Integrating microgrids into communities: socioeconomic and technical considerations

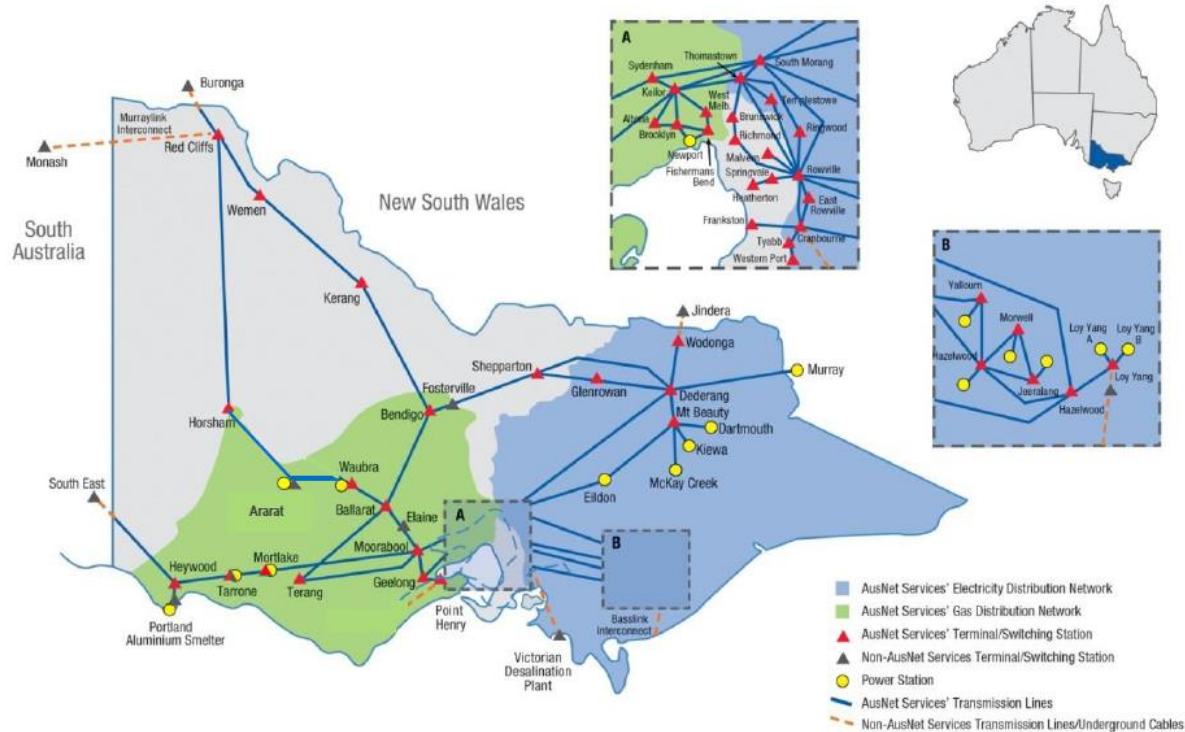## University of Melbourne &
International Institute for Energy Systems Integration

Justin Harding, Network Intelligence

21 March 2017

Who we are

Electricity Transmission
- 6,571km of transmission lines
- 13,000 towers

Electricity distribution
- 51,746km of electricity distribution network
- 698,648 customers

Gas distribution
- 10,993km of gas distribution network
- 668,899 customers

Transformation trends behind microgrids

▶ **Electricity sector undergoing exciting and unprecedented change**

▶ **Uncertainty is high but trends are evident and are inter-related**

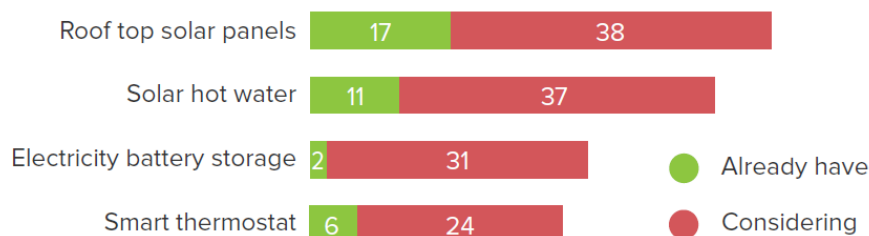Shift to decentralised energy

Shift to low carbon energy sources

Customers moving from literacy to empowerment

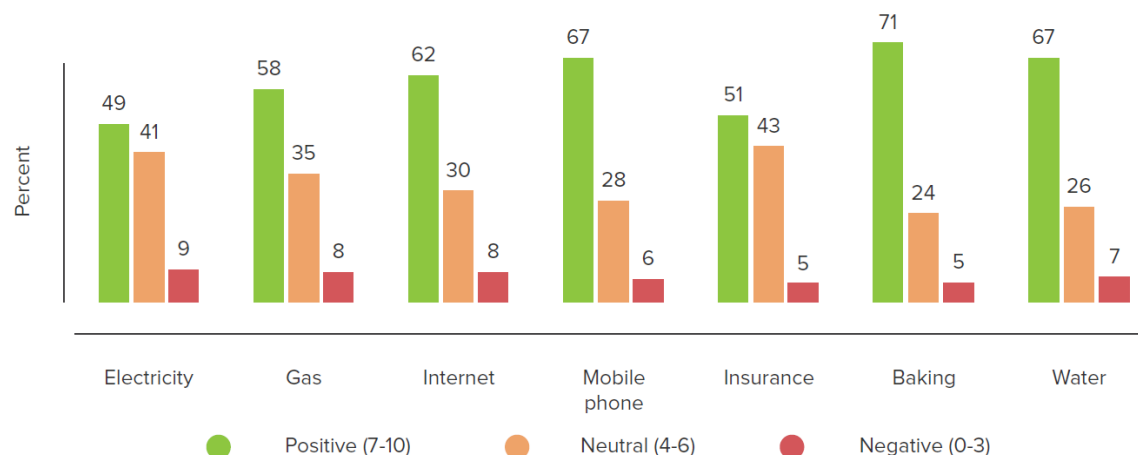Digital platforms & big data analytics

Driver 1: Customers

▸ **More customers are wanting to take charge of their energy needs, and expect AusNet Services to assist.**

› Strong interest in new technology

	Already have	Considering
Roof top solar panels	17	38
Solar hot water	11	37
Electricity battery storage	2	31
Smart thermostat	6	24

› Low value perception of retail electricity:

	Positive (7-10)	Neutral (4-6)	Negative (0-3)
Electricity	49	41	9
Gas	58	35	8
Internet	62	30	8
Mobile phone	67	28	6
Insurance	51	43	5
Baking	71	24	5
Water	67	26	7

Percent

Reference: Energy Consumers Australia, Energy Consumer Sentiment Survey, July 2016 - Victoria
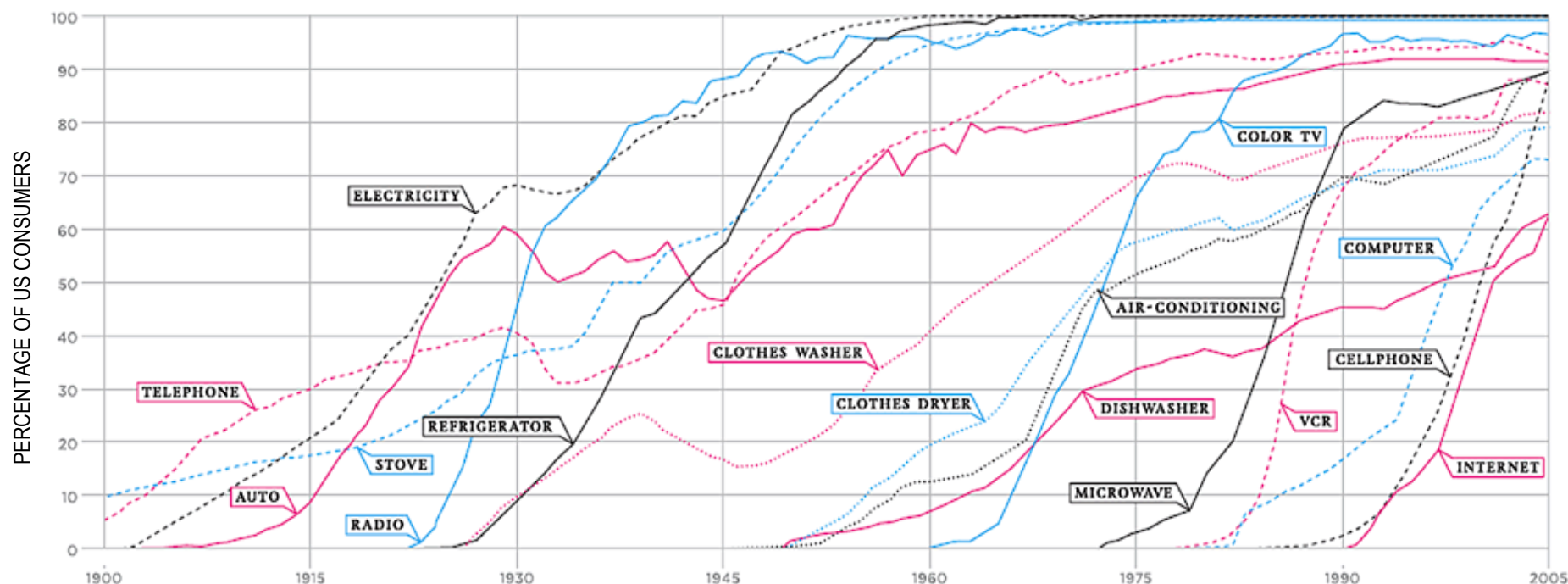
Driver 1: Customers

