicles



Electrification of transport reduces electricity bills

..and is projected to reduce Australian road transport emissions by 22 MtCO₂e per year by 2050

Projected reductions in average residential electricity bills due to EV adoption



Carbon abatement – key actions



FOUNDATION					
2017	2018	2019	2020	2021	2022

IMPLEMENTATION					
2023	2024	2025	2026	2027	2027+



CARBON
ABATEMENT

A stable Carbon Policy for higher targets

- » Develop nationally integrated carbon policy framework
- » Implement emissions Baseline & Credit Scheme
- » Set Light Vehicle emissions standard policy to provide incentives for electric vehicle uptake, supporting climate goals
- » Review Australia's emissions reduction target
- » Agile network connections and integration of large and small scale renewable technologies



Reviewing scope for greater efficiency

- » Review technology specific incentive schemes to focus on least cost abatement
- » Review scope for more efficient economy wide carbon pricing where consensus
- » Review Australia's emissions reduction target (2027)

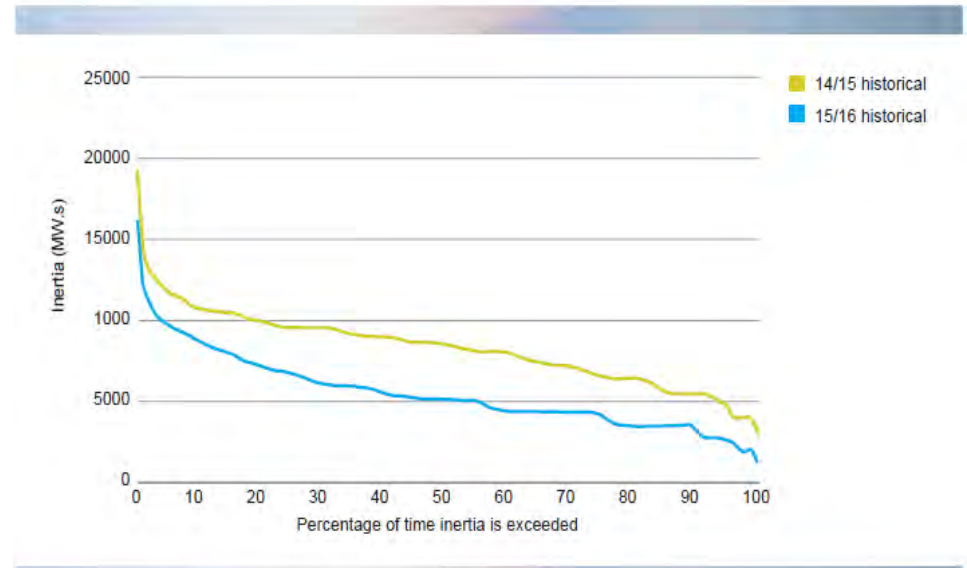


Power system security



Electricity networks and the power system as a whole are enabled to support an expanding diversity of energy sources, at both the customer and transmission levels of the system. System safety, security and reliability are a central focus and customer DERs are enabled to become an integral part of network optimisation and whole-of-system balancing

Changes in system inertia, South Australia



Key Findings – Power System Security

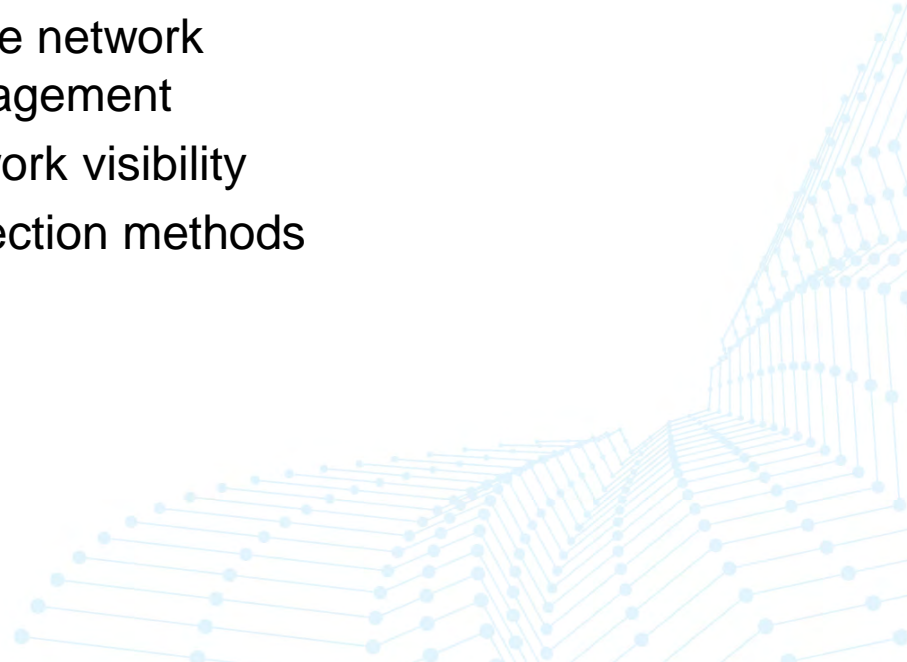


Finding 1: The roadmap supports the four priority technical challenges identified by AEMO:

- Frequency control
- Management of extreme power system conditions
- Visibility of the power system (information, data, and models)
- System strength

Finding 2: New forms of system architecture can be adopted to provide system security

