Whole-of-System Techno-economic Modelling (TEM)

Project Edge

22 November 2022

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Agenda

- Project Edge Background
- Whole-of-System, Techno-Economic Modelling Approach
- Scenario Methodology, Framework and Key Assumptions

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Project Background

Current State

Potential Future State

Key Project Questions

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Grid and Market Integration Key to Unlocking Benefits of DER

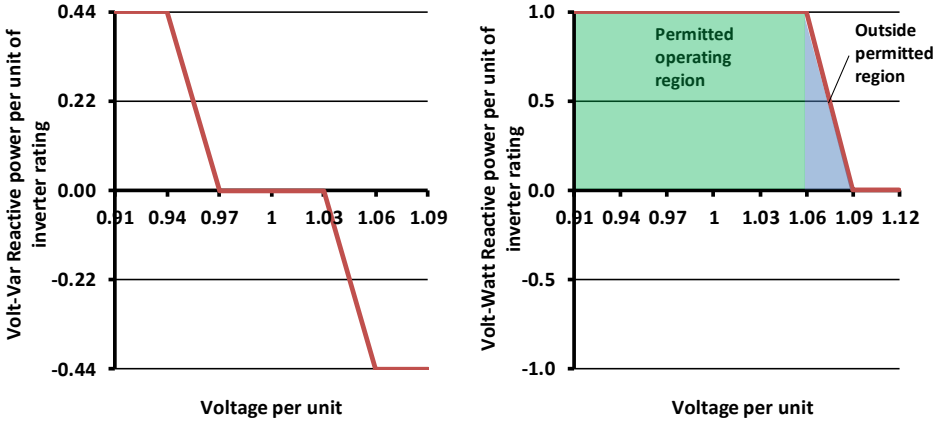
Static Limits

	Single Phase	Three Phase
EvoEnergy	5 kW	30 kW
Ausgrid	10 kW	30 kW
Essential	3 kW / 5 kW	30kW
Endeavour	5 kW	30 kW
Energex	5 kW	30 kW
Ergon	5 kW	30 kW
Power Water	5 kW	7kW
SAPN	5 kW	15 kW
TasNetworks	10 kW	30kW
United	10 kW	30 kW
CitiPower	5 kW	30 kW
PowerCor	5 kW	30 kW
Jemena	10 kW	30 kW
Ausnet	5 kW	15 kW
WesternPower	10 kW	30kW

Source: Clean Energy Regulator, DNSP Regulations

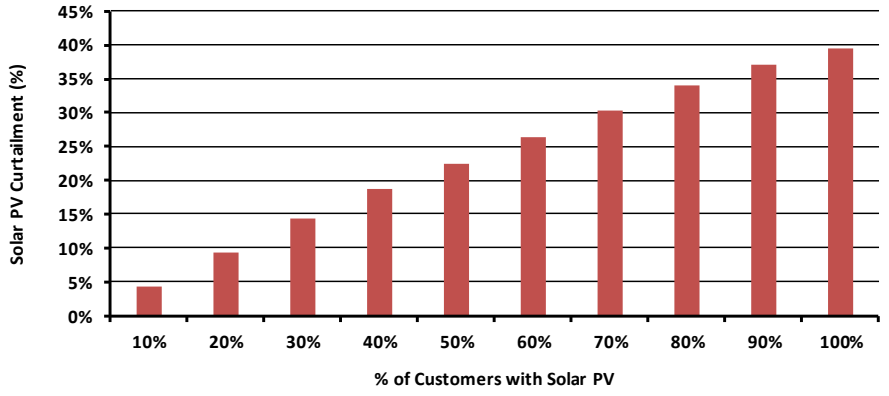
- Most DER integration in Australia based on static limits set on an annual, worst-case basis
- Introduction of smart inverter standards results in automatic curtailment by default
- Level of curtailment expected to continue to rise over time
- Export pricing and flexible export arrangements an evolutionary step towards better integration