▶ **Energy technologies are becoming real consumer products**
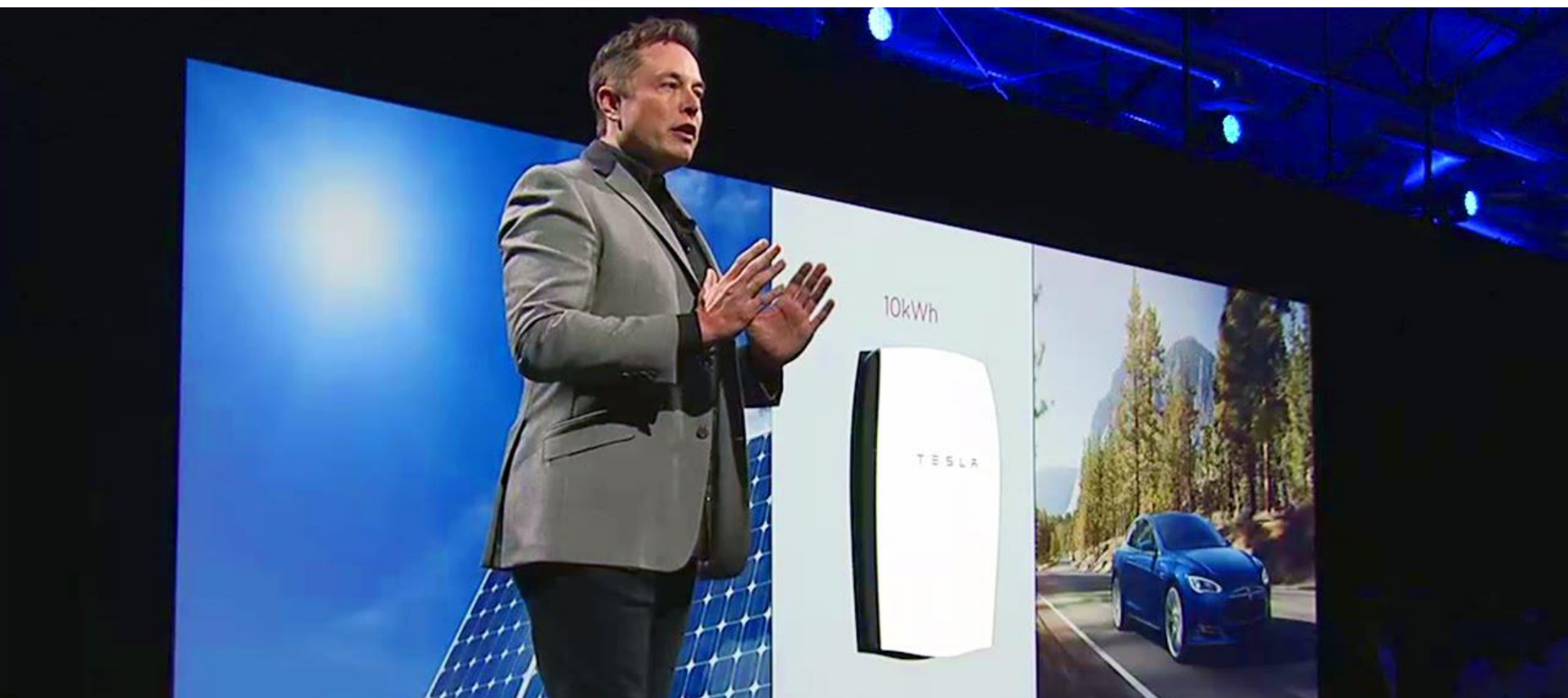
Driver 1: Customers

▸ **Customer uptake of technology uptake can be fast and unanimous**
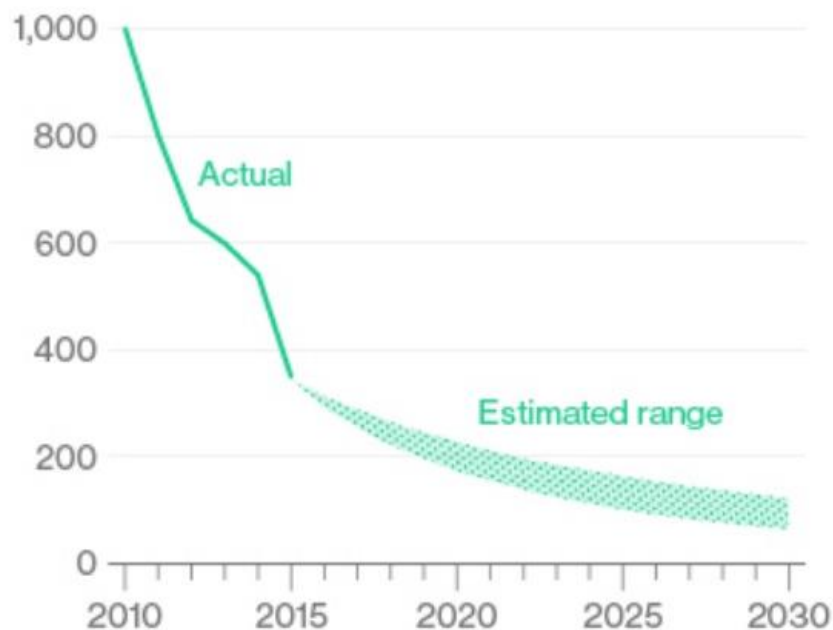

Reference: New York Times, http://www.nytimes.com/imagepages/2008/02/10/opinion/10op.graphic.ready.html

Driver 2: Technology

▸ **Technology costs can plummet**

Cost for lithium-ion battery packs

$1,200 per kilowatt hour

Actual

Estimated range

Yearly demand for EV battery power

800 gigawatt hours

Estimates

Actual

Source: Data compiled by Bloomberg New Energy Finance

Bloomberg
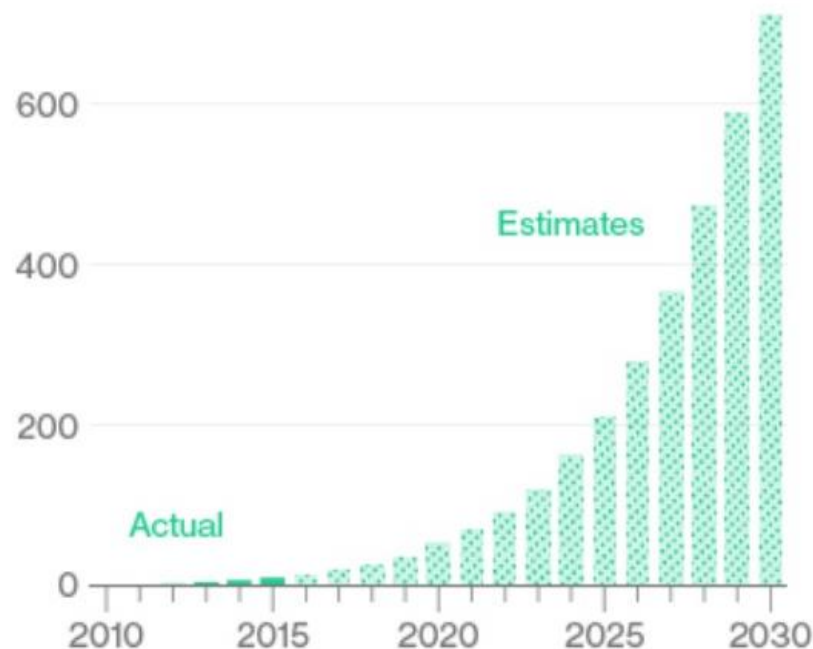
Driver 2: Technology

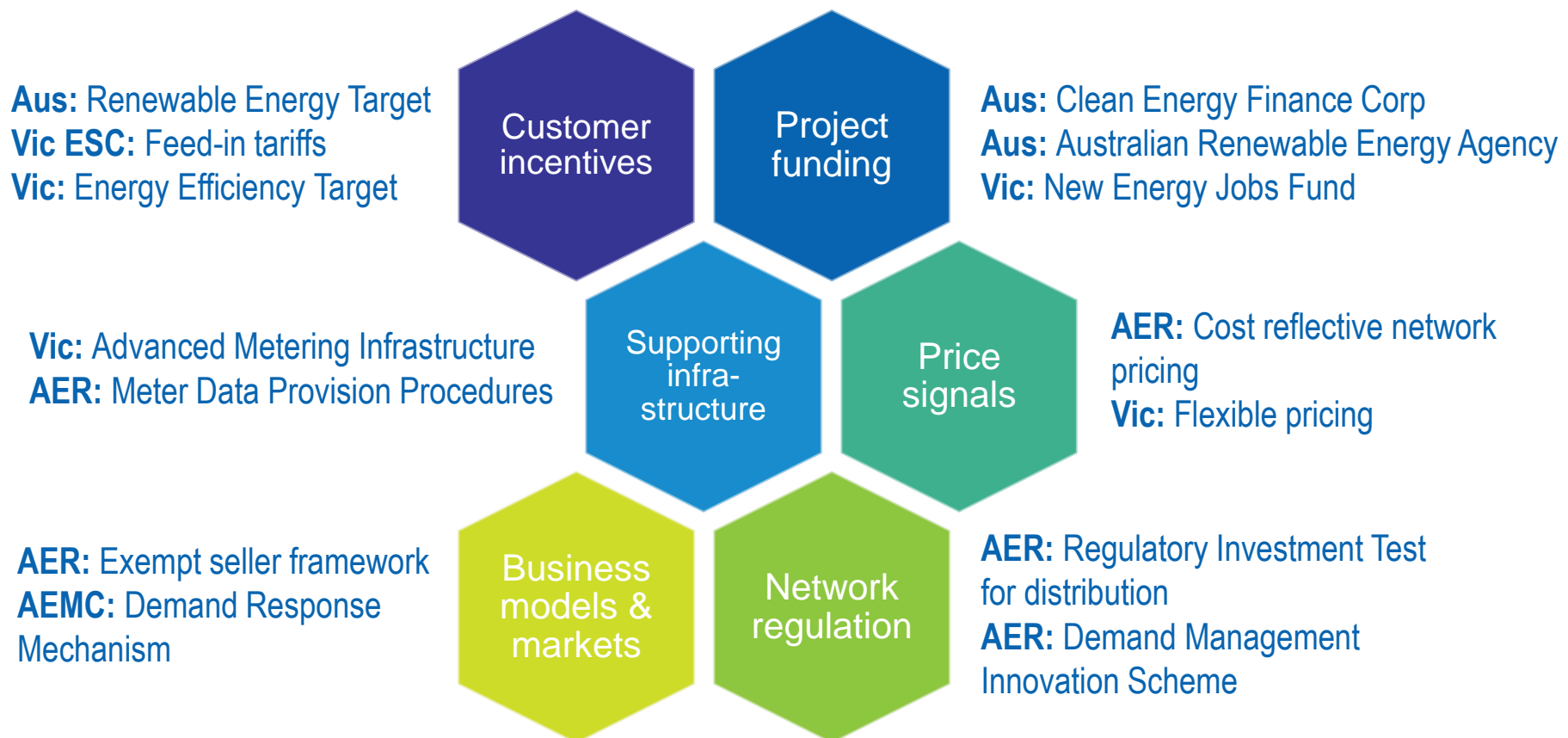▸ **Digital platforms can facilitate and leverage decentralised energy**