- Active network management
- Network visibility
- Protection methods



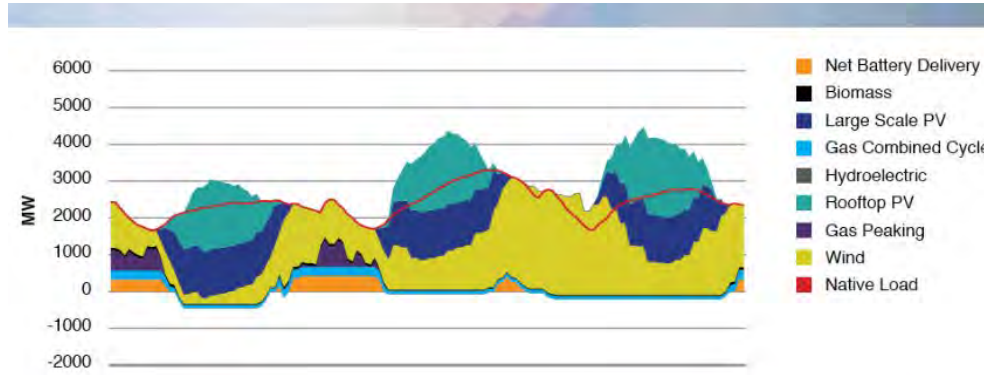
Key Findings – Power System Security



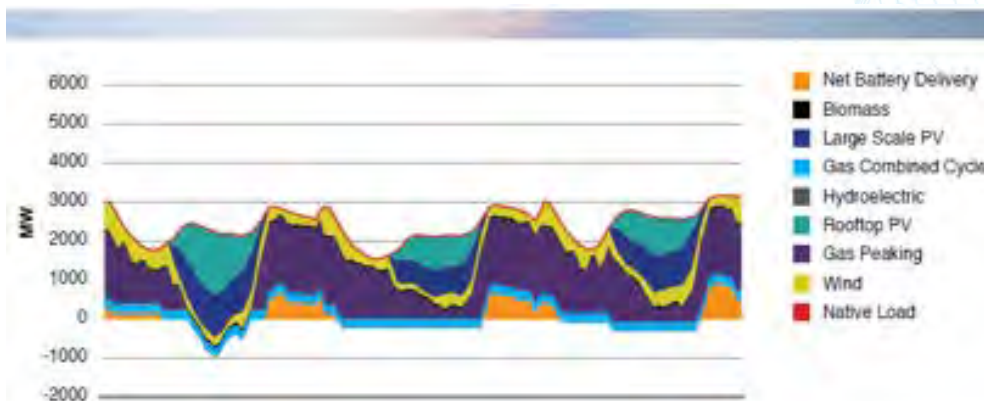
Finding 3: Multiple combinations of strategies will be needed

Individual NEM region balancing is unlikely to rely on one single strategy or solution but will need to consider all possible combinations of solutions to provide a secure and reliable power system.

South Australia, 2036, 80% Renewables, three sample days - summer



South Australia, 2036, 80% Renewables, three sample days - winter



Power system security – key actions



FOUNDATION					
2017	2018	2019	2020	2021	2022

IMPLEMENTATION					
2023	2024	2025	2026	2027	2027+



POWER
SYSTEM
SECURITY

New systems to support diverse generation

- » Update Transmission Interconnection test
- » Review frameworks for protection systems, efficient capacity and balancing services
- » New market frameworks for ancillary services
- » Develop new power system forecasting and planning approaches to anticipate system constraints
- » Enhanced intelligence and decision making tools
- » Close focus on physical & cyber security



Harmonised System Operations at all levels

- » Transmission networks support system stability with new services.
- » Distribution networks provide visibility of DER and potentially Frequency Control Ancillary Services (FCAS) and delegated balancing services.
- » Real-time communication and controls





ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

Incentives and network regulation



A fairer system through active implementation of tariff reform and modernised regulation and competition frameworks. More customer-oriented outcomes are supported ensuing those without DERs are treated fairly while those with DER are able to receive incentives for providing network-support services that improve the efficiency of the grid for all.

Key Findings – Pricing and Incentives

Finding 1: A fairer system of prices can only be achieved in a reasonable timeframe with changes to tariff assignment policy

Figure 16: Comparison of customers on fair and efficient tariffs (%)



Key Findings – Pricing and Incentives

Finding 2: Smart meters are essential to ensuring a fair system of prices

Finding 3: Over \$16bn in network savings can be achieved by 2050 through improving existing tariffs, introducing new tariffs and establishing frameworks for networks to buy grid services from customers with distributed energy resources

Finding 4: In a limited number of circumstances, standalone power systems and micro-grids are likely to become a lower cost alternative to traditional grid supply arrangements over the next 10 years.

Figure 17: Forecast penetration of smart meters in Australia

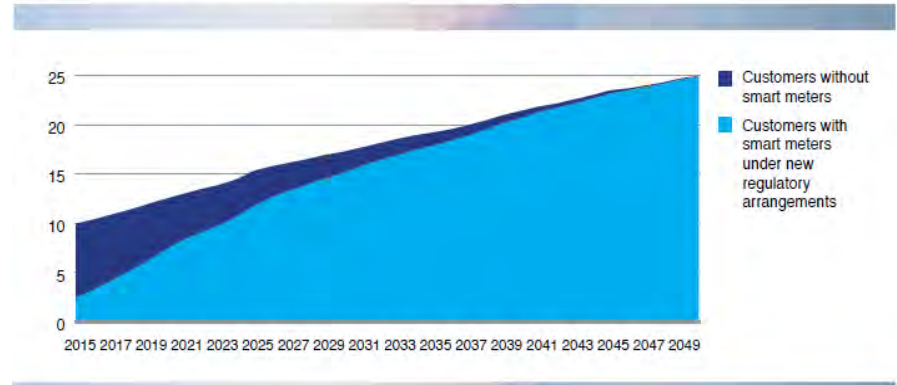
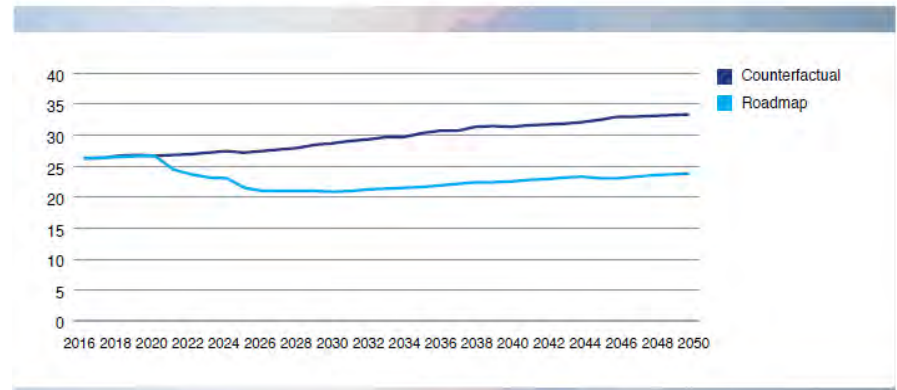