Smart Inverter Standards Effectively Curtailment Solution



Source: NREL, HECO (2019), *Impacts of Voltage-Based Grid-Support Functions on Energy Production of PV Customers*

Solar PV Gen Curtailment and Penetration (IEEE/U. Melb)



Source: L. Ochoa and A. Procopiou, (2019), Increasing PV Hosting Capacity: Smart Inverters and Storage, Webinar

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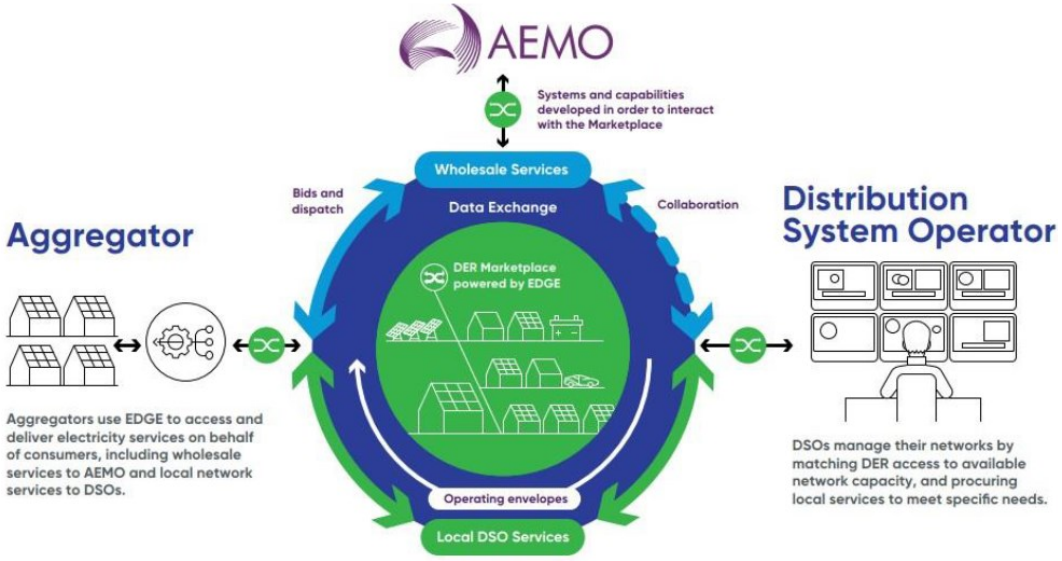
EDGE: Dynamic Operating Envelopes and Local Markets

Market and Grid Integrated, Market for Local Grid Services



Source: AEMO

- In 2018, AEMO and Energy Networks Australia (ENA) commenced the Open Energy Networks Project which sought to identify the most appropriate framework for building a two-sided marketplace
- The project identified the Hybrid model – where market operation functions are allocated to AEMO while Distribution Network Service Providers (DNSPs) optimise the distribution system operation – as the most appropriate framework for building a two-sided marketplace.
- However, the project also recognised there is no single definition of the Hybrid model, and it would need to be trialled to understand how best to implement it and maximise the efficiency and outcomes for customers and industry.
- Project EDGE (Energy Demand and Generation Exchange) is intended to build on the outcomes of the Open Energy Networks Project, utilising the Hybrid framework as a guide for developing a trial to test and demonstrate how a two-sided marketplace might work, and inform current and future regulatory reform and market design.

