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Electric Vehicles

Integration and Impacts

Dr Jenny Riesz
February 2014

Overview

- Introduction
- Factors affecting uptake of EVs
  - What will affect adoption?
- When are we likely to see widespread adoption?
- Impacts on electricity sector
- Industry response
- Long term potential
  - Vehicle to Grid?

Electric vehicles

What does this mean for the electricity sector?

Shift from petrol to electricity

Potentially large electric load

Help or hindrance?

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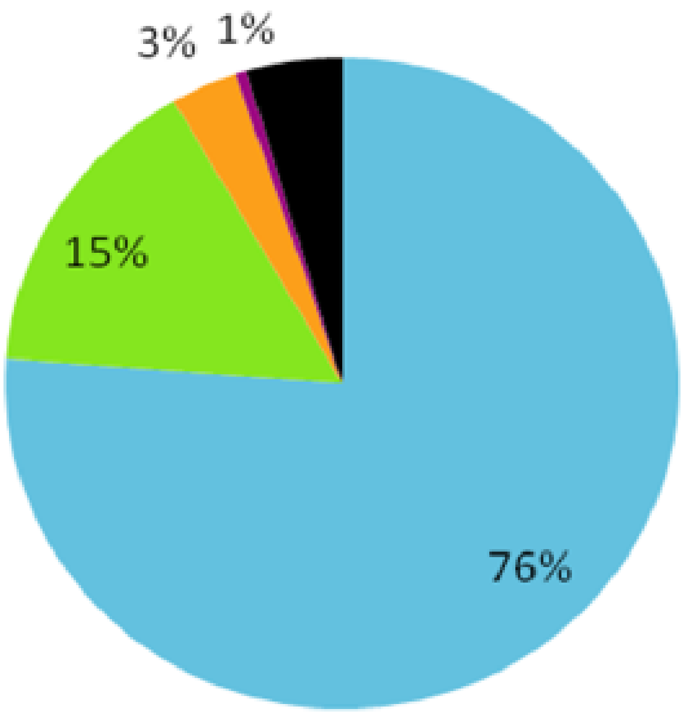
Vehicle types in Australia



16.7 million vehicles in Australia

- Passenger Vehicles (12-14km per day)
- Light Commercial Vehicles
- Trucks (20-70km per day)
- Buses (30km per day)
- Other

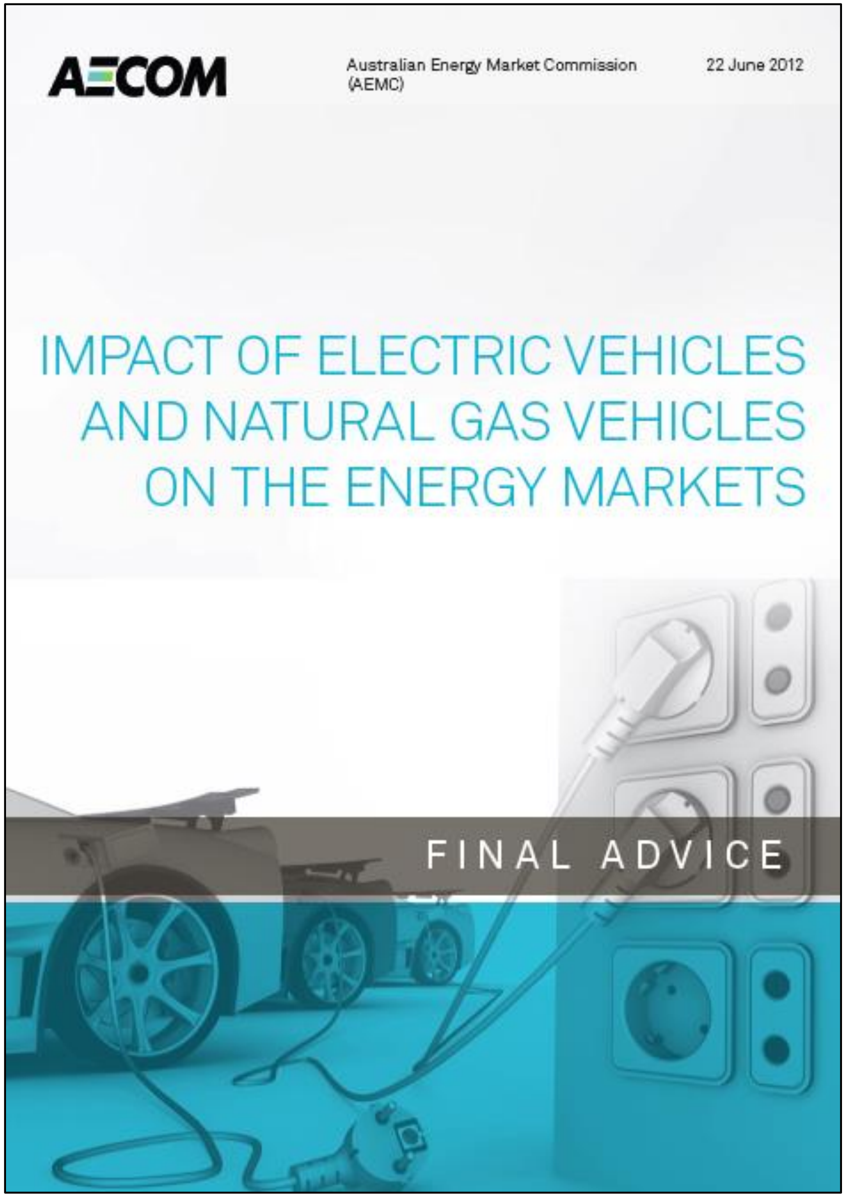
Average fuel efficiency = 19 kWh/100km

Potential to add 8% to annual electricity consumption

Refuelling

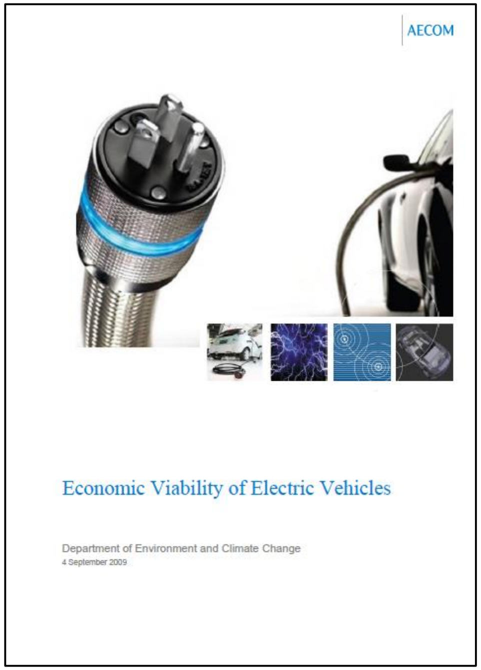
40 litres in 2 minutes = 12 MW

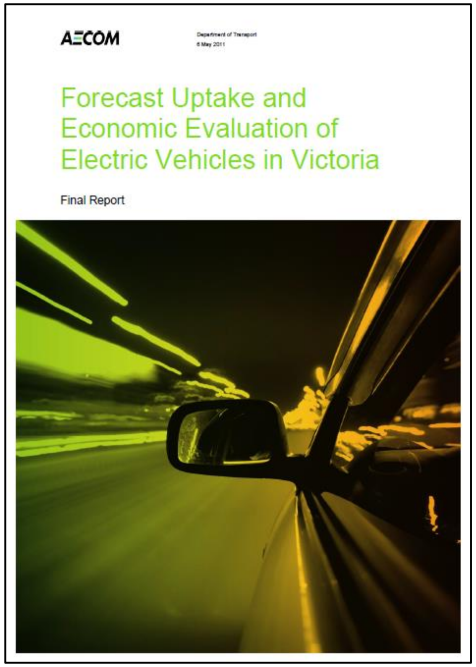
Studies on EVs



How many EVs, when?