Figure 18: Non-coincident substation peak demand





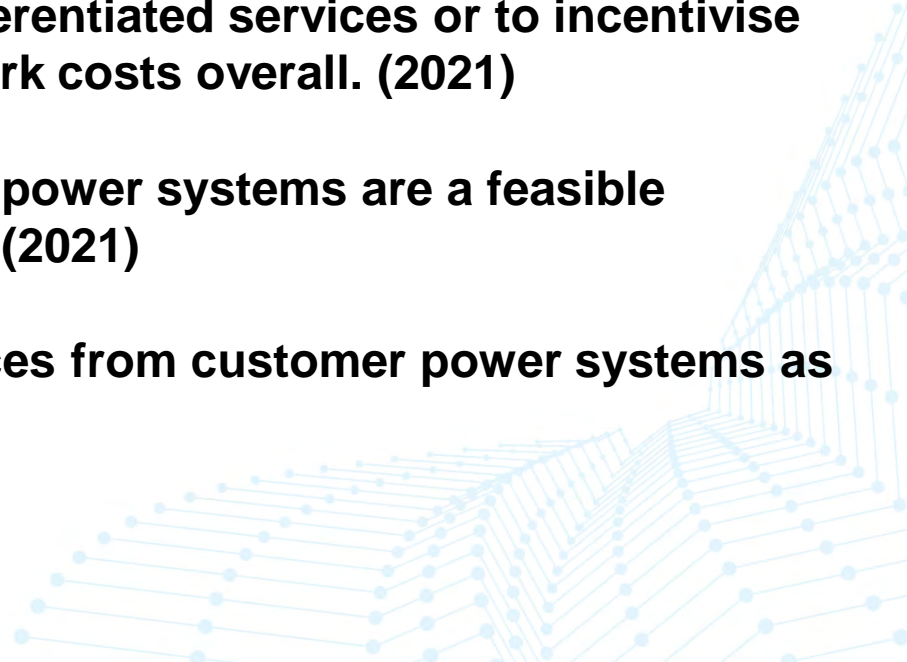
2017-27 Pricing & Incentives: Milestones and Actions

Milestone 1: Early transition to better tariffs. (2021)

Milestone 2: New prices for new and differentiated services or to incentivise customer response so as to lower network costs overall. (2021)

Milestone 3: Micro-grids and standalone power systems are a feasible alternative to traditional grid connection (2021)

Milestone 4: Networks buying grid services from customer power systems as an alternative to grid investment.(2027)





2017-27 Regulatory Policy & Frameworks: Milestones and Actions

Milestone 1: By 2018, the customers' role is central to regulatory processes covering core regulated services for agreeing network outputs and risk allocation.

Milestone 2: By 2018, structured trialling of alternative regulatory approaches is well advanced, including customer settlement approaches, as well as TOTEX trials. TOTEX is adopted as default approach by 2027.

Milestone 3: By 2019, new regulatory frameworks that are more adaptive to emerging competition are implemented (i.e. tests for whether regulation is needed, shifting services out of regulation).



ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-21

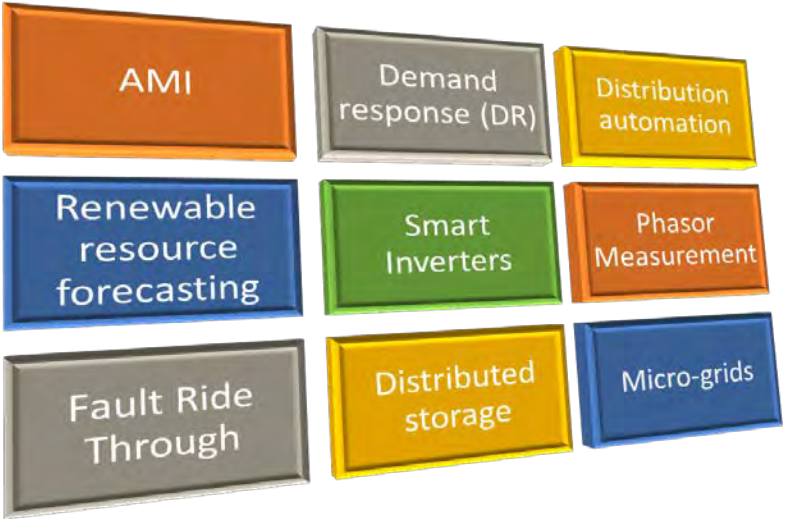
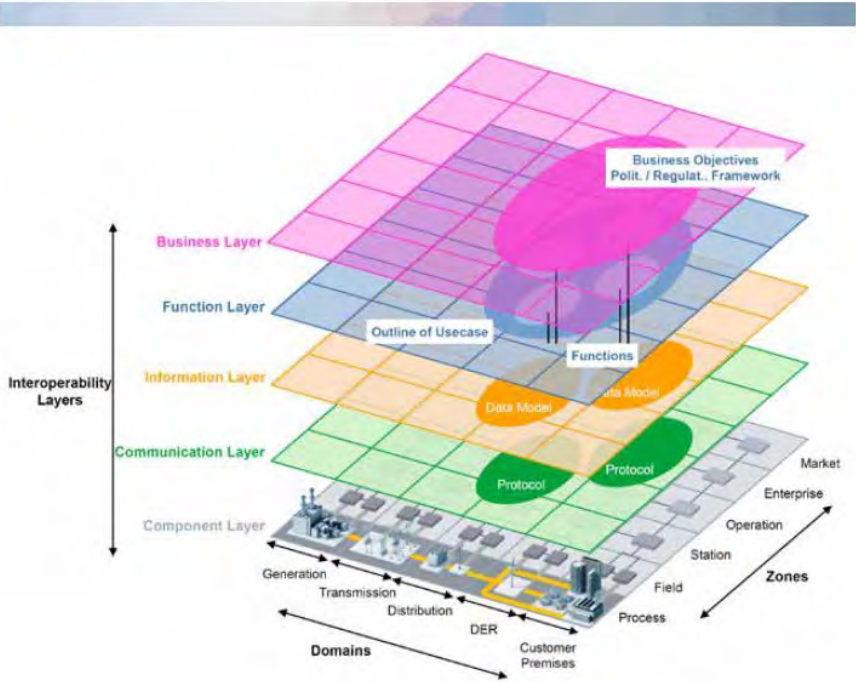
Intelligent networks and markets



An expanding range of new energy technologies and services are supported while continuing to efficiently provide a range of traditional electricity services. Advanced network planning, operation and intelligence systems ensure the safe and efficient integration of large scale renewable generation, hundreds of microgrids and millions of customer DERs. Market-based mechanisms reward customers with DERs for providing network-support services, orchestrated either directly or by other market actors