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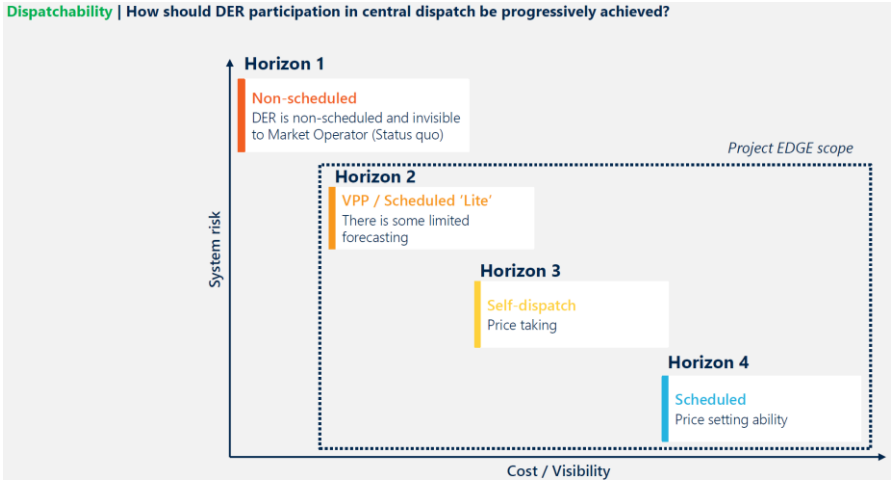
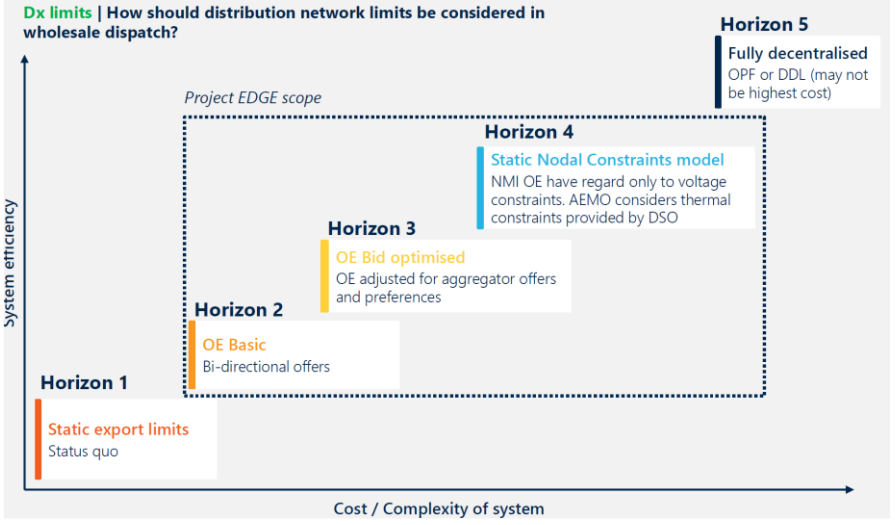
Valuing the Benefits of a Centralised, Nodal Services Market

Valuing Different Levels of Visibility



Valuing Different Levels of Optimisation



- Key improvements offered by an EDGE-like platform and supporting industry arrangements include
  - Increased visibility
  - Increased levels of optimisation
- Project EDGE required the development of a methodology to estimate their incremental value
- Energeia and Deloitte proposed a whole-of-system, scenario driven analytic approach
  - Wholesale market impact assessment
  - Distribution impact assessment
  - Cost-benefit assessment