Driver (or handbrake) 3: Regulation & policy

▶ **No shortage of DER policy reforms, but fundamental issues exist**

Aus: Renewable Energy Target
Vic ESC: Feed-in tariffs
Vic: Energy Efficiency Target

Customer incentives

Project funding

Aus: Clean Energy Finance Corp
Aus: Australian Renewable Energy Agency
Vic: New Energy Jobs Fund

Vic: Advanced Metering Infrastructure
AER: Meter Data Provision Procedures

Supporting infra-structure

Price signals

AER: Cost reflective network pricing
Vic: Flexible pricing

AER: Exempt seller framework
AEMC: Demand Response Mechanism

Business models & markets

Network regulation

AER: Regulatory Investment Test for distribution
AER: Demand Management Innovation Scheme

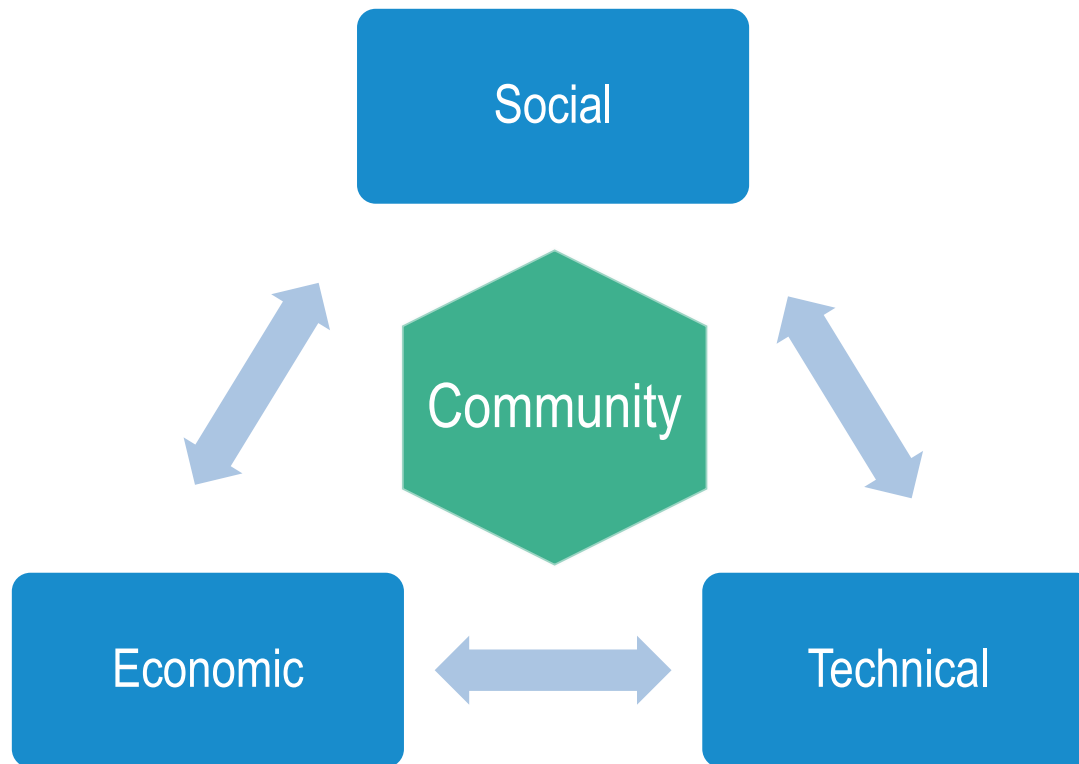# Where will this take us?

▶ **Energy forecasts are uncertain – but microgrids and community energy projects are a growing force**
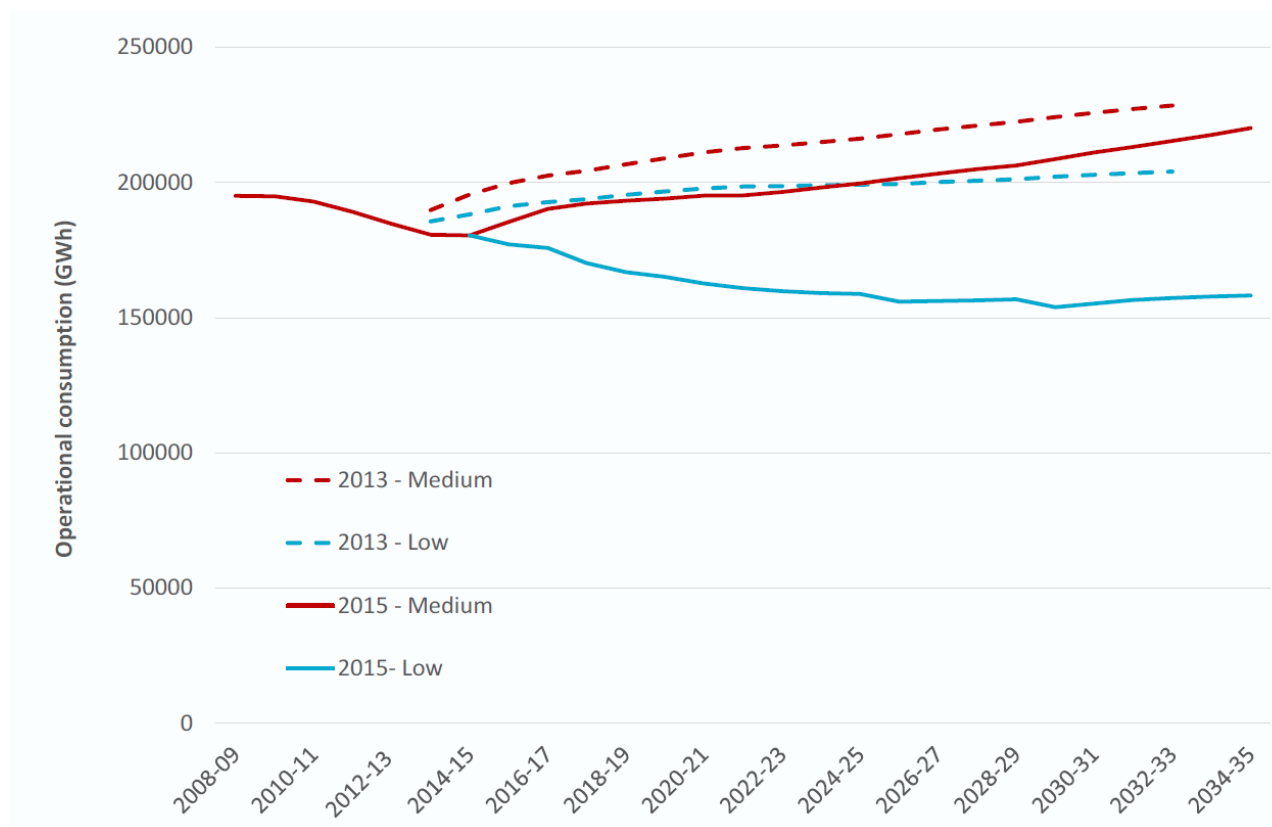
Reference: Australian Energy Market Operator, 2015
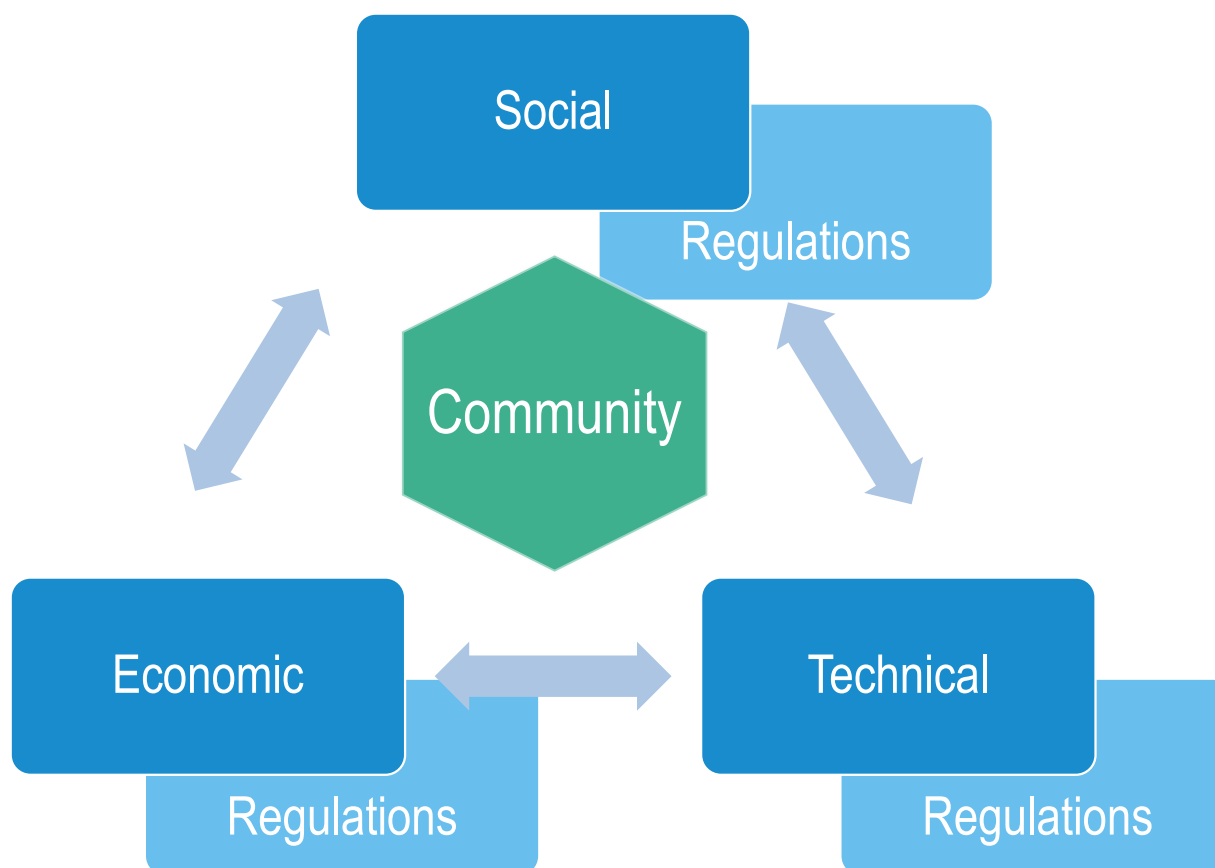
The microgrid integration challenge