Impact on electricity sector?





Vehicle types

ICE	• Internal Combustion Engine
BEV	• Battery Electric Vehicle
PHEV	• Plug-in Hybrid EV
HEV	• Hybrid EV

FACTORS AFFECTING VEHICLE CHOICES

WHAT AFFECTS EV UPTAKE?

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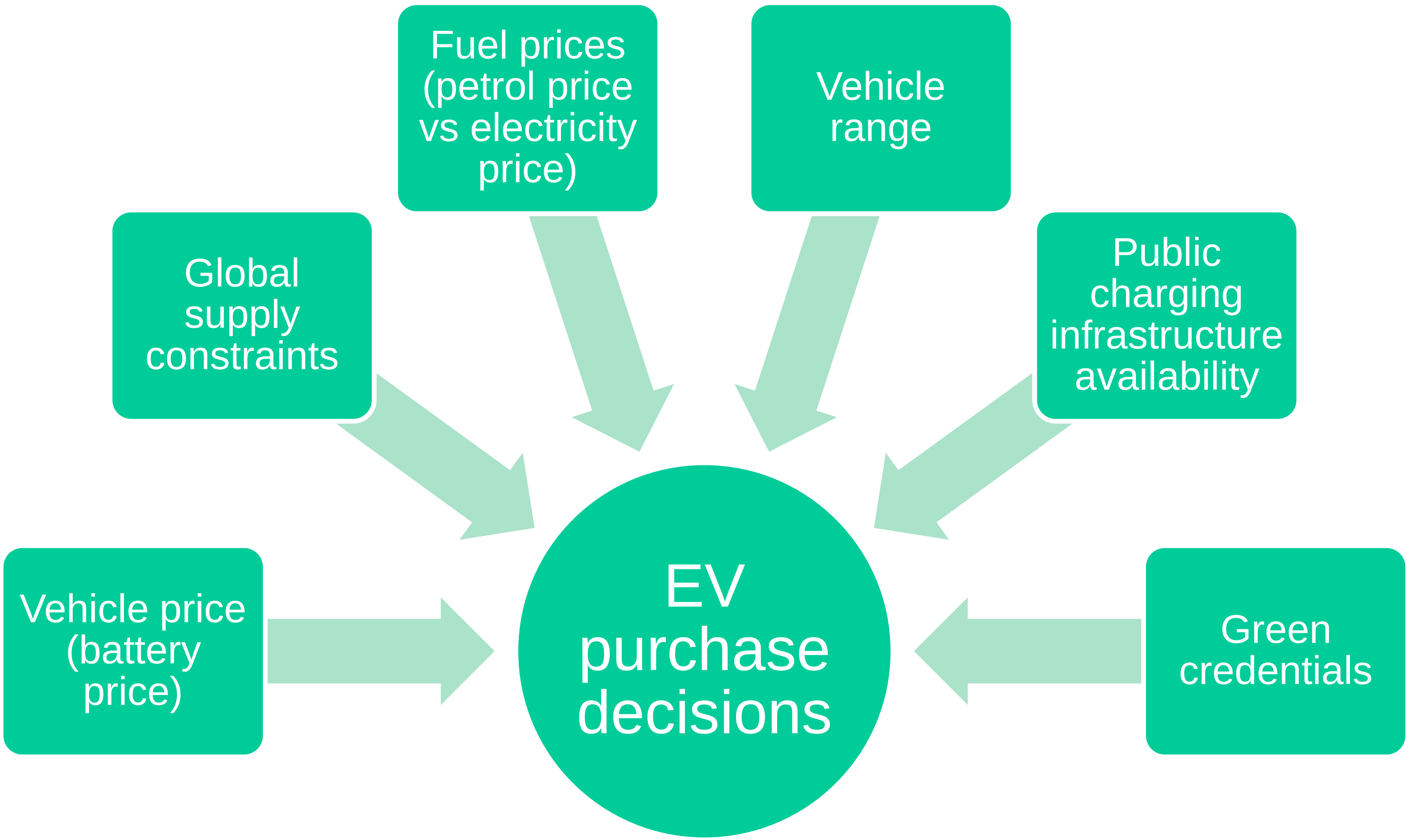
Factors affecting uptake



Supply constraints & vehicle price

- Large number of EVs available or planned imminently
  - Only a select number bound for Australian market
  - Supply constraints most significant factor limiting growth?

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Mitsubishi iMiEV

BEV
City driving
Tiny, seats 4

90-150km range

Available now
$48,000

First mass-produced EV in Australia
Payback time: 43 years!

"If you're expecting any kind of grunt, prepare to be disappointed"

Choice Magazine, Jan 2012

Nissan Leaf

BEV, 100-160km range
Seats 5 (normal sedan)
Available now, $30,000

"Proof that electric cars can have spirited performance"

Drive.com.au

Holden Volt

PHEV, 60km range
Planned for Australia
$60,000 (triple price of similar sized ICE)

Renault Fluence Z.E.