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Methodology

Cost-Benefit-Assessment

Whole-of-System Model

Results Expansion

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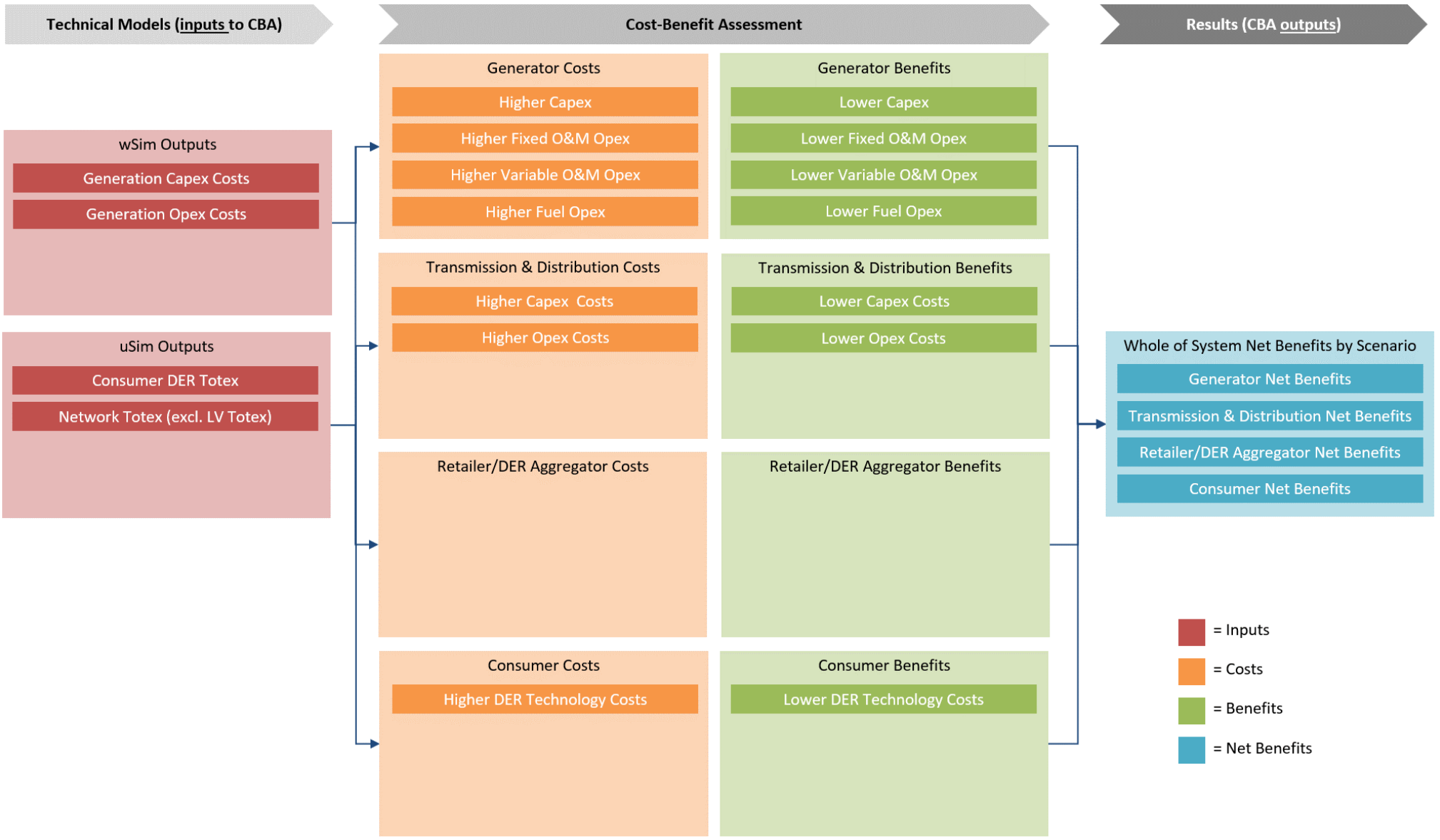
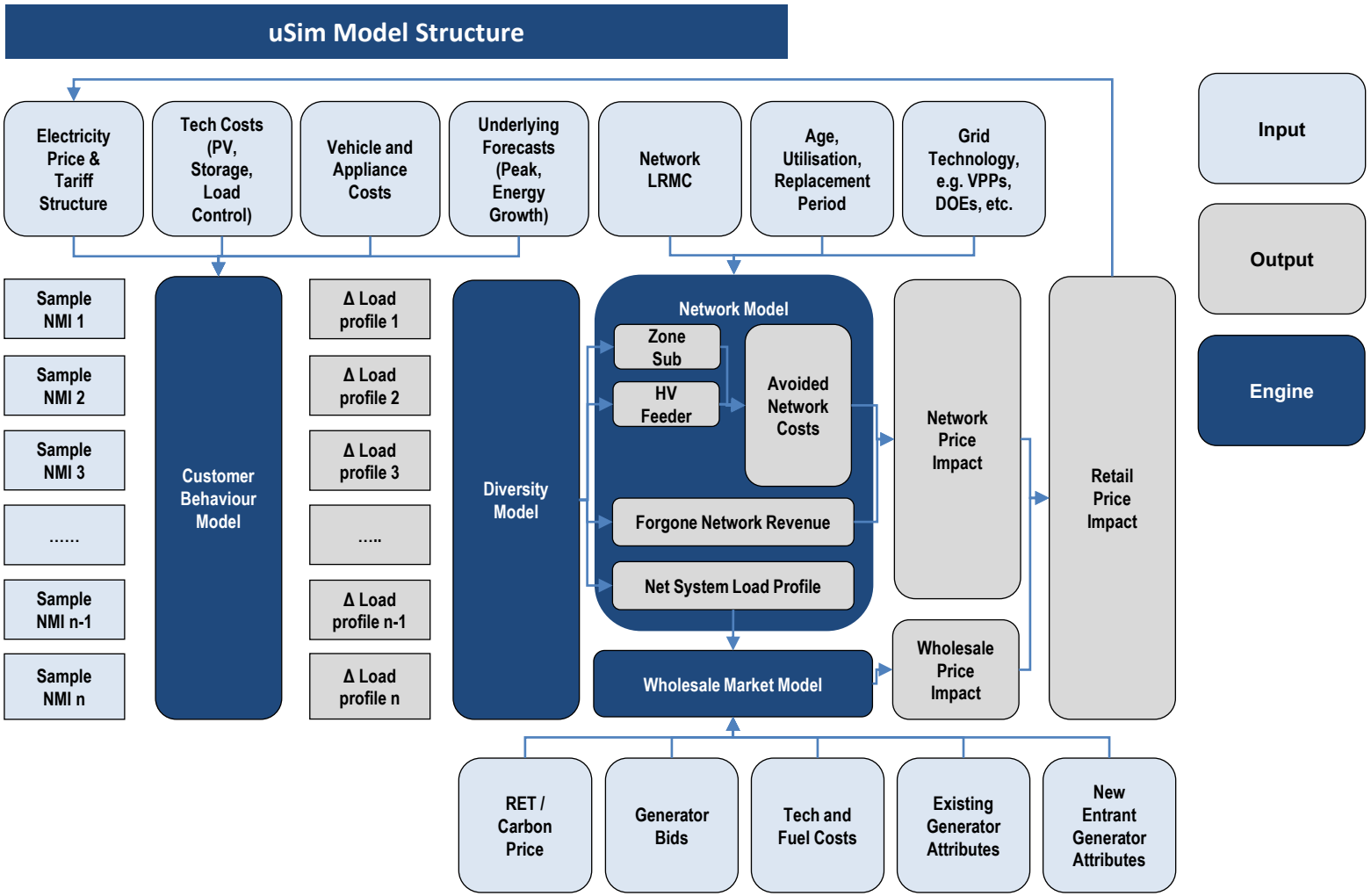
A Whole-of-System, Cost-Benefit Assessment Solution