Key Findings – Grid Transformation

Figure 23: Smart Grid Architecture Model (SGAM)



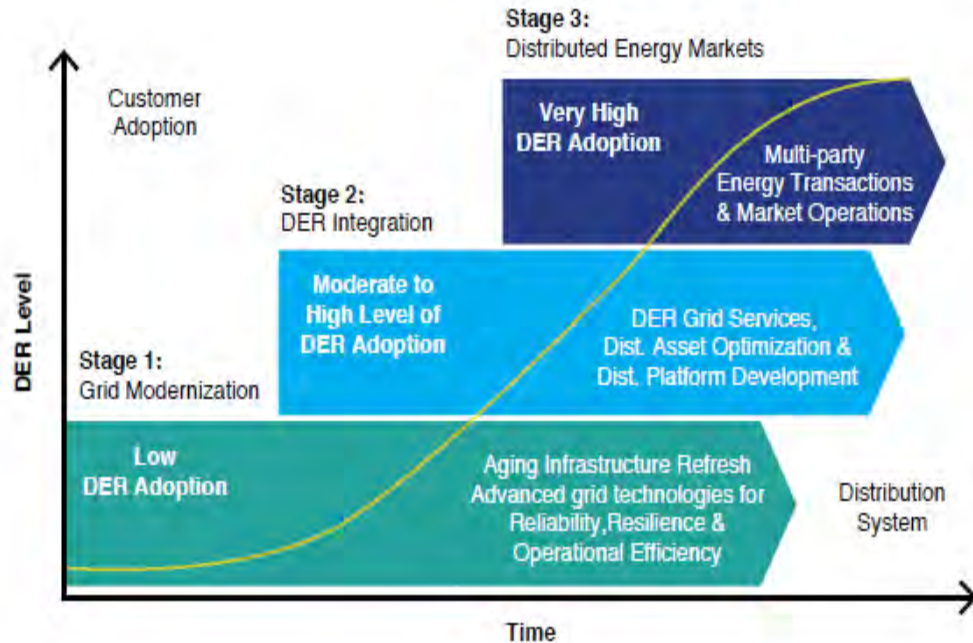
2017-27 Grid Transformation: Milestones and Actions



- Milestone 1: Communication Protocols between networks and distributed energy resources support coordination in real time (2018)**
- Milestone 2: Advanced network planning models & DER valuation methods (2019)**
- Milestone 3: Distributed grid intelligence and control architectures (2019)**
- Milestone 4: Advanced network operations including DER visibility (2020)**

Key Findings – Network Optimisation and Platforms

Figure 27: Three Stages of Distribution System Transformation (De Martini)



Key Technical Enablers

1. Standards

2. Future Workforce Requirements

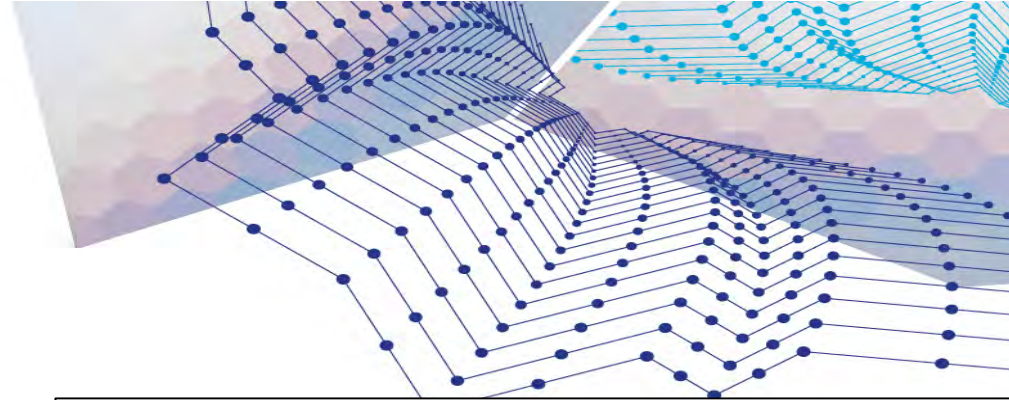


Figure 28: Snapshot of the current state of Australian standardisation

OVERVIEW OF TOPIC AREAS

MARKET SYSTEMS AND OPERATIONS

Market Systems	Electrical System Operation
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GOVERNANCE AND SERVICES

Asset management	Security	Cyber Security	Critical Infrastructure Resilience	Terminology
------------------	----------	----------------	------------------------------------	-------------

GENERATION: DISTRIBUTED AND CENTRALISED

General Generation	Solar	Marine	Wind	Hydro	Thermal Power Plants
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TRANSMISSION AND DISTRIBUTION

Substations	Switchgear	Transformer	Protection Relays	Cable and LinesOverhead	Grid Size Energy Storage	Distributed Energy Coordination
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PROSUMERS