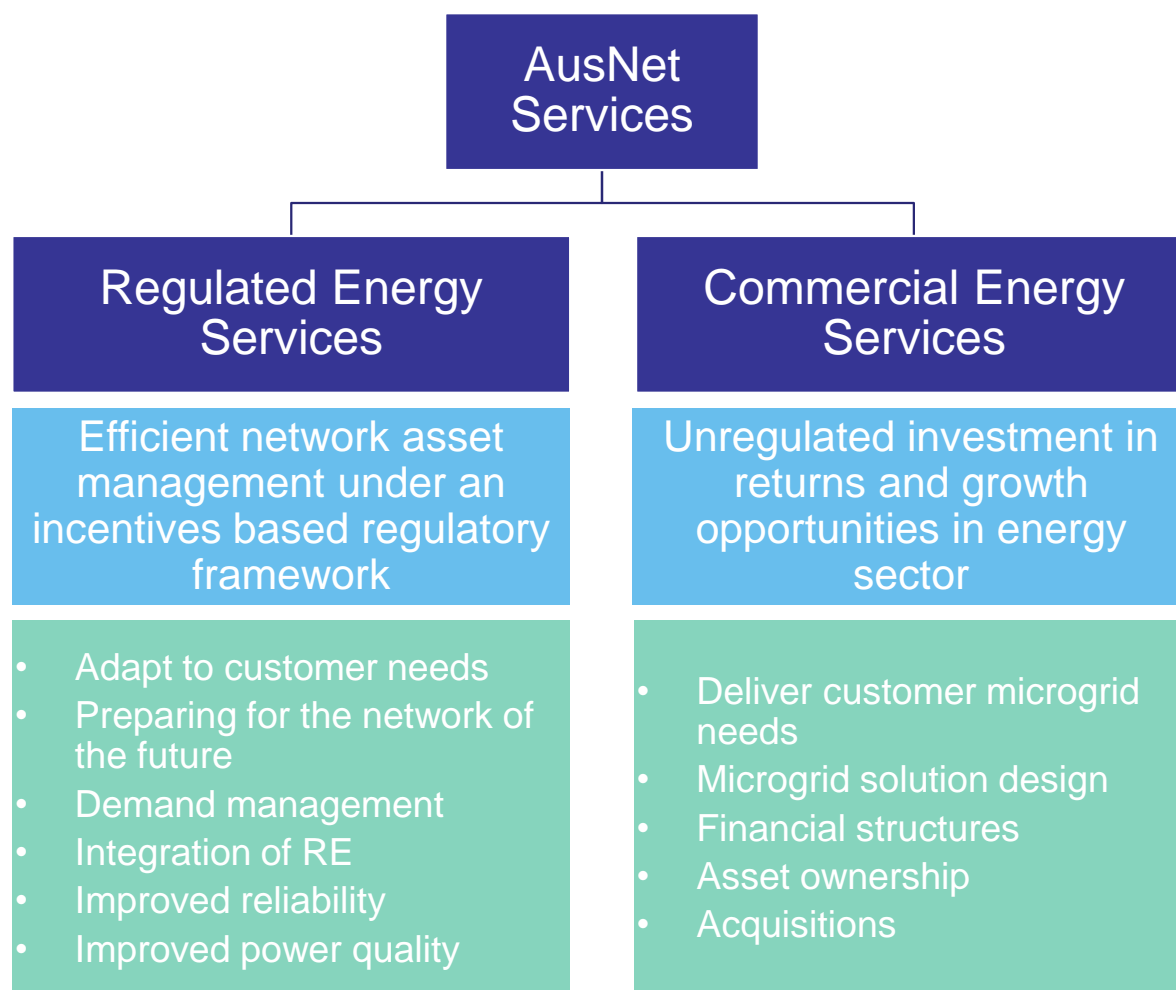▶ **For success, a microgrid has to integrate on three inter-related levels**

The microgrid integration challenge

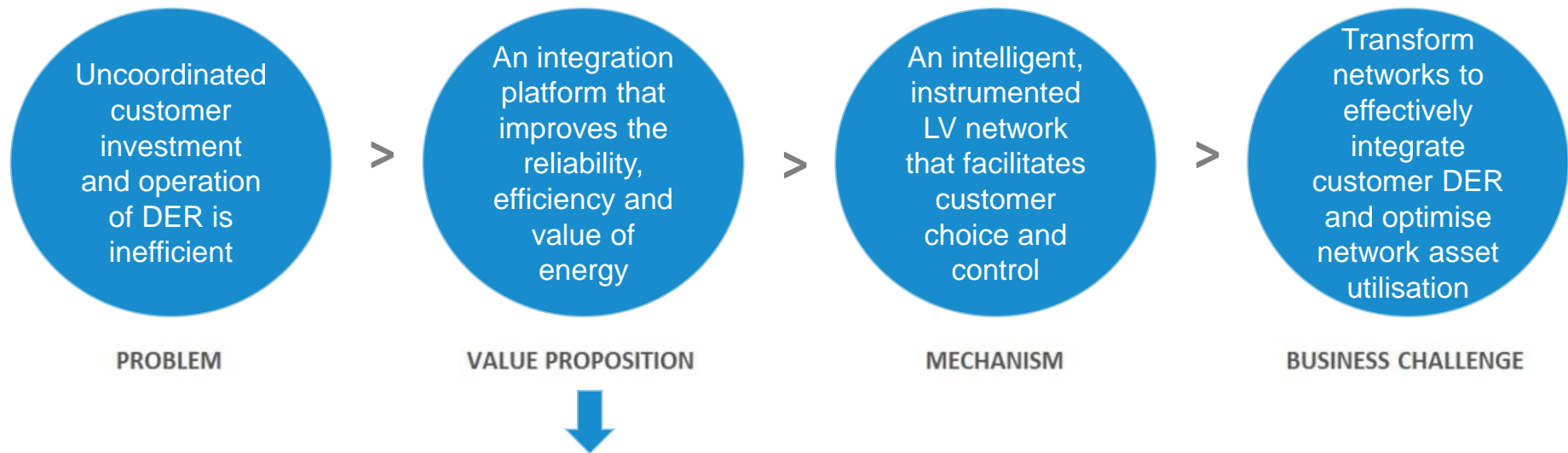▸ **Regulations play a major role in each integration level**

AusNet Services' perspective

AusNet Services

Regulated Energy Services

Efficient network asset management under an incentives based regulatory framework

- Adapt to customer needs
- Preparing for the network of the future
- Demand management
- Integration of RE
- Improved reliability
- Improved power quality

Commercial Energy Services

Unregulated investment in returns and growth opportunities in energy sector

- Deliver customer microgrid needs
- Microgrid solution design
- Financial structures
- Asset ownership
- Acquisitions