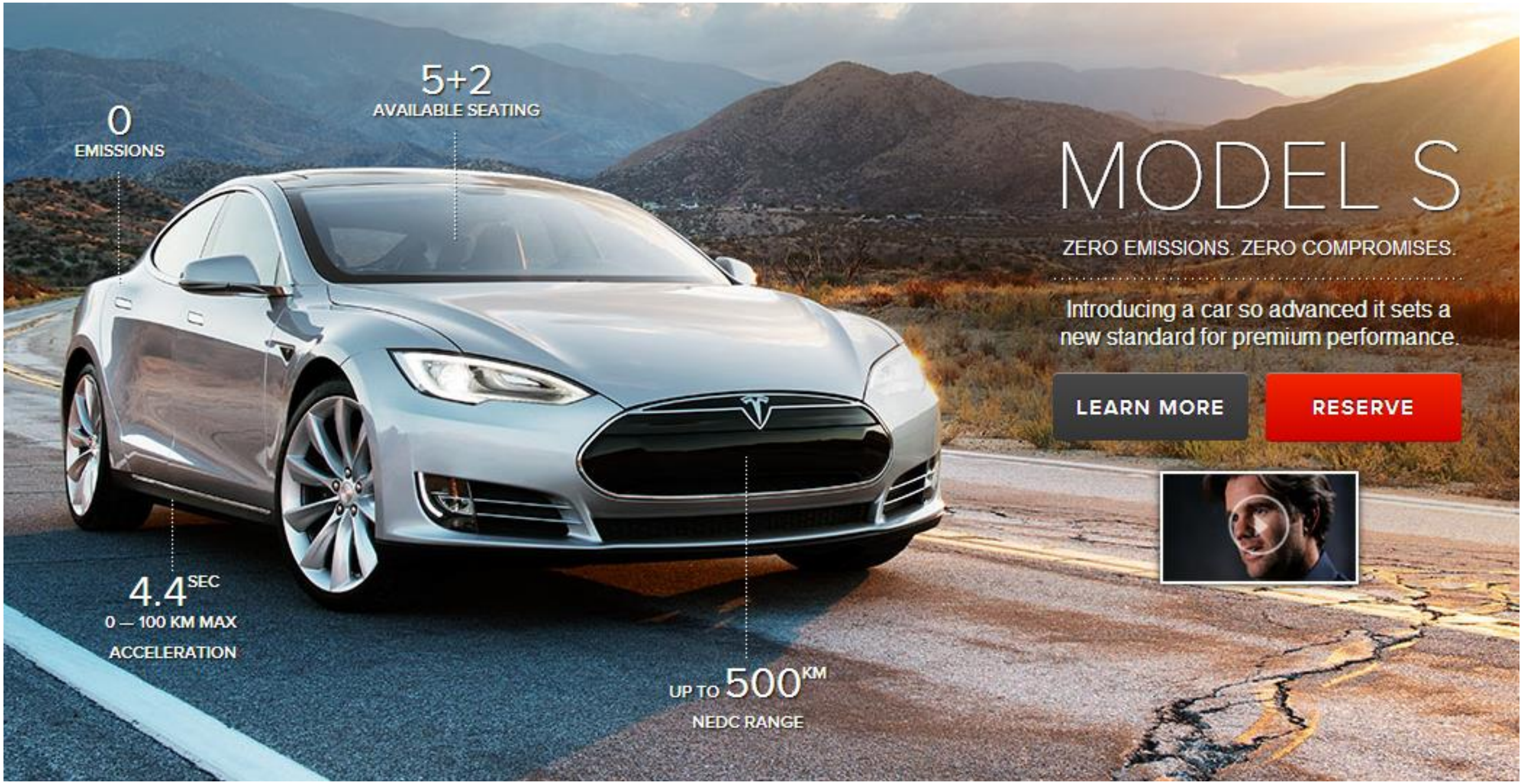
BEV, compact sedan
Battery swap (4 mins) – Better Place?
185km range
$40,000+?

“It feels and performs like a real car, not some pretend one”
“The very fact that we’ve been driving this car suggests the change is closer than you think”

Tesla - Roadster

BEV, 394km range
Available now, $200,000
$100,000 second hand

Tesla - Model S



BEV
Sedan, 500km range
Available autumn 2014
$60,000 to $100,000 (depending upon battery size)
Rave reviews, outselling Porsche & Audi in California

Tesla - Model X

BEV
SUV, seven seats
500km range
Available 2014
To cost “slightly more” than the Model S

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Tesla

- Hopes to introduce a $30,000 car in the next 3-4 yrs
  - Gen III
- Merger with Apple?
- Supercharger stations – 14 across Europe
  - Germany (key autobahn routes)
  - March 2014 – half of Germany
  - Charge for 30mins every few hours

China

- Megacity air pollution in China
- Chinese Government:
  - Switch to e-mobility (e-bikes, e-cars, e-buses, etc)
  - Mass production leading to significant cost reductions?

Supply constraints & vehicle price

- Remain significantly more expensive up-front
  - Premium of $21,000 to $50,000, compared with equivalent ICE
  - Premium to purchase in Australia vs internationally

- But cheaper to operate:

ICE

- Petrol at ~$1.50/litre
- ~7.5 litres/100km
- **$11.25 per 100km**

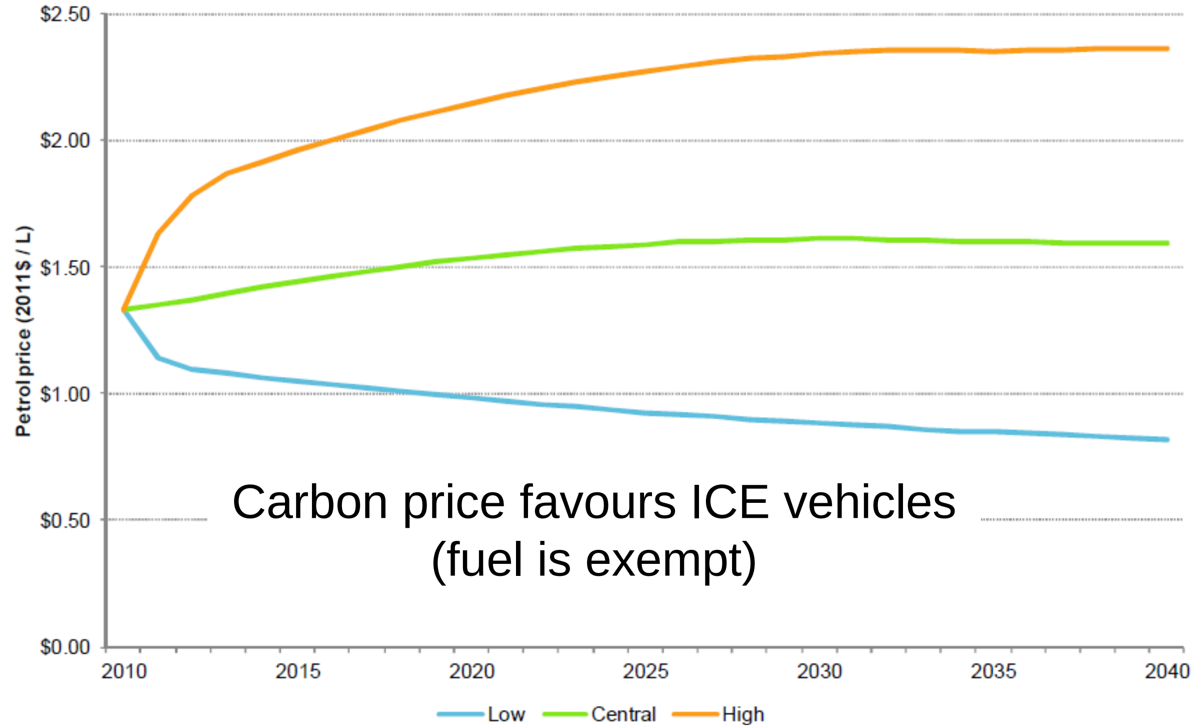
EV

- Electricity at ~30c/kWh
- ~19 kWh/100km
  - **$5.70 per 100km**
- **OR**
- Off-peak charging at ~12c/kWh
  - **$2.30 per 100km**