Whole-of-System Electricity Sector Model



Source: Energeia

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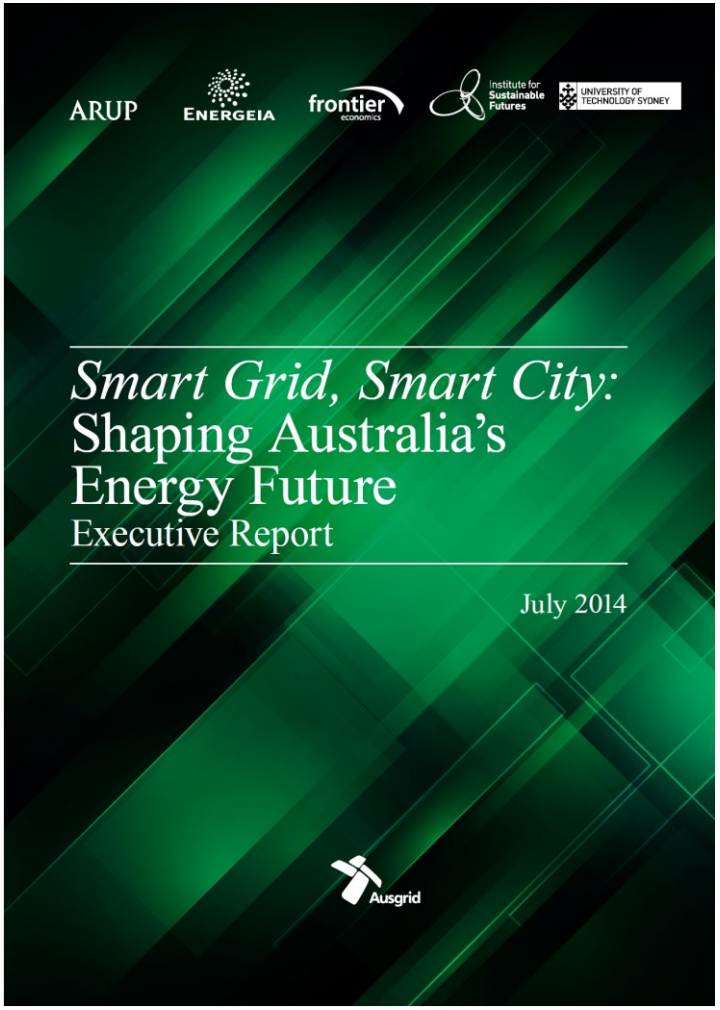
Approach to Expanding Results Nationally

Smart Grid, Smart City Expanded from AusGrid Trial



- T&D
  - Estimate average impact by asset category, e.g. feeder type, substation type, and potentially customer mix
  - Expand by multiplying out based on counts of other DNSPs and unit price differentials (e.g. for 11kV HV networks)
- Wholesale
  - Estimate impact on wholesale market new entry for Victoria
    - Expand based on ISP forecast new entry capacity, capex and opex unit price relativities, including fuel
    - Pricing levels a transfer between generators and retailers / consumers
- Key Precedent – $100m Smart Grid, Smart City Project
  - Ausgrid trial results were scaled nationally based on asset and customer mix
    - Substation results based on HV/STS and STS/BSP categories
    - Feeders based on reliability category, e.g. CBD, urban, short rural and long rural
    - Key issue of 11kV vs. 22kV costs factored in using different unit prices (e.g. Repex model)

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Scenarios

Framework

Key Inputs

Key Assumptions

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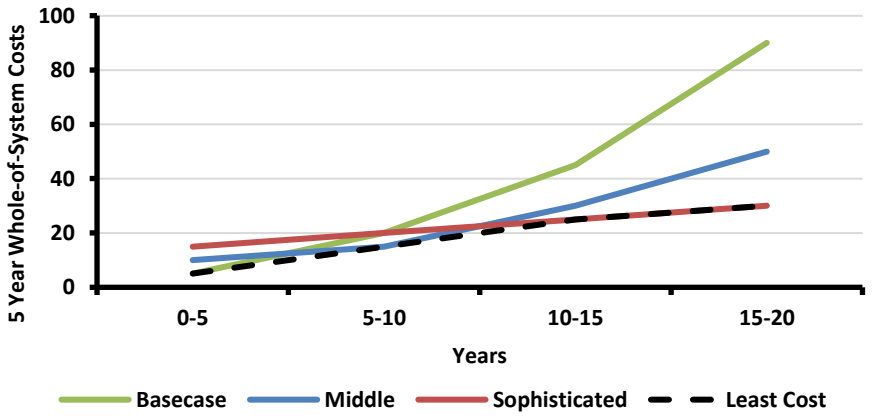
Scenario Driven Net Benefits Assessment Methodology