Regulated Network Strategy: the Distribution System Operator

- **Base assumption:** We will have a high DER future

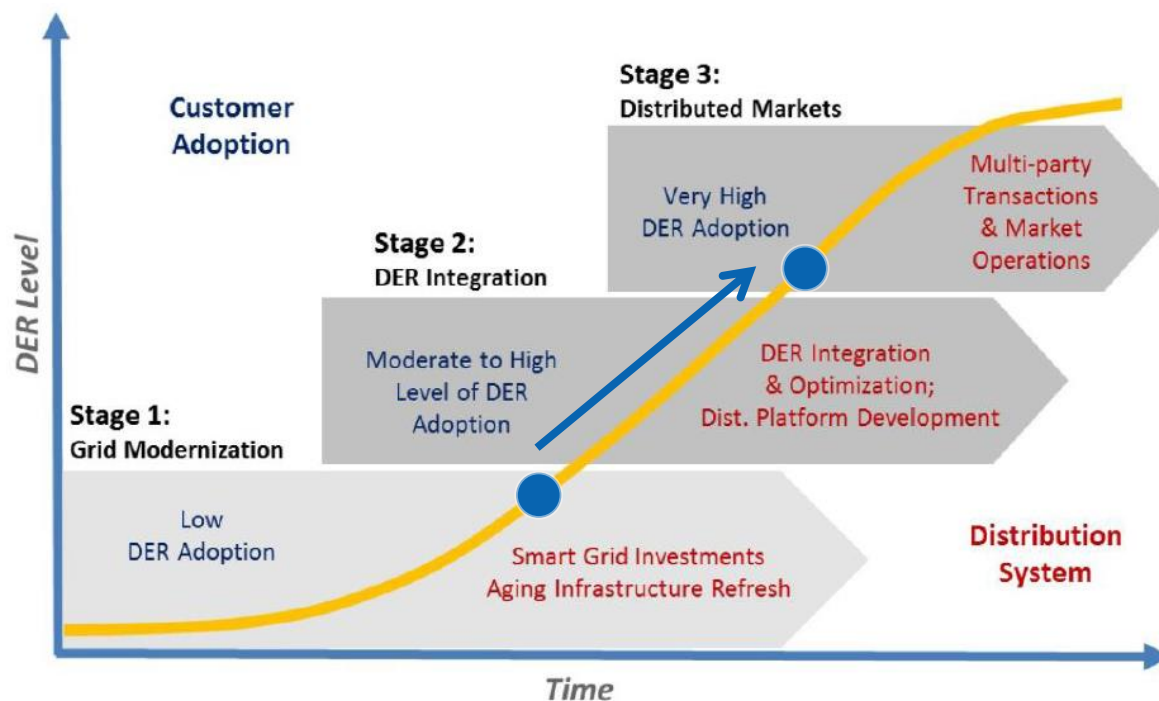| Uncoordinated customer investment and operation of DER is inefficient	>	An integration platform that improves the reliability, efficiency and value of energy	>	An intelligent, instrumented LV network that facilitates customer choice and control	>	Transform networks to effectively integrate customer DER and optimise network asset utilisation
PROBLEM		VALUE PROPOSITION		MECHANISM		BUSINESS CHALLENGE

Customer value

- **Direct value:** Reduced costs, increased choice, access value streams

  - **Network value:** Efficient asset investment, increased network flexibility & adaptability
  - **Energy market value:** Increased market diversity, resilience and competition

The emerging DSO opportunity

› Manages the network under high DER penetration
› Harnesses the value in dispersed DER through optimisation and control
› The Mooroolbark Mini Grid project is a glimpse into the future

FIGURE: Distribution system evolution

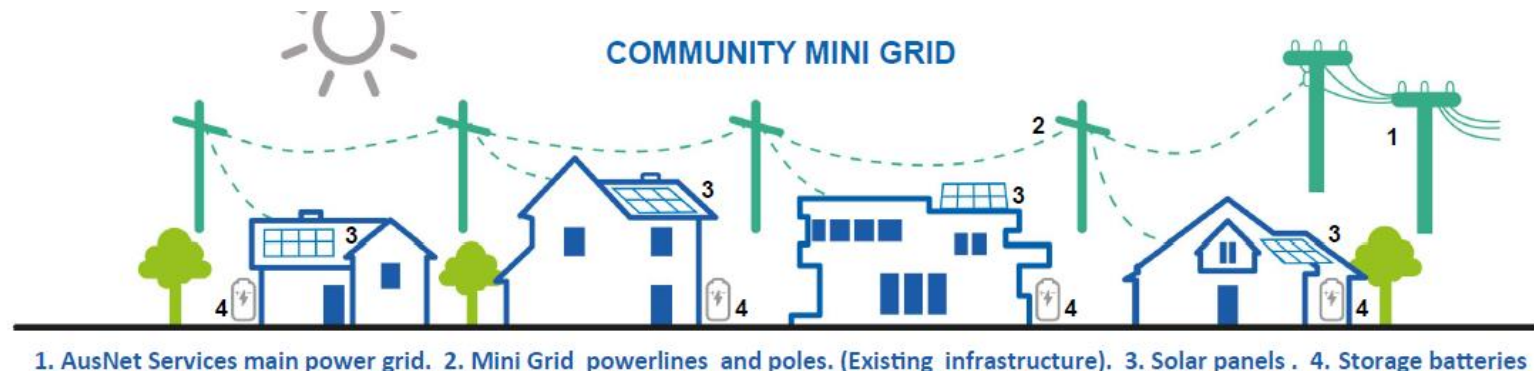*Ref: De Martini, P. & Kristov, L., Distribution Systems in a High Distributed Energy Resources Future: Planning, Market Design, Operation and Oversight, LBNL, 2015.*

Case Study 1: The Mooroolbark Mini Grid
Testing the DSO function in a Mini Grid construct

▸ **Mini Grid Trial objectives**

› Test the technical viability & understand challenges

› Understand the commercial value of DSO applications

▸ **Our Mini Grid definition:**

› Multiple interconnected customers and supply sources (generation or storage) that have a common point of connection to the main grid, but can **coordinate** supply & demand **separately** from the main grid

COMMUNITY MINI GRID

1. AusNet Services main power grid. 2. Mini Grid powerlines and poles. (Existing infrastructure). 3. Solar panels. 4. Storage batteries

Project Site
Mooroolbark CYN31 Feeder

Distribution
Transformer
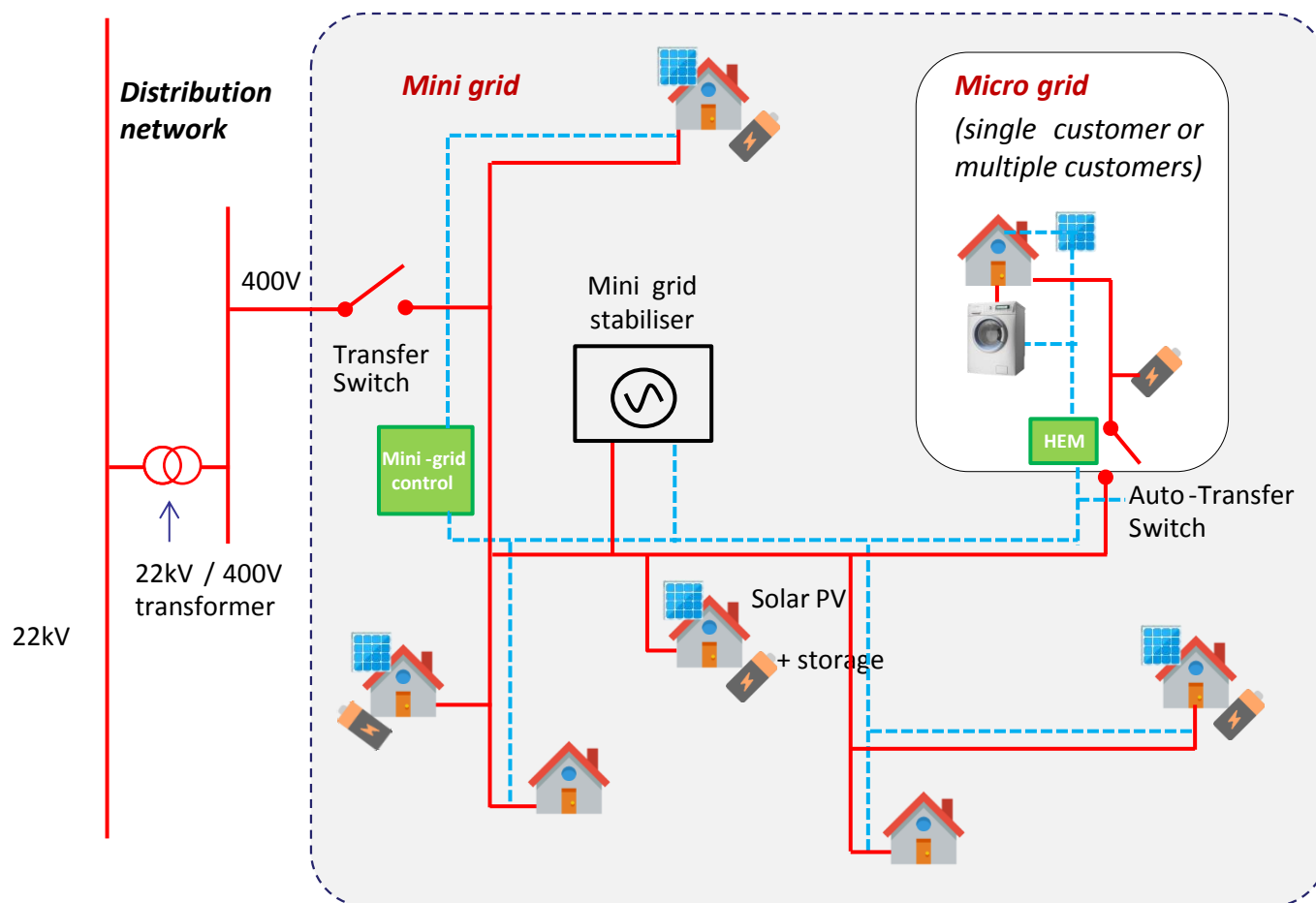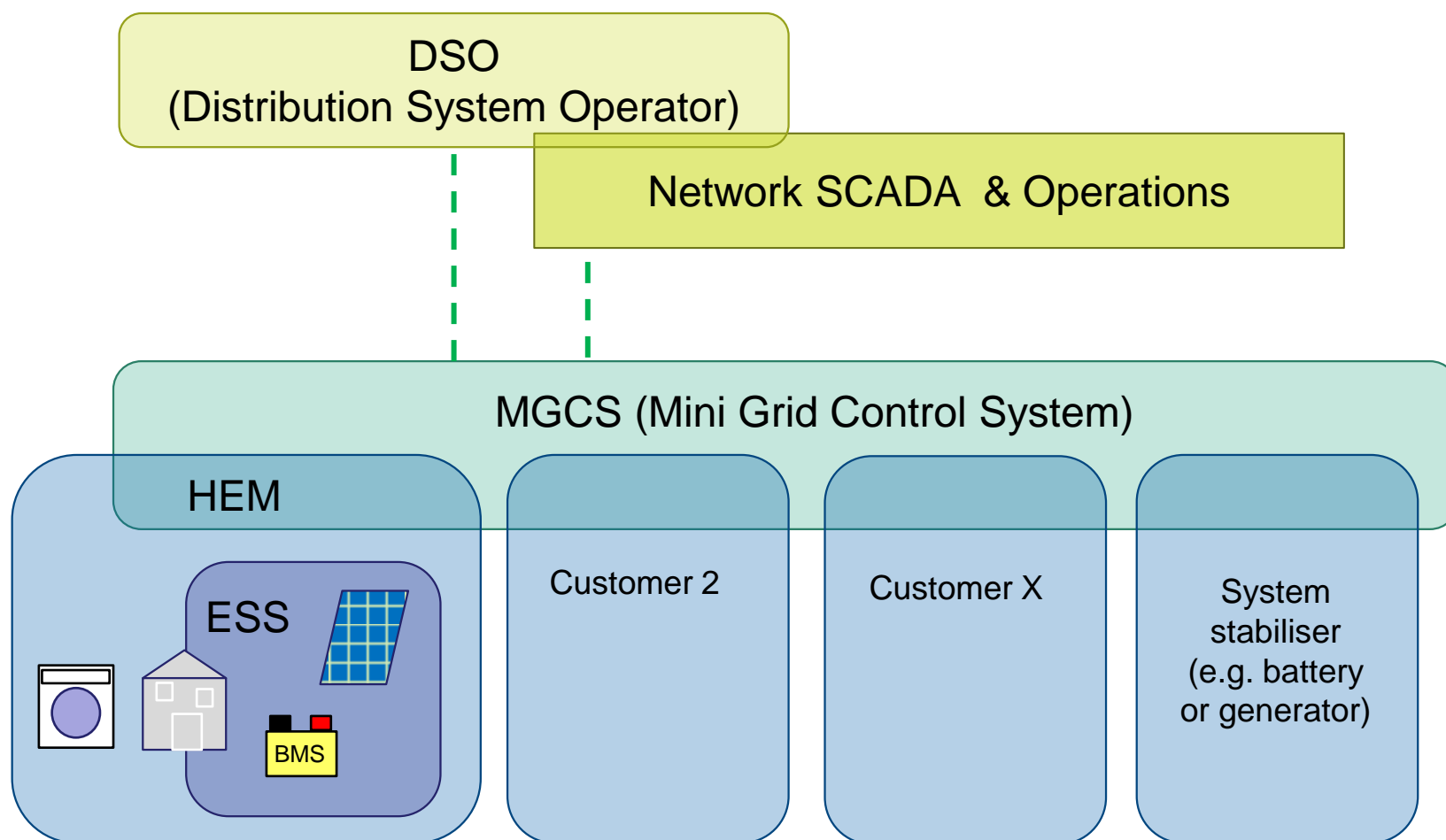22kV/400V