Building Management System	Customer Energy Management	Process Automation Systems	Demand Response Management Equipment	Advanced Metering	Local Energy Storage
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Electric Vehicles	Inverters	Microgrids
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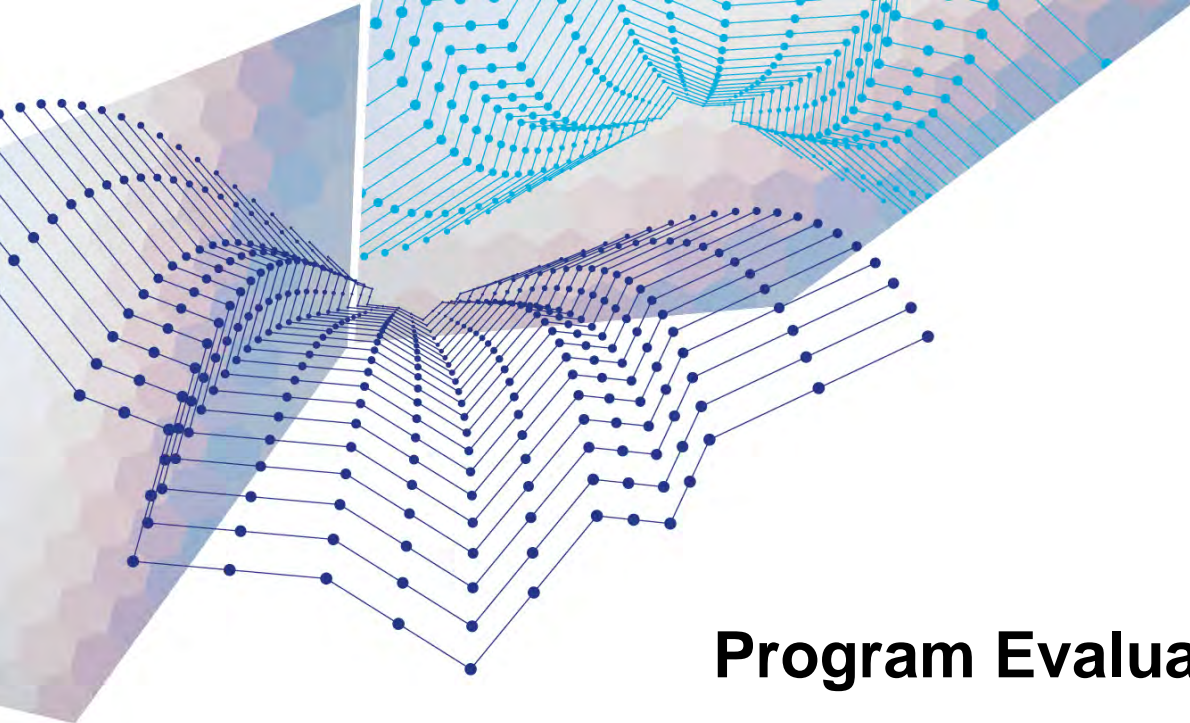
SUPPORTING TECHNOLOGIES

Communications	Electromagnetic Compatibility	Power Quality
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DATA

Frameworks	Privacy
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- Identified as in need of urgent work or broader participation
- Identified as in need of work
- Identified as lack of Australian activity, but consensus for work not clear
- Current Work Underway or Active Committee with broad representation
- No clear status identified or discussed



ELECTRICITY NETWORK TRANSFORMATION ROADMAP

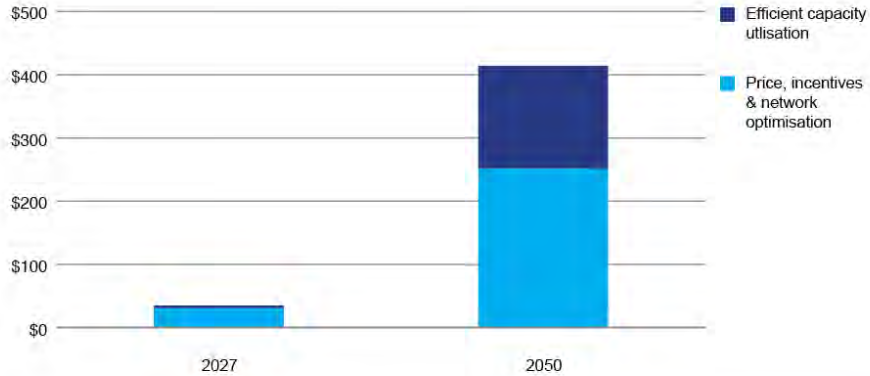
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Program Evaluation and Benefits

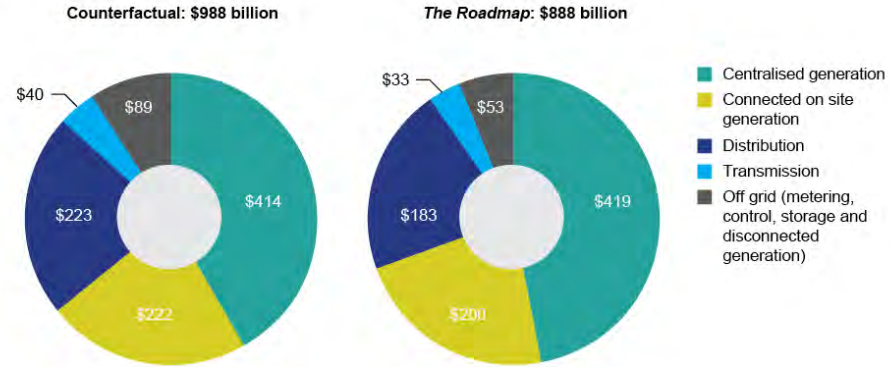


Comparing the roadmap Outcomes

Projected savings in average residential bills under the roadmap scenario







Cumulative electricity system total expenditure to 2050 – Roadmap & counterfactual

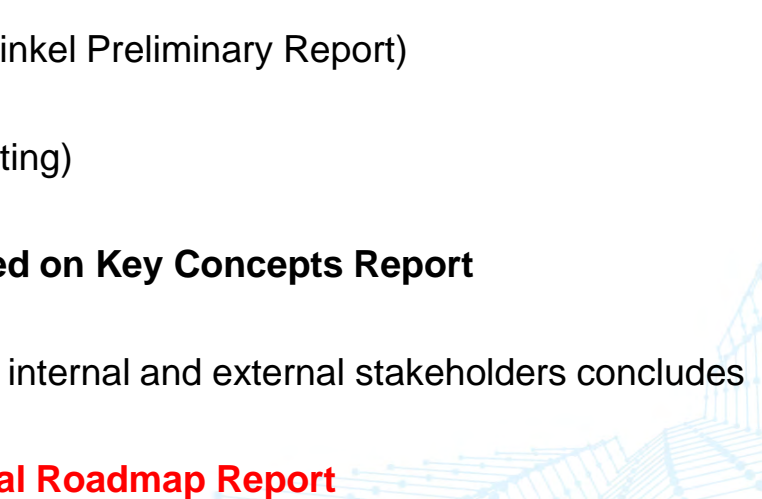


Comparing the Roadmap Outcomes

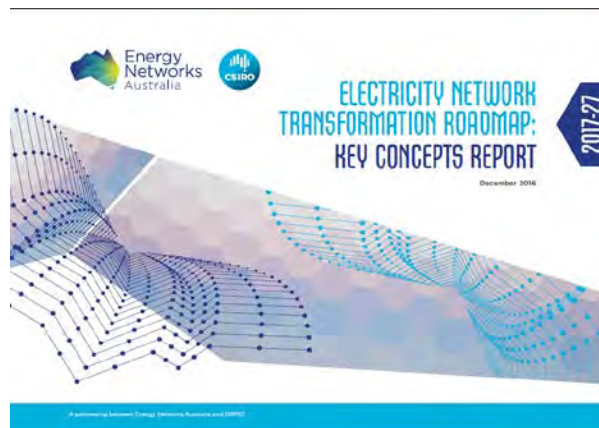
Figure 6: Residential bill outcomes for selected Australian household types in 2050 under the counterfactual and *Roadmap* scenarios