Fuel prices

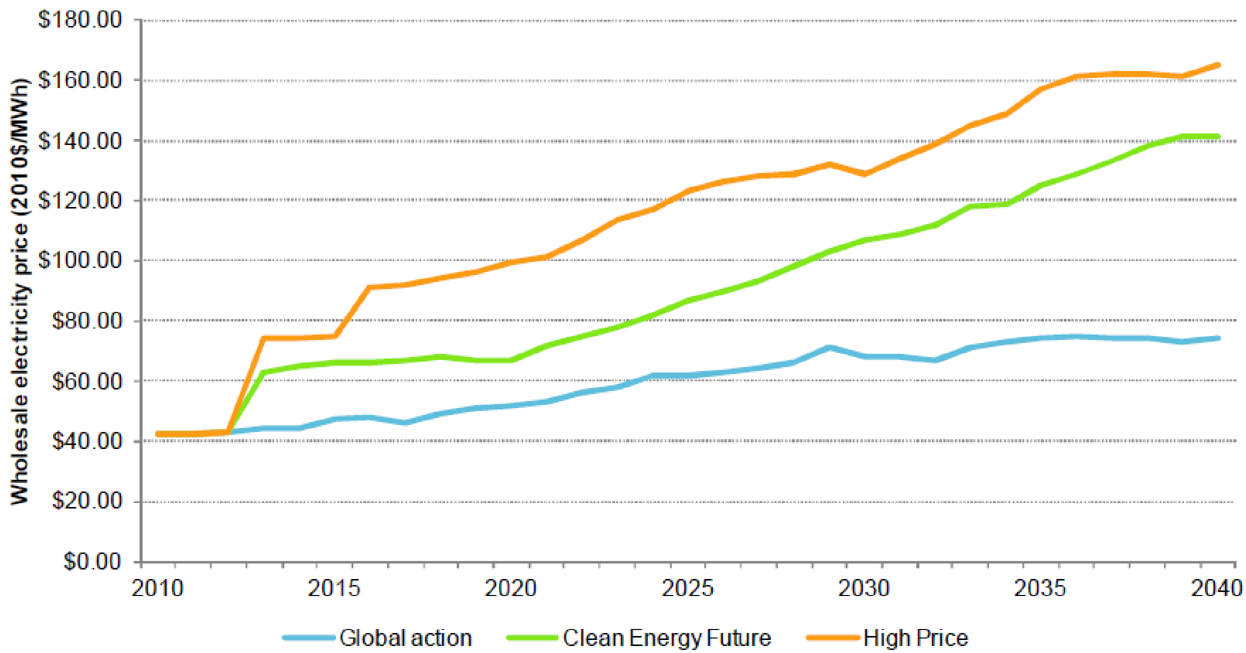
Petrol prices

US Energy Information Administration Annual Energy Outlook 2011



Electricity prices

Treasury, Strong Growth Low Pollution Future Modelling, 2011



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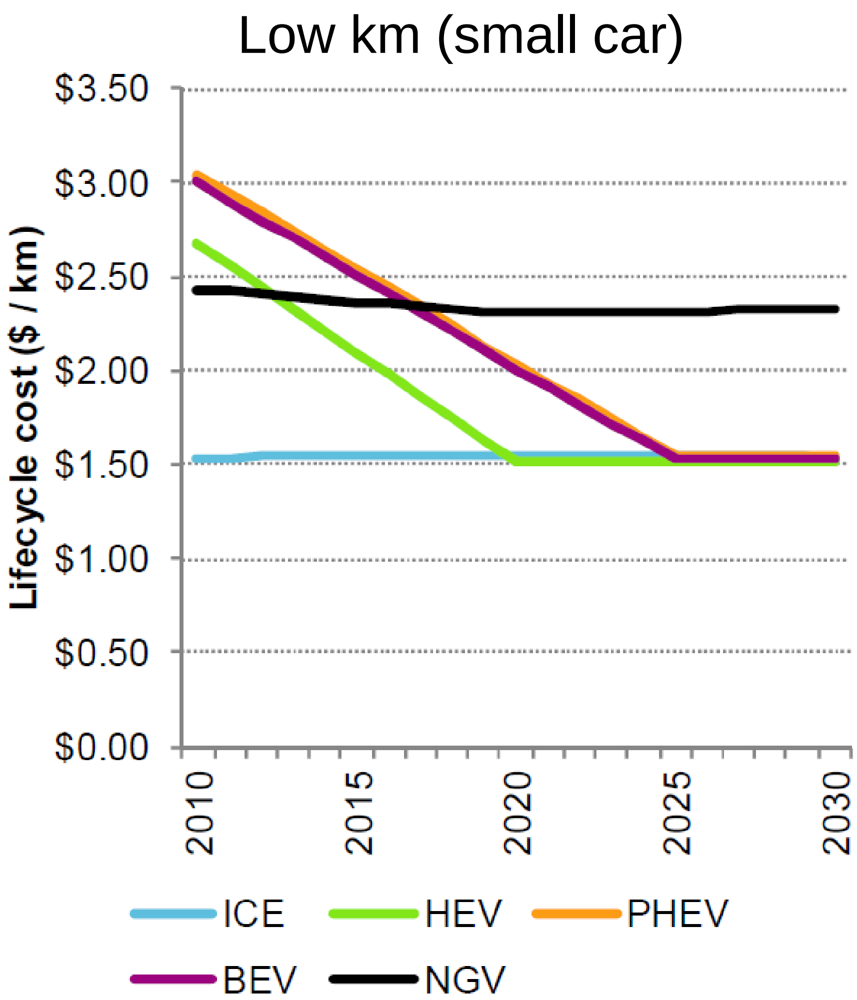
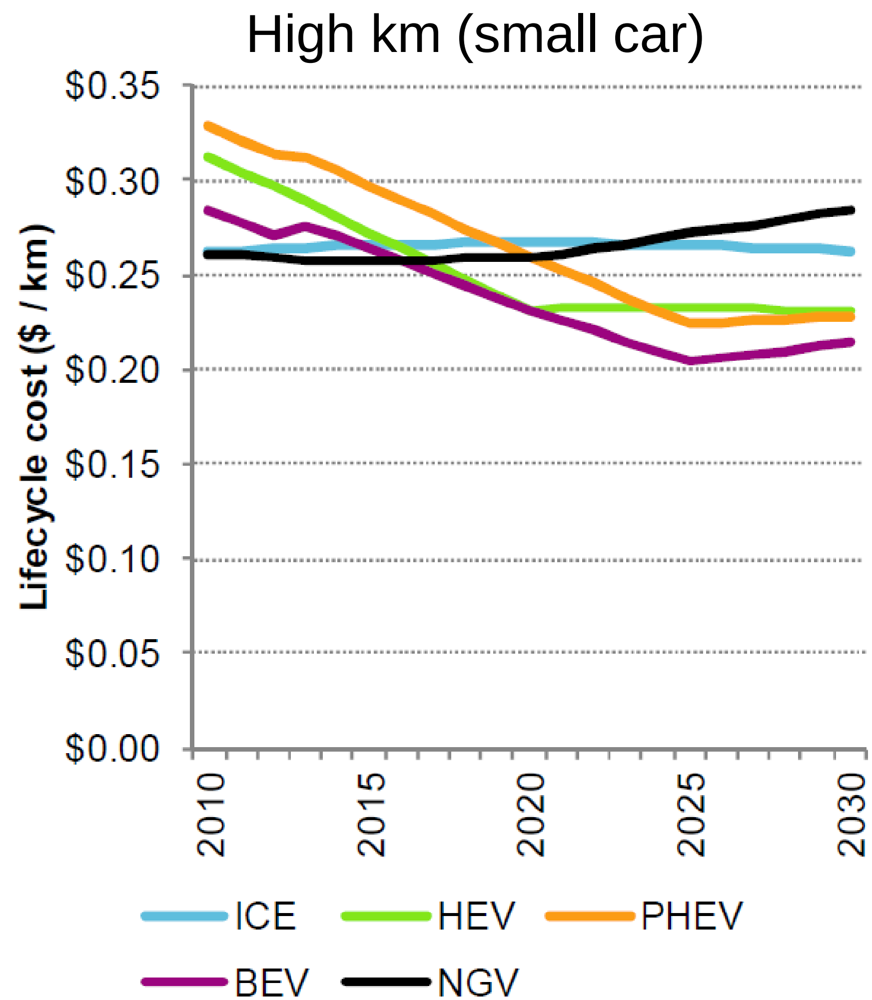
Lifecycle cost comparison