Illustrative Least Cost Pathway



Source: Energeia

- Wholesale market, transmission, distribution and behind the meter costs calculated by scenario using uSim and wSim over the 20-year modelling horizon
- Relative economic impacts (capex and opex) of a given horizon estimated based on difference to base case across:
  - Wholesale
  - Transmission
  - Distribution
  - Customer (behind the meter)
- Least cost pathway for the National Electricity Market (NEM) identified as least cost scenario per 5-yearly time increment (see dotted line in figure to left)
  - EDGE scenario expected to be on the sophisticated end of the spectrum, higher cost but higher net benefits as DER penetration rises

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EDGE Whole-of-System Scenario Framework (TBC)

Key Settings by Scenario

Scenario Element	Low DER Scenario 1	2	3	4	5	High DER Scenario 7	8	9	10	11
Load and DER Assumptions										
Customer and Energy Growth	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High
Solar Uptake	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High
Battery Uptake	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High
EV Uptake	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High
Heat Pump Water Heating Uptake	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High
VPP uptake	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	AEMO Step Change	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High	Renew / ECA High
DER Service Use Cases										
AEMO RERT Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AEMO AS Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AEMO Ramping Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AEMO FCAS Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Retailer Capacity Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Retailer NEM Charges Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Retailer Network Charges Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Network TX Voltage Service	×	×	×	×	×	×	×	×	×	×
Network TX Thermal Service)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Network ZS Thermal Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Network HV Thermal Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Network HV Voltage Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Network LV Thermal Service	×	×	×	×	×	×	×	×	×	×
Network LV Voltage Service	×	×	×	×	×	×	×	×	×	×
DOE / Market Arrangemets										
Constraint Optimization Frequency	Annual	Daily	Daily	2-Hour	2-Hour	Annual	Daily	Daily	2-Hour	2-Hour
Co-optimization Model	N/A	VPP Only	VPP Only	100%	100%	N/A	VPP Only	VPP Only	100%	100%
DOE Optimization Methodology	N/A	Approximation	Approximation	LV Data Driven	LV Data Driven	N/A	Approximation	Approximation	LV Data Driven	LV Data Driven
Target Operating Model (TOM)	N/A	Max Service	Max Service	Max Service	Max Service	N/A	Max Service	Max Service	Max Service	Max Service
Flexible Energy Arrangements	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
VPP Standards and P2P / Hub & Spoke Integration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Data Hub			✓		✓			✓		✓
Local Services Exchange			✓		✓			✓		✓

Key Scenario Assumptions – ECA / Renew & AEMO Step Change

ECA / Renew Scenarios

	Scenario Name	
	AEMO Step Change (2022)	Consumer High DER
Key Scenario Drivers		
Distributed Technology Prices		
Solar PV	AEMO Step Change	Trend
Storage	AEMO Step Change	Trend
Distributed Technology Adoption Rates		
Solar PV	AEMO Step Change	80% by 2030, 90% by 2040
Storage	AEMO Step Change	80% by 2030, 90% by 2040
Distributed Technology Adoption Sizes		
Solar PV	AEMO Step Change	Economically Optimal
Storage	AEMO Step Change	Economically Optimal
Electrification Rates		
Buildings	80% by 2030, 90% by 2040	80% by 2030, 90% by 2040
Transportation	AEMO Step Change	AEMO Step Change
Inputs		
Water Heating	AEMO Step Change for EVs	80% by 2030, 90% by 2040
EV Charging	AEMO Step Change	80% by 2030, 90% by 2040
Storage	AEMO Step Change	80% by 2030, 90% by 2040
Solar PV	AEMO Step Change	80% by 2030, 90% by 2040
National Electricity Market		
Fuel Prices	AEMO Step Change	AEMO Step Change
Technology Costs	AEMO Step Change	AEMO Step Change
Networks		
LRMC	Published	Estimated