	Counterfactual			<i>The Roadmap</i>		
	Active \$	Passive \$	The Gap \$	Active \$	Passive \$	The Gap \$
Working Couple 	\$1,346	\$1,811	\$465	\$1,123	\$1,422	\$299
Medium Family 	\$1,816	\$2,601	\$785	\$1,428	\$1,988	\$560
Large Family 	\$2,794	\$3,950	\$1,156	\$2,346	\$2,734	\$288
Single, Retired 	\$1,058	\$1,730	\$672	\$883	\$1,355	\$472

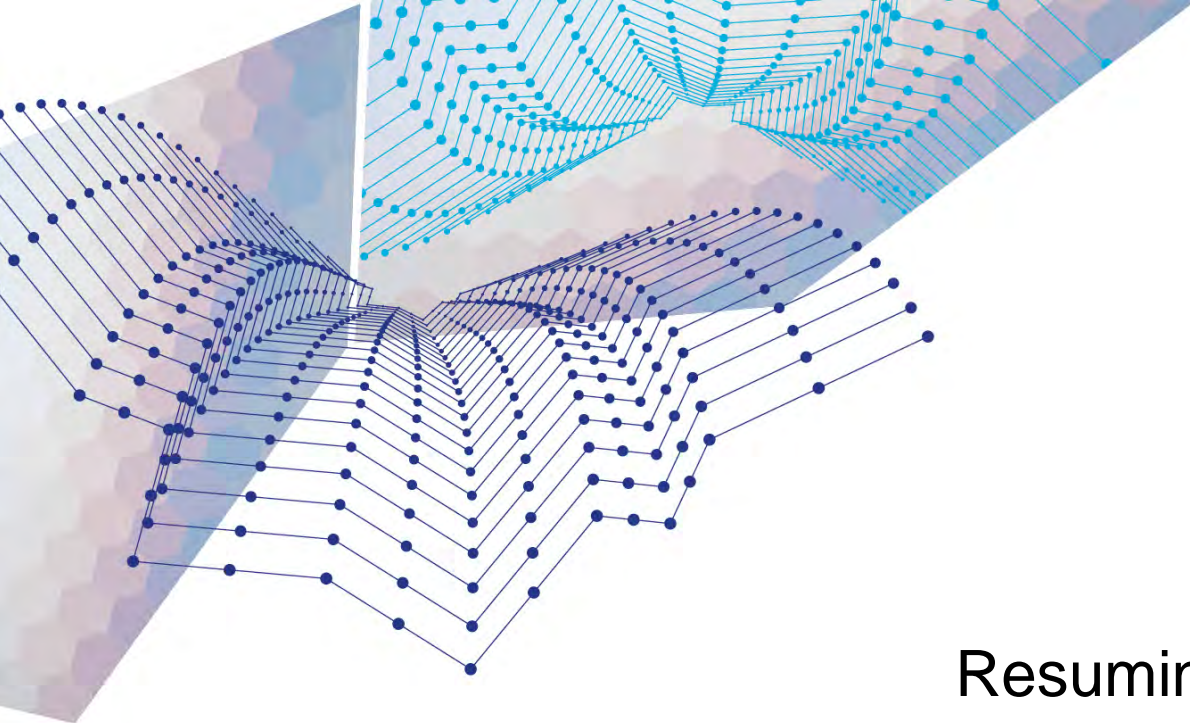
Next Steps -

- 6 Dec 2016** **Public launch of *Key Concepts Report and Roadmap Overview***
 - 9 Dec 2016** (COAG meeting considers Finkel Preliminary Report)
 - 14 Dec 2016** (COAG Energy Council Meeting)
 - 16 Feb 2017** **Written Feedback requested on Key Concepts Report**
 - 28 Feb 2017** Consultation period with key internal and external stakeholders concludes
 - 31 Mar 2017** **Delivery and launch of Final Roadmap Report**
- 

Feedback & Discussion



<http://www.energynetworks.com.au/roadmap-publications>



ELECTRICITY NETWORK TRANSFORMATION ROADMAP

2017-27

Morning Tea
Resuming at 11.30 (AEDT)





Energy Network Transformation Roadmap Key Concepts Report Launch

Steven Graham
Board Director
Energy Consumers Australia
6 December 2016

Energy
Consumers
Australia



ECA objective

To **promote the long term interests of consumers of energy with respect to the price, quality, safety, reliability and security of supply** of energy services by providing and enabling strong, coordinated, collegiate evidence based consumer advocacy on National Energy Market matters of strategic importance or material consequence for Energy Consumers, in particular Residential Customer and Small Business Customers.

The NTR vision

1. Consumers calling the shots.
2. Networks providing the security of a grid connection and a platform for an array of new energy services.

From the *Death Spiral* to more positive and productive territory:

- How do we innovate?
- How do we create and capture value for consumers and businesses?
- How do we optimize the overall efficiency of an increasingly dynamic and complex system?