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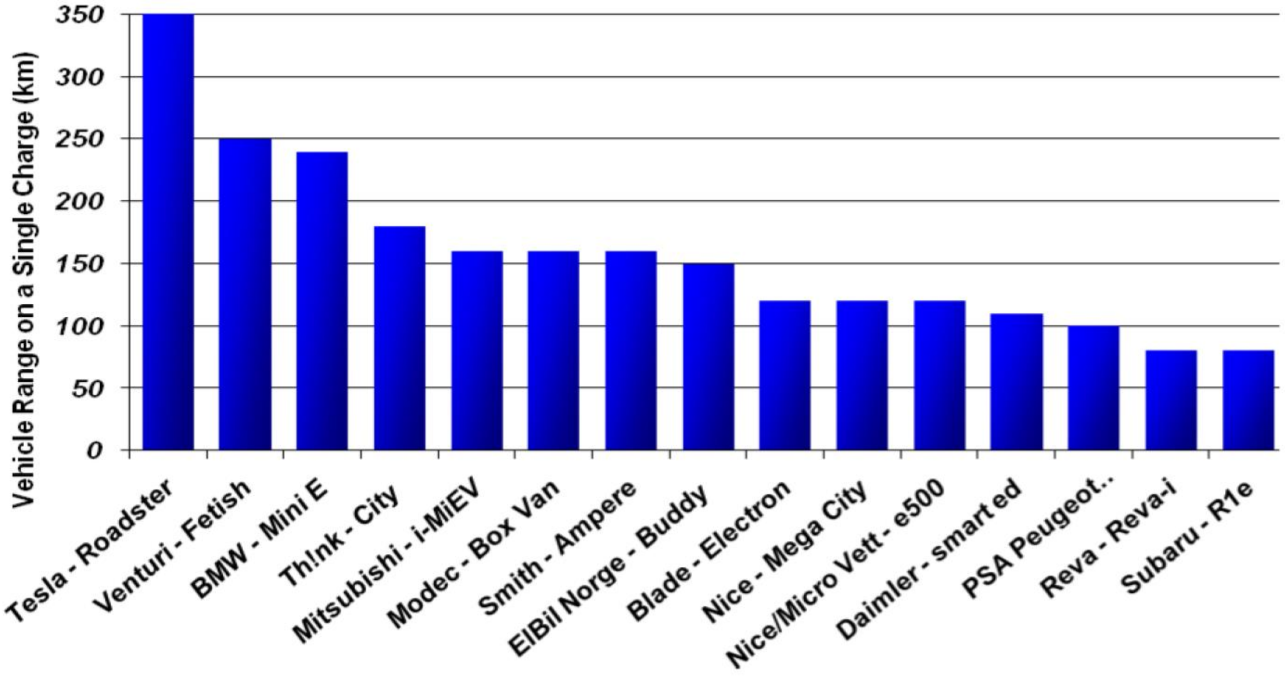
Vehicle Range

– Concern around vehicle range ("range anxiety") limits uptake
  - Often used as an argument for installation of rapid charge stations
– Most EVs have a range of 80-160 km, sufficient for majority of trips