- DER and electrification profiles based on AEMO and ECA / Renew studies
- Key wholesale and VPP assumptions sourced from AEMO's Step Change scenario

Source: AEMO, Energeia

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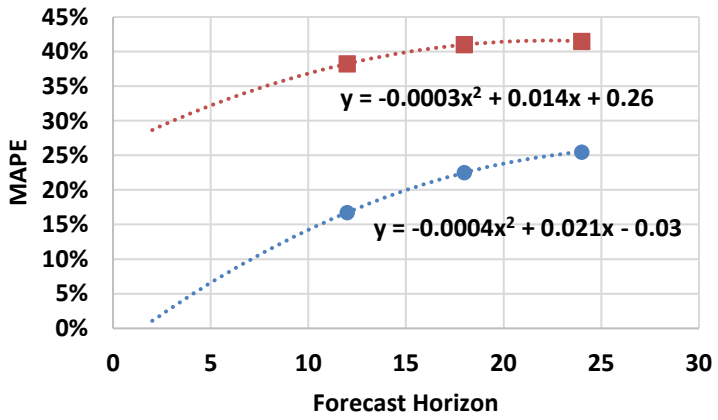
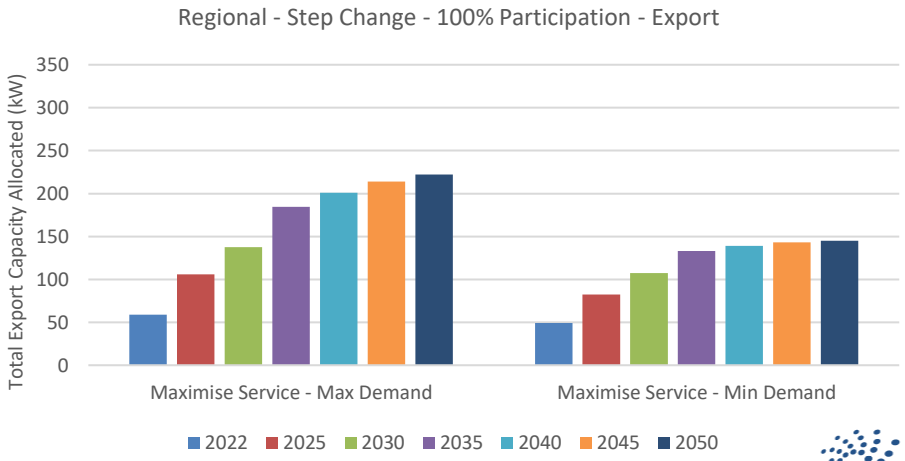
Scenario DOE/Market Adjustment Coefficients

- uSim assumes perfect information and no voltage constraints in deployment of DER for grid and wholesale markets
  - This project will apply voltage and thermal constraints on DER delivered grid and market services
- Plan is to use trial data to parameterize key constraints
  - Voltage and thermal limits estimated by the DOE engine by time of day as DER increases (example UoM chart below)
  - DOE model error (based on high/low accuracy methodology)
  - Forecast error that the DOE will have to reflect (trial data not available until Jan)
- Forecast error estimate needs to be estimated to complete first round of modelling
  - Energeia developed indicative forecast errors





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Key Questions

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Key Questions Related to the Approach

1. Q – How will you take the different starting points of DNSPs in terms of their flexible exports and DOE implementations?
   A – The scenario design will allow these differences to be taken into considering in the CBA by weighting the results by state according to their specific conditions

2. Q – How will the field trial data be used in this approach?
   A – Field trial data will be used to validate the estimated levels of effectiveness (defined as percentage of perfect with hindsight) across visibility and optimisation scenario settings

3. Q – How do virtual power plants work in this system, as they seem to stand between uSim and wSim?
   A – Energeia uses a VPP module that takes the quantity of resources available by hour and type from uSim, and applies them in wSim, mainly addressing high and negative prices

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Thank You

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