The challenge from here

Energy
Consumers
Australia

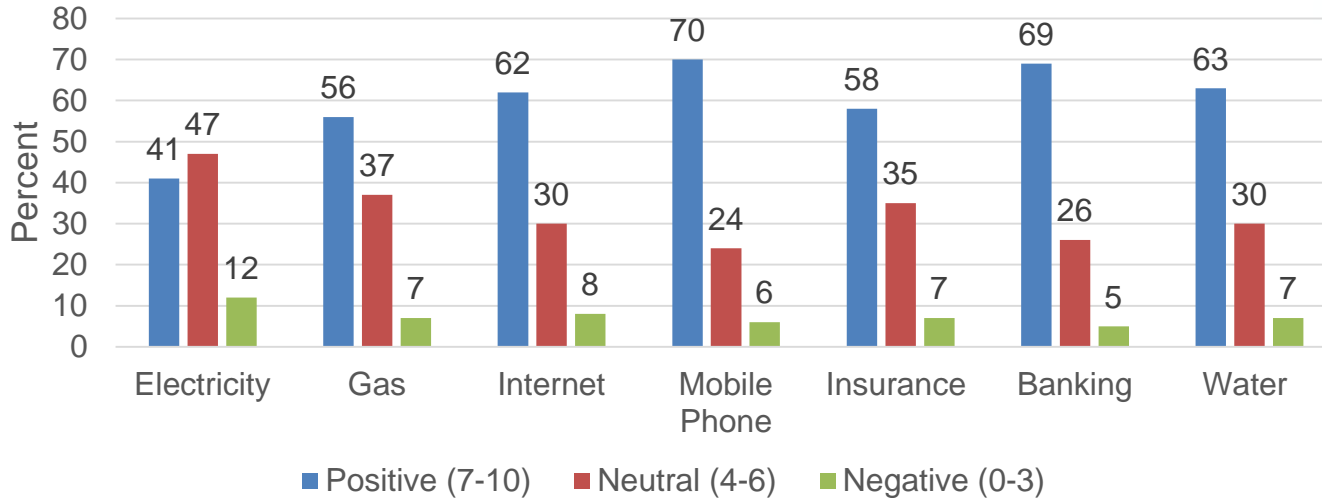
In a sense consumers are becoming regulators. If we don't understand the power of the consumer, business models will be blown out of the water.

Jennifer Westacott, Chief Executive
Business Council of Australia



Am I getting value for money?

Energy
Consumers
Australia



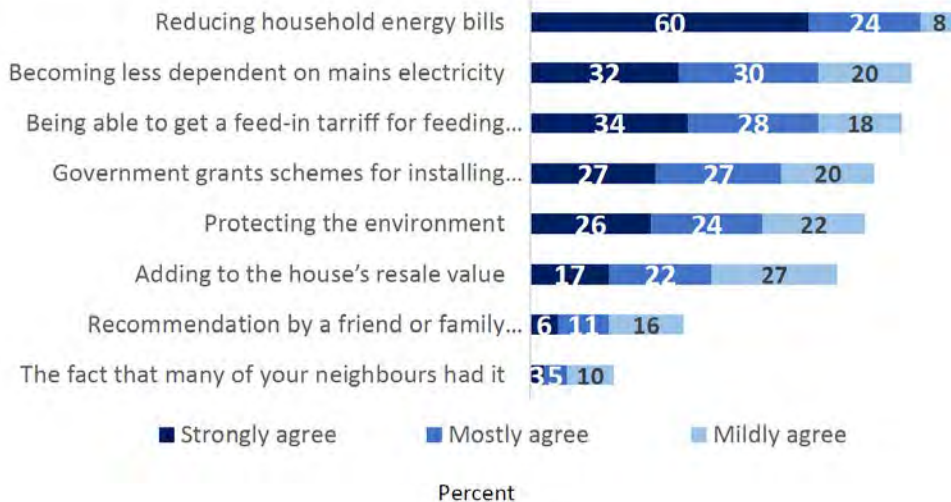
Source: Energy Consumers Australia, Energy Consumer Sentiment Survey, December 2016 (to be released in January 2017).

Energy consumers think they get less “value for money” from electricity services than from insurance, banking, water, internet and mobile phone services.



Reduce my costs and give me control

How much have following factors contributed to your decision to install a solar electricity system?



Source: ECA's (forthcoming) research of the experiences of 1800 consumers that have invested in solar.

From litigation to engagement and innovation

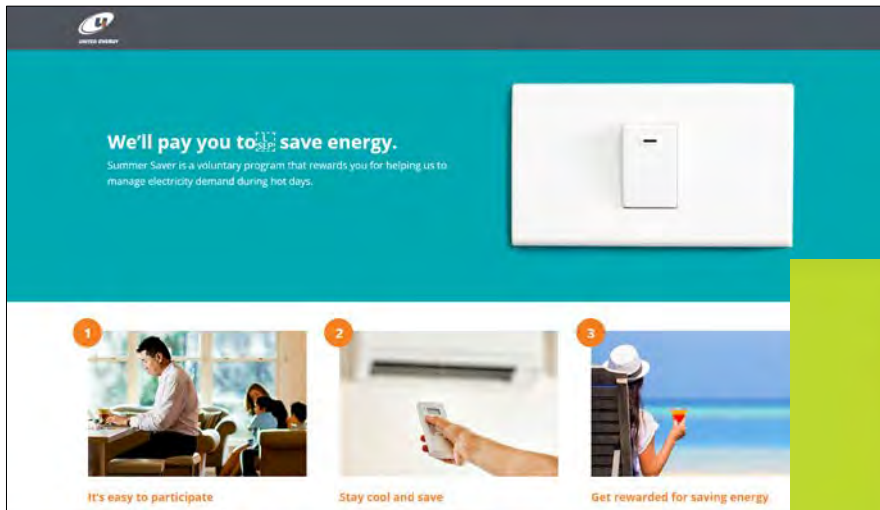
Energy
Consumers
Australia

Engage early and innovate to align interests rather than falling back on regulatory or legal solutions.



From trials to BAU

Energy
Consumers
Australia

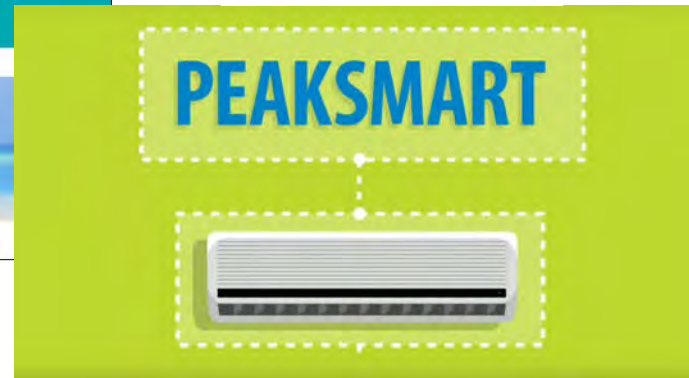


We'll pay you to save energy.
Summer Saver is a voluntary program that rewards you for helping us to manage electricity demand during hot days.