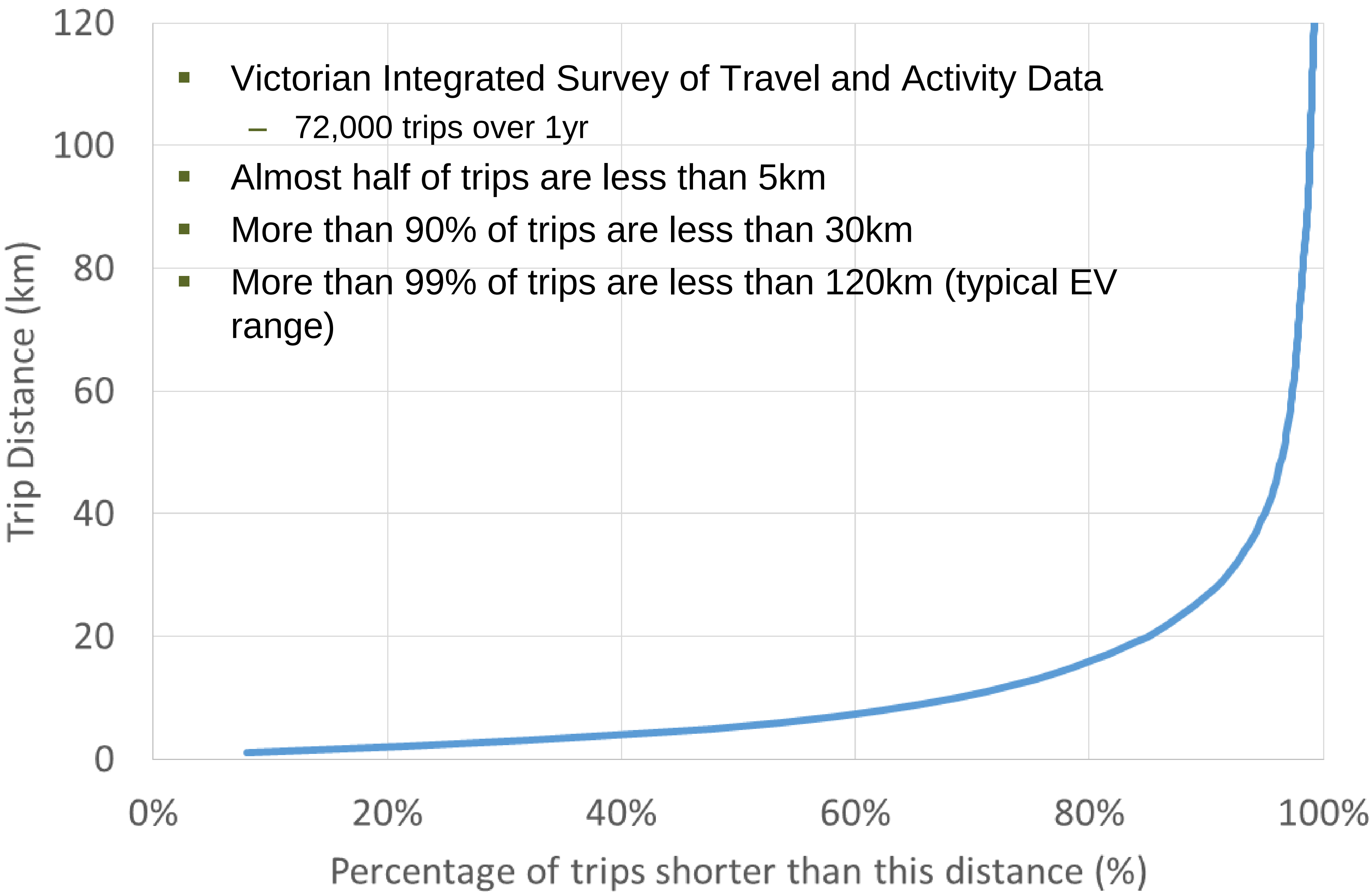


– Potential to address range anxiety with public awareness campaigns
  - Trials show range anxiety reduces once people use EVs regularly

Source: CSIRO 2011, Barriers to and policy solutions for EV adoption in Australia

Typical vehicle trips

- Victorian Integrated Survey of Travel and Activity Data
  - 72,000 trips over 1yr
- Almost half of trips are less than 5km
- More than 90% of trips are less than 30km
- More than 99% of trips are less than 120km (typical EV range)

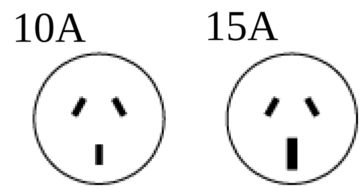


Charging infrastructure

Type of charging	Power requirements	Time to charge
Level 1: Standard Charge	10A – 15A 240V AC ~3.5kW	Total: 6 – 8 hrs Top up: 2 – 3 hrs
Level 2: Fast Charge	32A 240V AC ~7.5kW	Total: 2 – 3 hrs Top up: 30 mins
Level 3: Rapid Charge	125A 400-600V DC 50 – 75 kW	Total: 10 – 20 mins Top up: few mins

– Complex new technology is generally not required
  - Level 1 & 2 are sufficient for charging at homes, commercial premises and public charging facilities
  - Level 3 used only at dedicated “quick charge” facilities

Charging infrastructure



- Home charging can be done with a standard 15A plug
  - Can be installed by an electrician
  - Level 2 electrician can also install a second meter
  - Costs will depend upon site
- Main providers of commercial EV charging infrastructure:

better place

Bollard | Wall Mount | Domestic

chargepoint

Bollard | Pole Mount | Wall Mount | Domestic

Charging infrastructure costs - ChargePoint

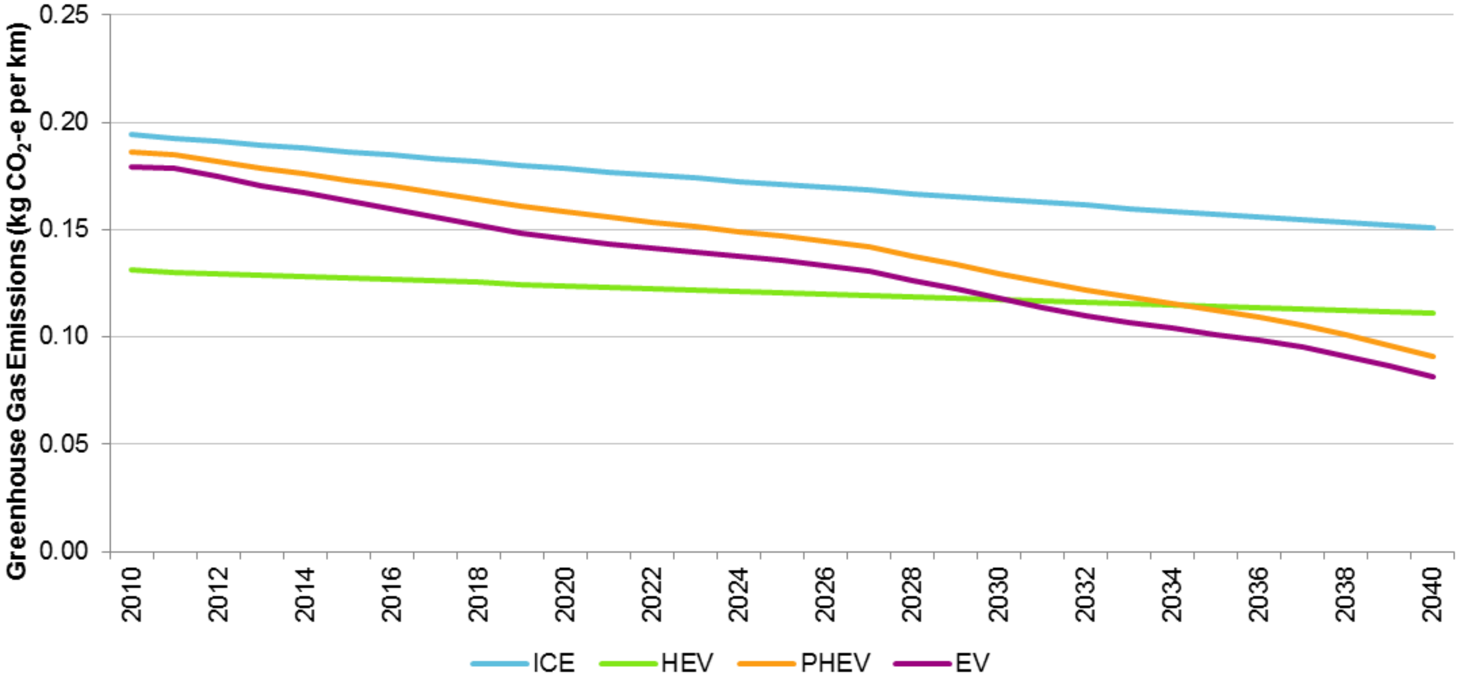
Unit and installation quoted separately

Location	Type	ChargePoint Product	Price per unit (single unit only)	Price per unit (2 – 24 units)
Indoor	Level 1	CT1500	$3,000	$2,800
	Level 2	CT500	$3,860	$3,550
Outdoor	Level 1	CT1500	$3,000	$2,800
	Level 2	CT2000	$6,350	$6,284