Trial site:
14 Participants

Mini Grid conceptual system design

Key attributes:

- *Customer preference*
- *Control*
- *Optimisation*
- *Services*
- *Islanding*
- *Exploits diversity*

Conceptual control design

DSO
(Distribution System Operator)

Network SCADA & Operations

MGCS (Mini Grid Control System)

HEM

ESS

BMS

Customer 2

Customer X

System
stabiliser
(e.g. battery
or generator)

Trial operating configurations

▶ **Test case 1: Grid connected (Normal mode)**
  › Most time spent in this configuration
  › Mini Grid is grid connected but can co-ordinate resources to:
    • Provide network support to grid
    • Optimise power within minigrid
    • Manage solar PV exports
    • Share power between customers, etc
    • Participate in energy markets

▶ **Test case 2: Home is islanded (UPS mode)**
  › Battery & PV provide backup supply to home

▶ **Test case 3: Minigrid is islanded (network of 16 customers)**
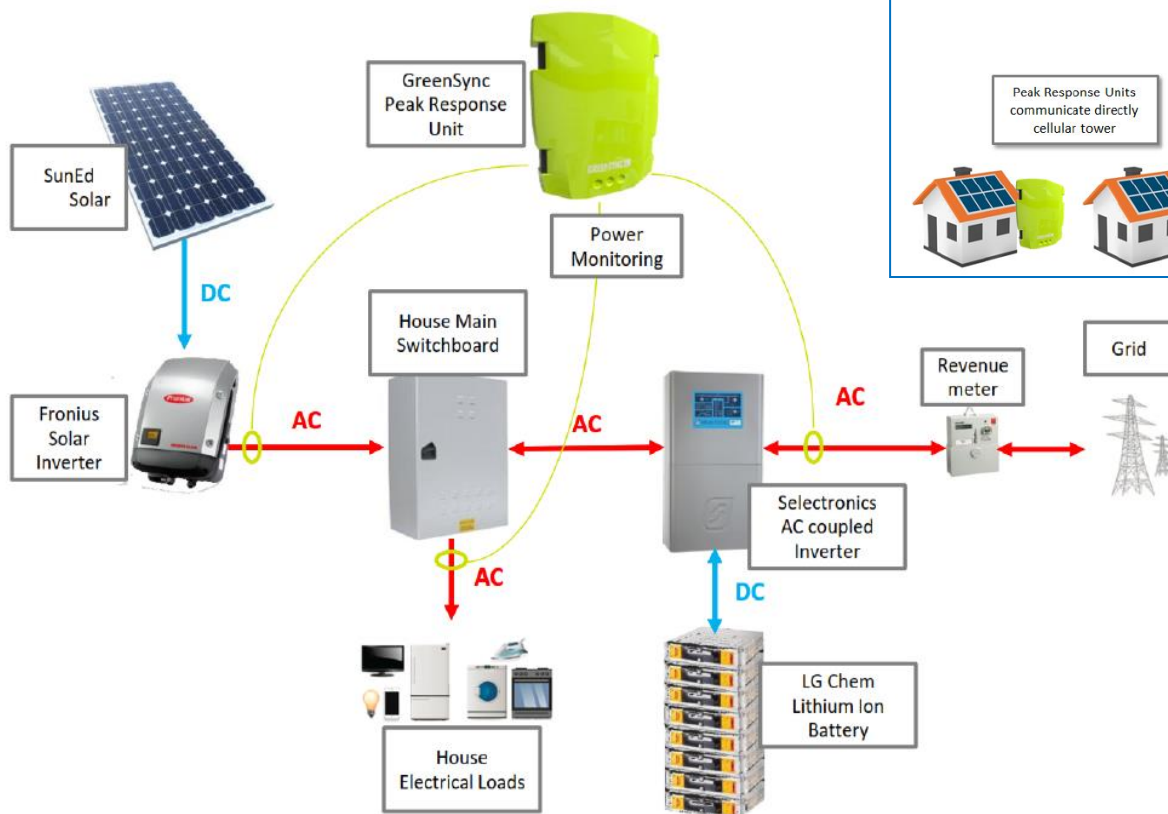 › Mini Grid disconnected from main grid, but minigrid LV remains energised

Distributed energy equipment

Distributed energy specs:
- *3kW+ PV: SunEdison & Fronius*
- *5kW Selectronic battery inverter*
- *10kWh LG Chem Li-ion batteries*
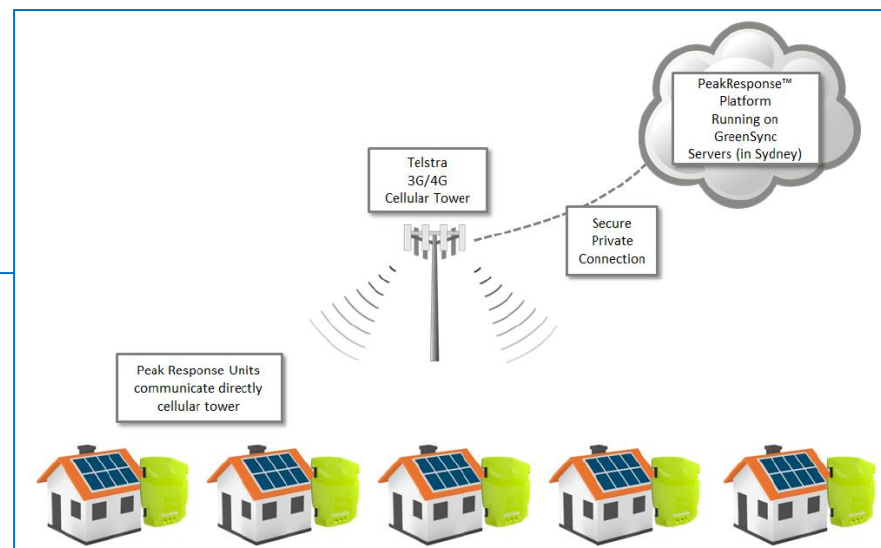
Control specs:
- *GreenSync 'Peak Response Unit' (RTU)*
- *4G comms*
- *GreenSync cloud based control platform 'MicroEM'*

Centralised energy equipment

Switching cabinet (EIV)

- Motorised circuit breaker
- Power quality meter
- Current transformers
- UPS

Stabiliser unit (Power Technology)

- 15kVA 3-phase inverter
- 10kWh battery (high C-rating)
- Protection relay
- Initially only active when mini grid islanded