1 It's easy to participate

2 Stay cool and save

3 Get rewarded for saving energy

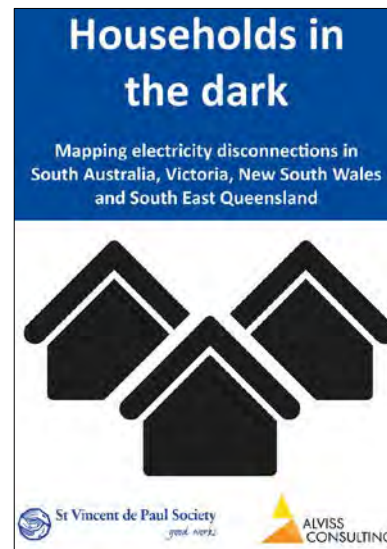


PEAKSMART



Working together

Energy
Consumers
Australia



Towards NEM 2.0 in a crowded landscape

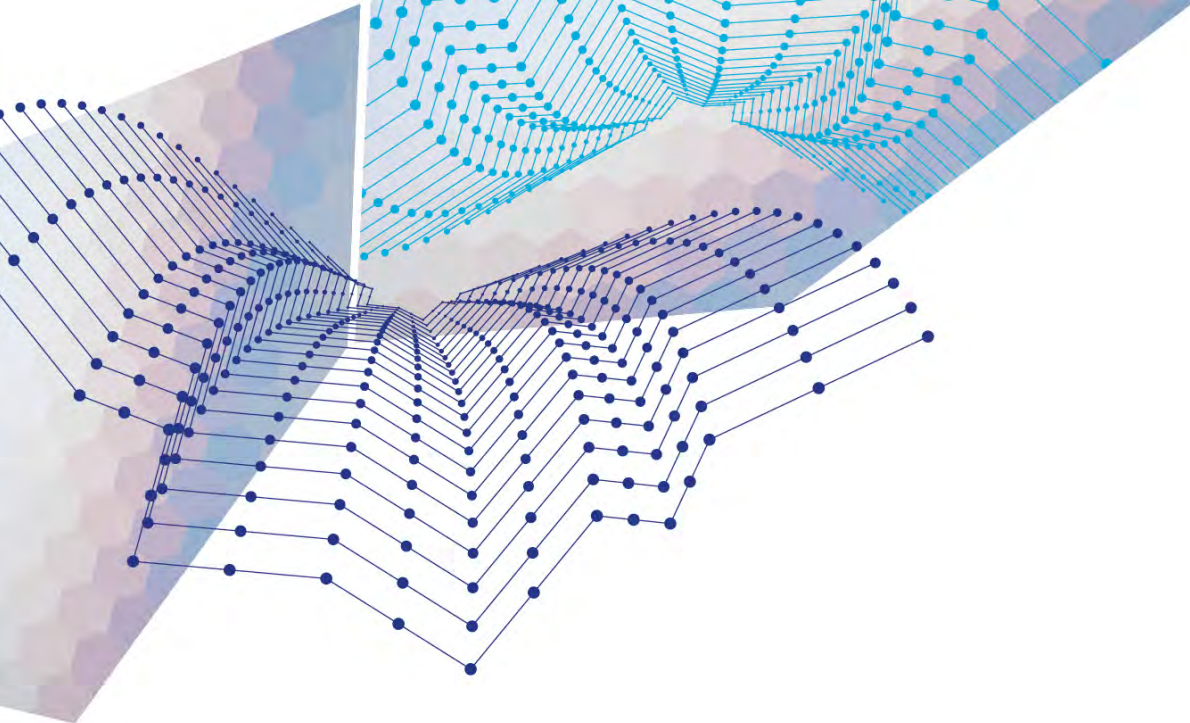
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Thank you

Energy
Consumers
Australia





ELECTRICITY NETWORK TRANSFORMATION ROADMAP

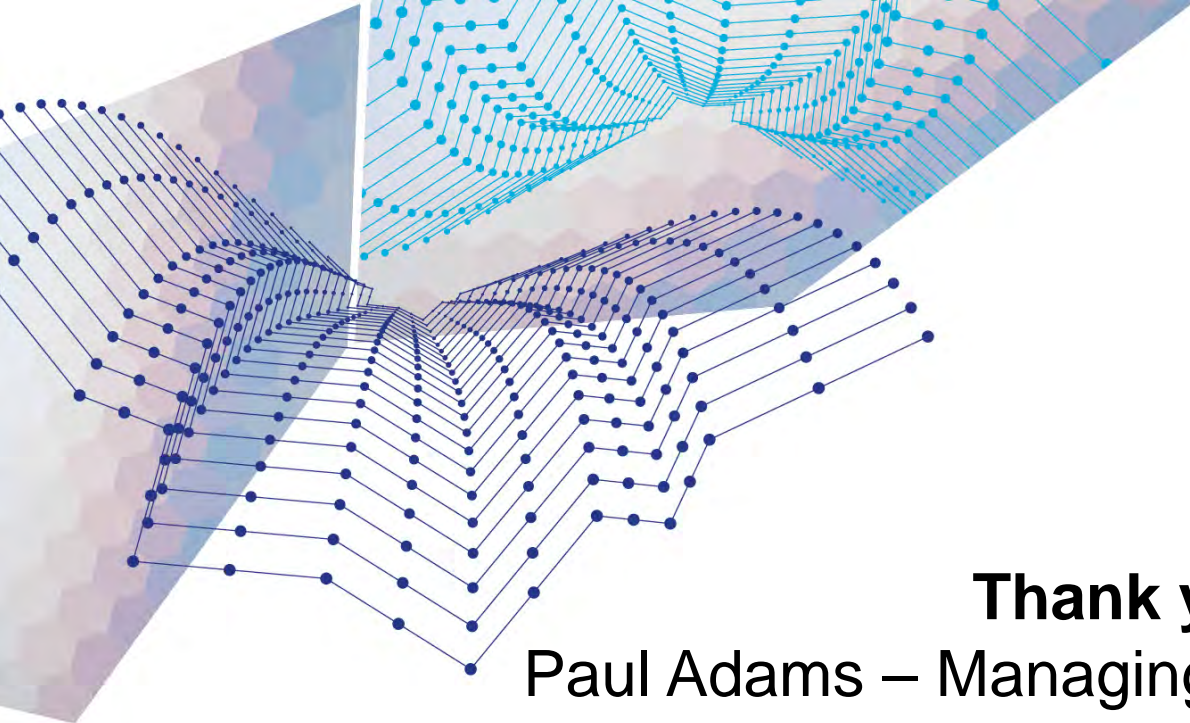
2017-27

Panel Discussion



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ELECTRICITY NETWORK TRANSFORMATION ROADMAP

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Thank you & Next steps:
Paul Adams – Managing Director, Jemena



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