Stability & protection studies

▶ **DIgSILENT engaged to undertake studies into:**

- › Steady state power flow
- › Dynamic stability
- › Protection

▶ **Assessment of protection performance**

- › 3 test cases
- › Multiple fault locations
- › Low fault current environment

▶ **Stabiliser picks up transient power surplus / deficit**
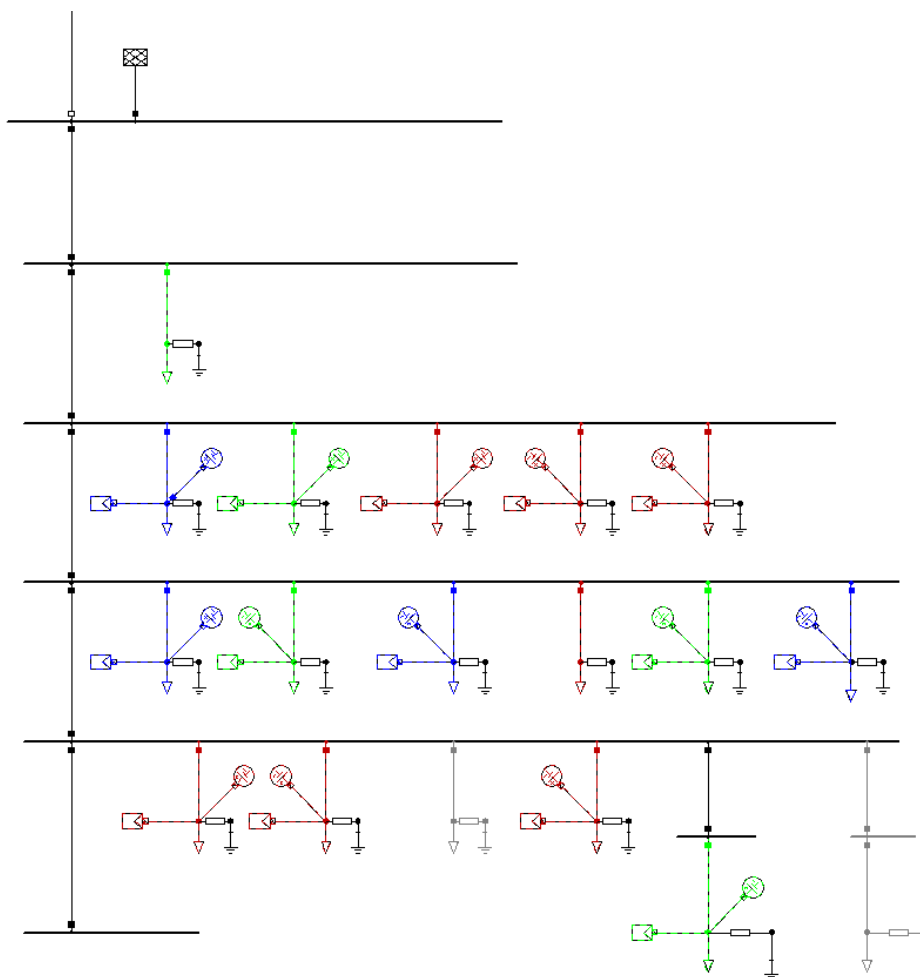
Social integration

- **Aim to achieve customer acceptance**
- **Build excitement and interest**
- **Role of informal community leaders**
- **Role of local Government**

- **Sense of empowerment**
- **Noise issues**
- **Safety review**

Economic integration

- **Trial project: Attractive offers to customers, not a commercial offer**
- **Simplicity: Customers stay on standard retail**
- **Simple customer-side economics:**
  - › $5k for solar – good investement
  - › $15k for battery storage - poor investment

- **Trial will run a series of economic use cases under a DSO framework**
- **Economic viability relies on value stacking**
- **Facilitate customer access to different markets (network, wholesale..)**
- **Community retail model**
- **Local trading model**

The DER Integration Proposition
What is it, and what makes it work?

AusNet services

Investors

Customers

Energy Networks
Businesses

Retailers

Market Actors
(>energy)

Others?

Resources

Generation

**Energy
Storage**

Active Load
Management

+/- Real Power (P)
+/- Reactive Power (Q)
Reducing CO_2 Emissions
Time Duration

Economic Value

Energy Arbitrage

NEM Participation

Demand Management

Supply Continuity

Renewable Energy Certificates

Flexibility Services

Quality of Supply

Peer-to-Peer Trading

Reduced Network Losses

Social/Environmental

Alternative Supply

- Scale of resources ?
- Whom should invest ?

- Access
- Leverage
- Monetise

- **Market Framework**

- **Technology Platform/s**

- **Business Models**

Technical integration

▸ **Standards: fast moving, gaps, international vs Australian**
  › Industry standards
  › Internal policies

▸ **Safety: Protection system performance**
  › Low fault currents
  › Legacy equipment

▸ **Interoperability: 3 x suppliers**
  › integration challenge bw protocols and devices

▸ **Design & performance**
  › Models vs reality
  › Spec sheet vs reality

Case study 2: Yackandandah

Challenges & lessons

▸ **Socio-economic**

› Strong will in community to attain social and environmental benefits, but want it at the same or better price

› Social aims tend to over-ride environmental aims

› Business model only works under a common retailer

› Customer offer needs to be simple

› Aesthetics and interface important for integration

▸ **Technical**

› Lack of interoperability and standardisation

› Proprietary control systems

› Network limitations

› Lack of depth in supply market

› Technical challenges from aesthetic design
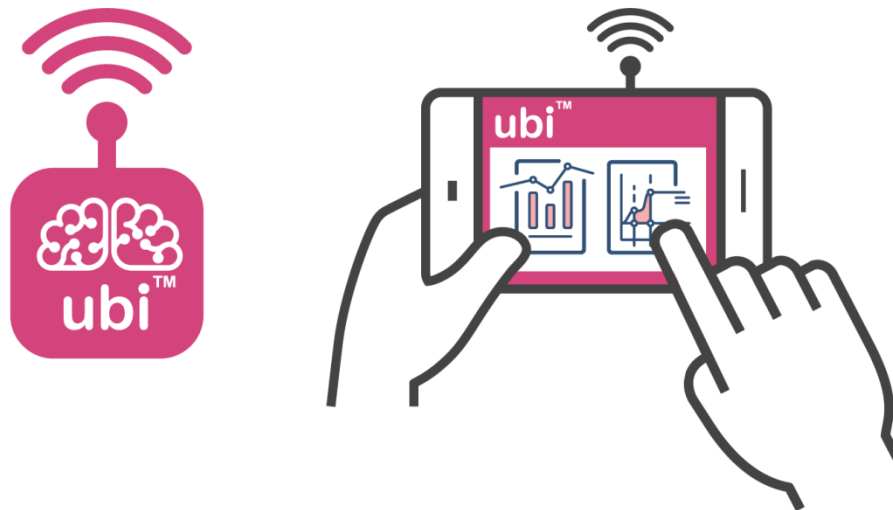
Social integration:
The renewable energy journey

Solar power

Solar power at the home

% of homes involved

30%

100%

13%

% of renewable energy

2017

2022
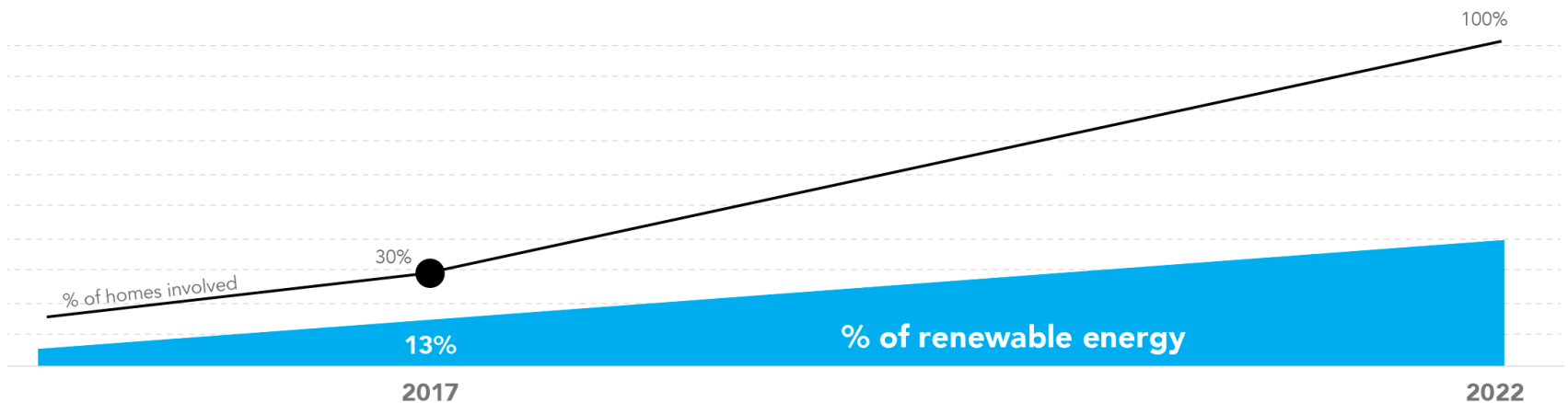
Social integration:
"Ubi" Smart home energy system

Helpful hints like:

You're using a lot more power this week.

It's time to think about adding a battery to your system.

Time to clean your solar panels.

Consider changing to a different tariff.

Social & economic integration: The mini grid vision

Stage 1
Solar power at the home
Each house is equipped with a solar PV system.

Stage 2
Community-wide solar installation and monitoring
Detailed energy and system data is sent via the Mondo™ Ubi™ to a central monitoring and control point.

Stage 3
Community-wide battery deployment
Local community wide battery storage houses capture solar energy storing it batteries and either use it, of feed it back into the grid.
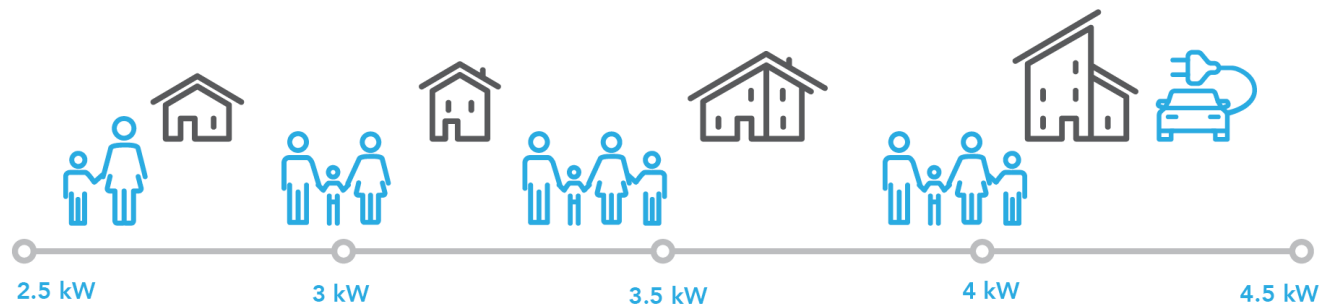
Stage 4
Community mini grid vision
Could involve increased battery storage and community network power sharing and a community retailer.

Stage 5
Other renewable sources delivered via the network

100%

% of homes involved

30%

13%

% of renewable energy

2017

2022
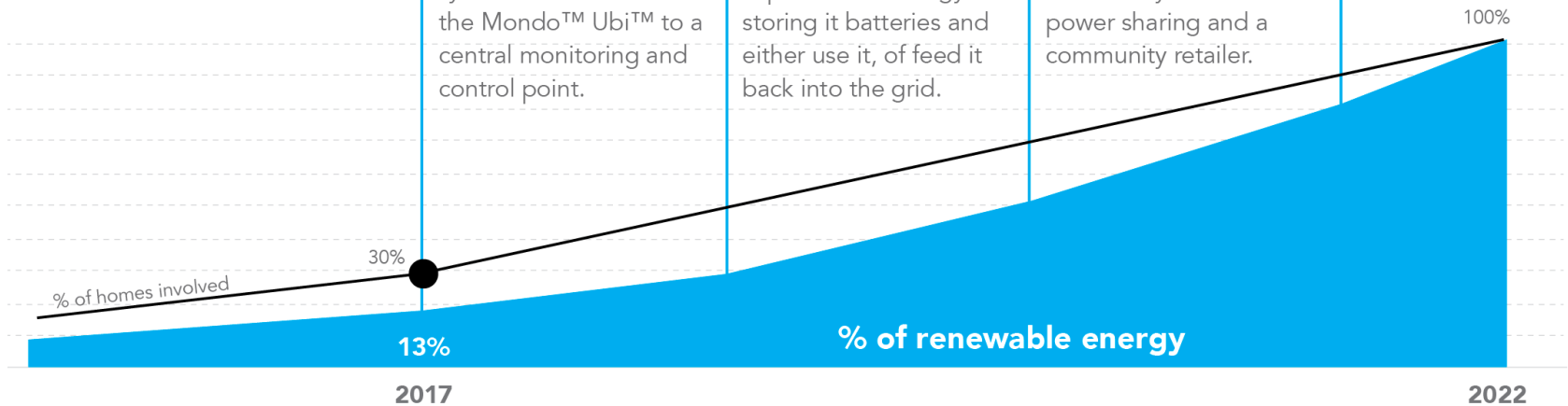
THE YACKANDANDAH MINI GRID UBI + SOLAR STARTER PACK

2.5 kW   3 kW   3.5 kW   4 kW   4.5 kW

2.5 kW System	3 kW System	3.5 kW System	4 kW System	4.5 kW System
$72/mo over 5yrs	$80/mo over 5yrs	$88/mo over 5yrs	$96/mo over 5yrs	$104/mo over 5yrs
Buy outright $4320	Buy outright $4800	Buy outright $5280	Buy outright $5760	Buy outright $6240

ubi™ **Each system includes the Mondo™ Ubi™ portal with 'Helpful Hints' and access to the online portal that delivers information about your energy consumption.[3]**

Stress free installation

Includes Solar Panels, Inverter, Mondo™ Ubi™ and 5 years access to the online portal and maintenance for 5 years (inspect and clean if required).

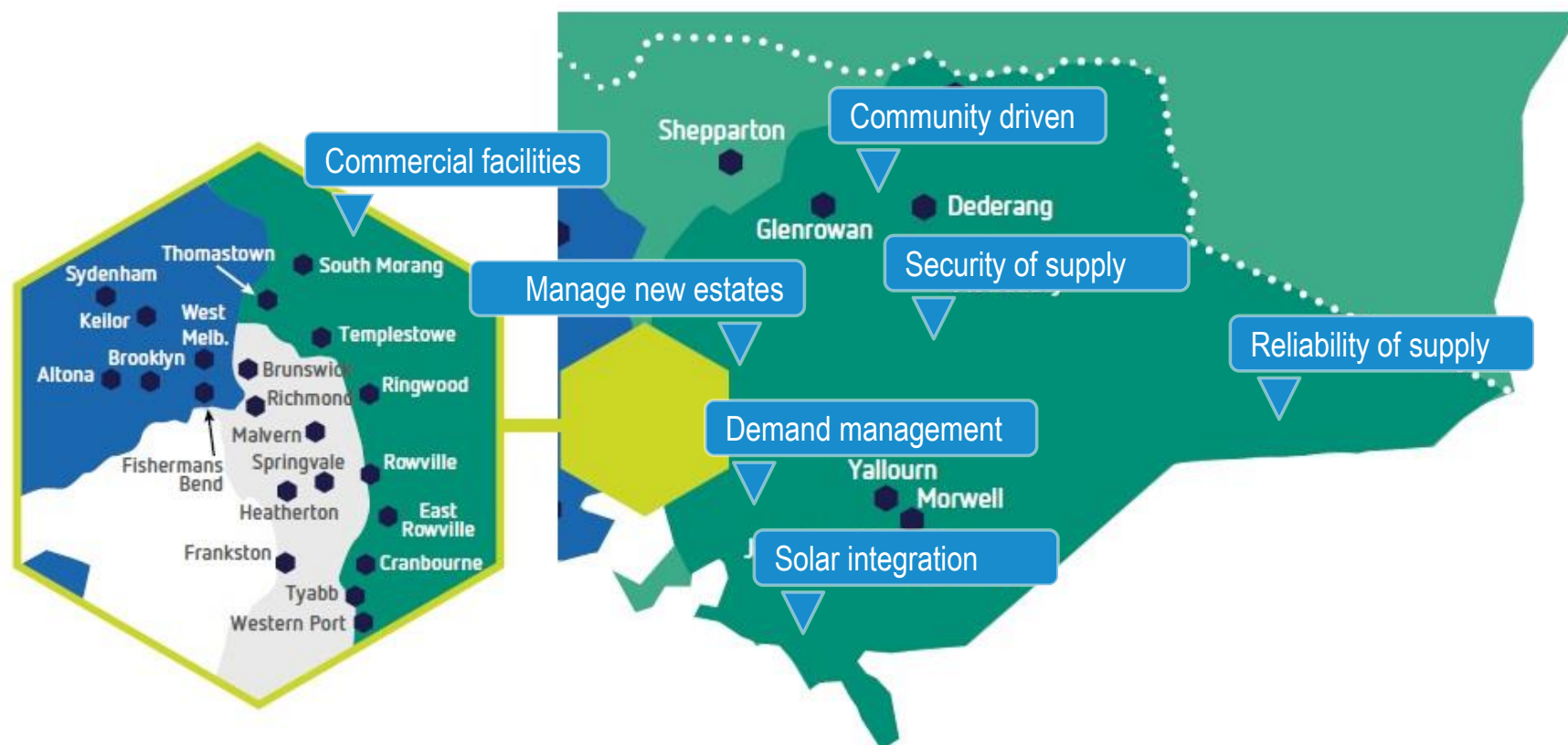# Social & technical integration: New product designs

Integration of energy technology into social environment

▸ **Solar groves for community solar generation**

▸ **Underground batteries integrated into landscaping**
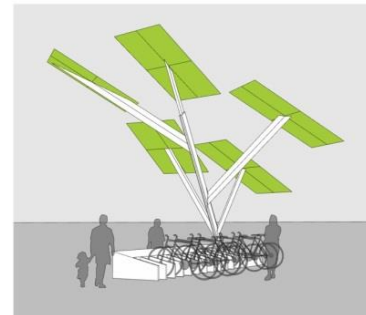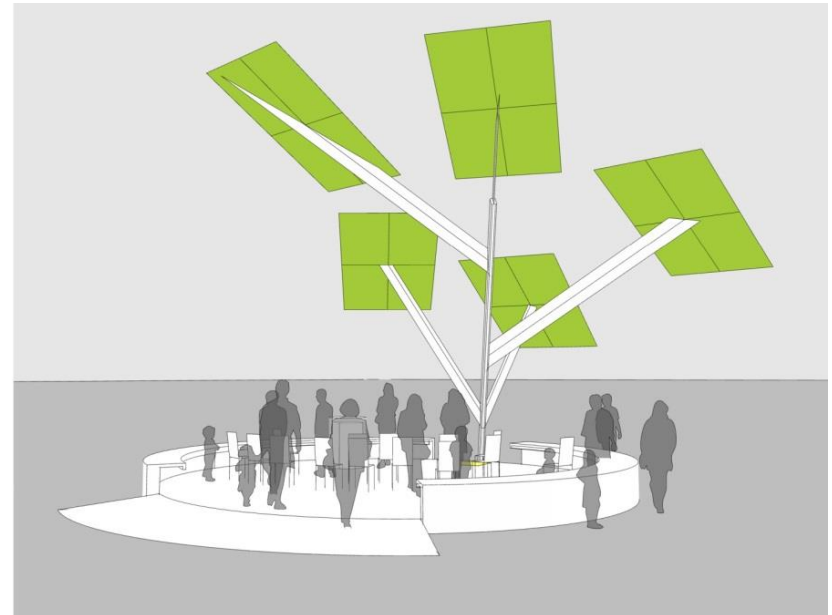
What could the future look like?

- **Heterogeneous network topology with diversity of microgrid projects**

Thank you

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