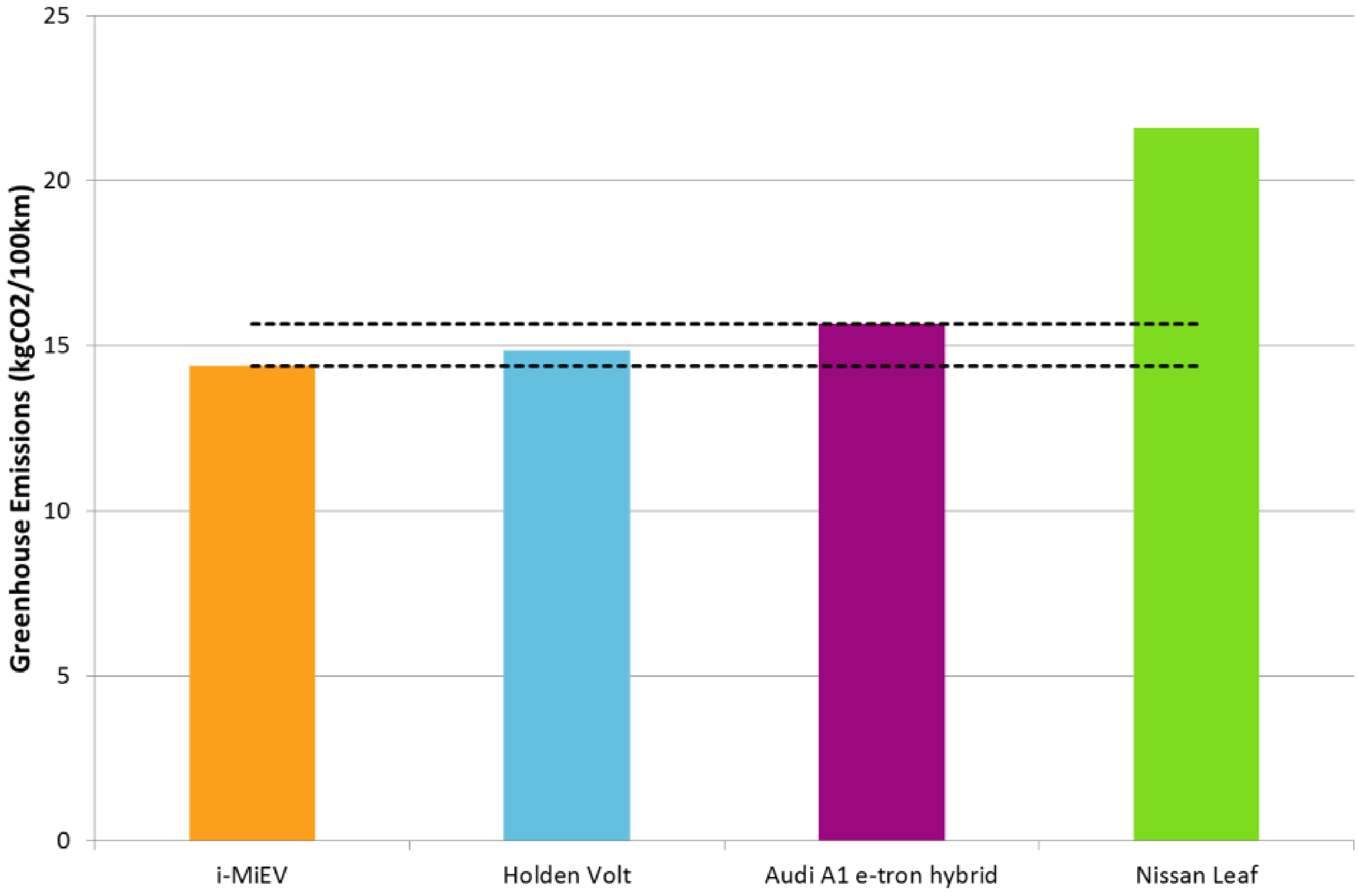
Location	Unit type	Indicative installation cost	Notes
Domestic garage	CT500	$600 - $1,200	Will depend upon site complexities.
Commercial car park	CT2000	$1,000 - $2,500	Will depend upon site complexities. Cost per installed unit decreases as the number of units installed increases. (eg. installing 5 x CT2000 could reduce the installation cost per unit to $800)
On-street bollard		$10,000 +	Includes development approvals, permits, electrical, earthworks, pedestrian and traffic control, civil reinstatement, etc.

Greenhouse emissions

- Average EV has moderately lower emissions than average ICE at present
- Improves over time as renewables enter the electricity market
- Can use 100% GreenPower



Individual vehicles vary



Not as good as walking, cycling and public transport

EVs don't address **traffic congestion** and **parking** issues, and have **embodied energy** in the battery and car components

Re-designing transport systems

Low cost personalised transit services:

- Road-going autonomous vehicles – genuine alternative to private car ownership?
- BEVs already outperform ICEs in high use applications

Electrified Freight, bus and ferries:

- Rapid recharging stations
- Catenary charging on main routes

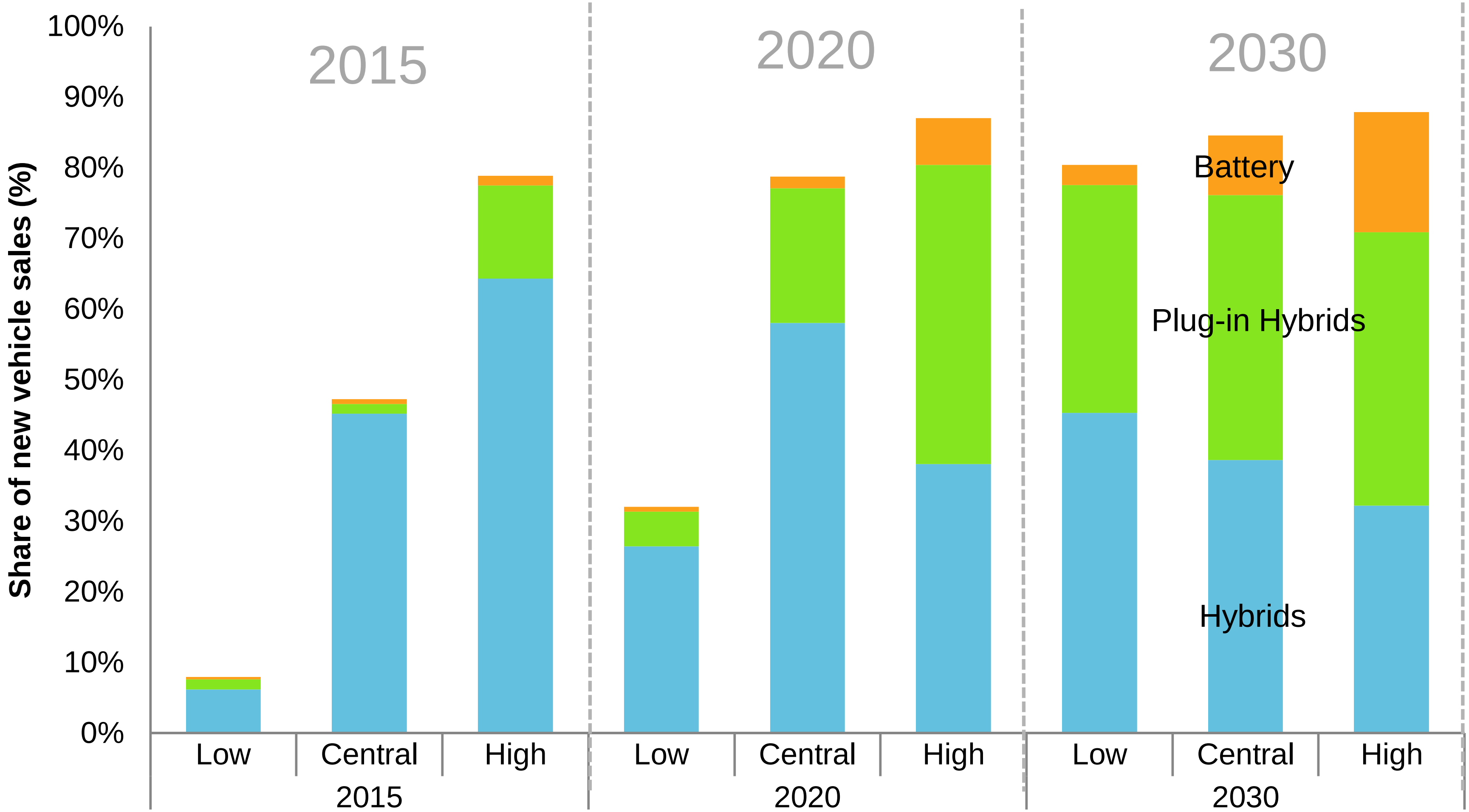
- Different grid impacts
- Increased opportunities for controlled charging?

FORECAST UPTAKE

MODELLING RESULTS

Forecast EV uptake

- **Inevitable**
- **Time** to respond
- But **uncertainty** around timing



"Don't expect any gradual effect in the e-mobility industry. Volumes increase exponentially and prices decline exponentially"

Clean Technica

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Factors influencing impact on electricity sector

Vehicle size

Uptake favours small vehicles in early years

Spatial clusters

Early adopter communities

Hybrids uptake

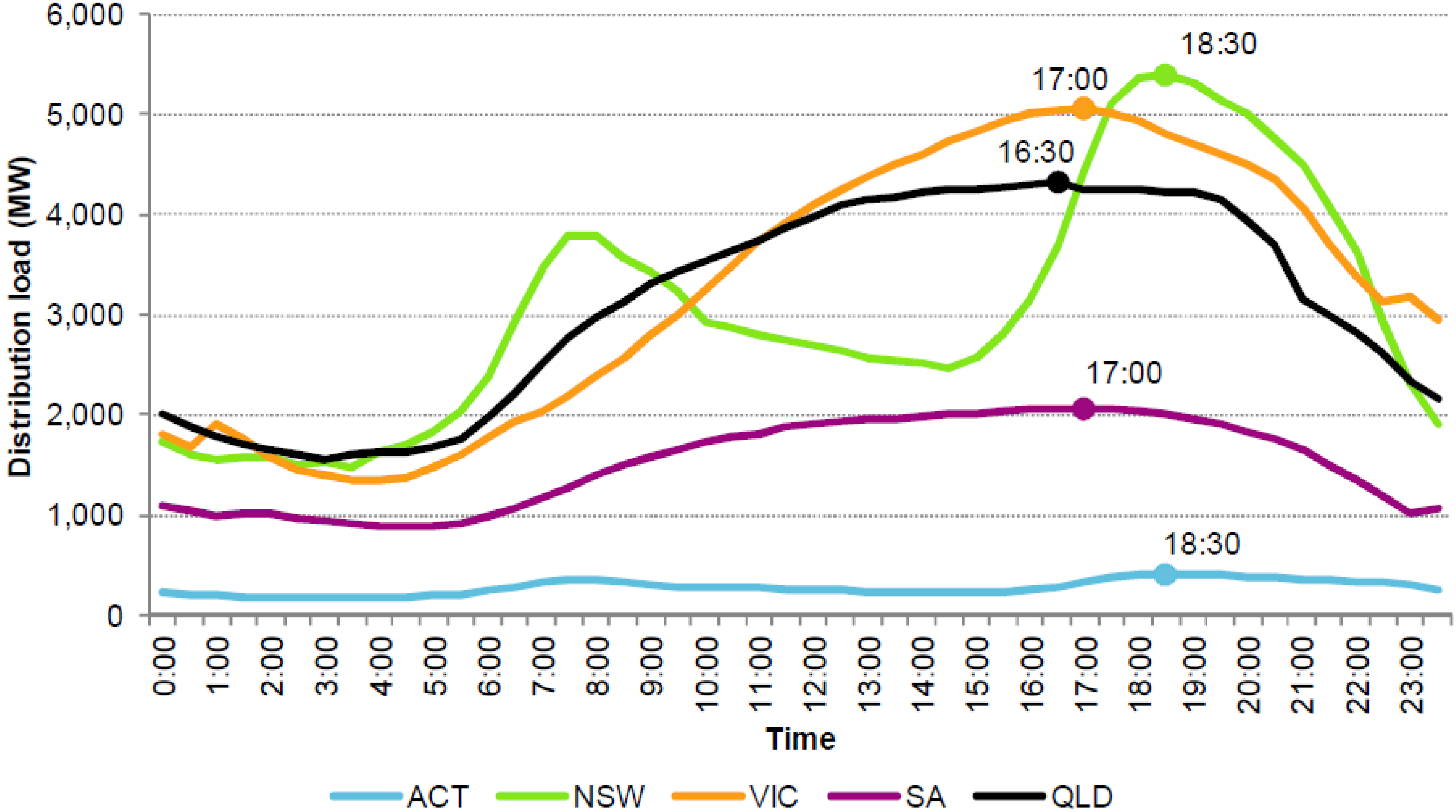
Uptake favours hybrids in early years, limits impact

Charge management incentives

Dictates network impacts

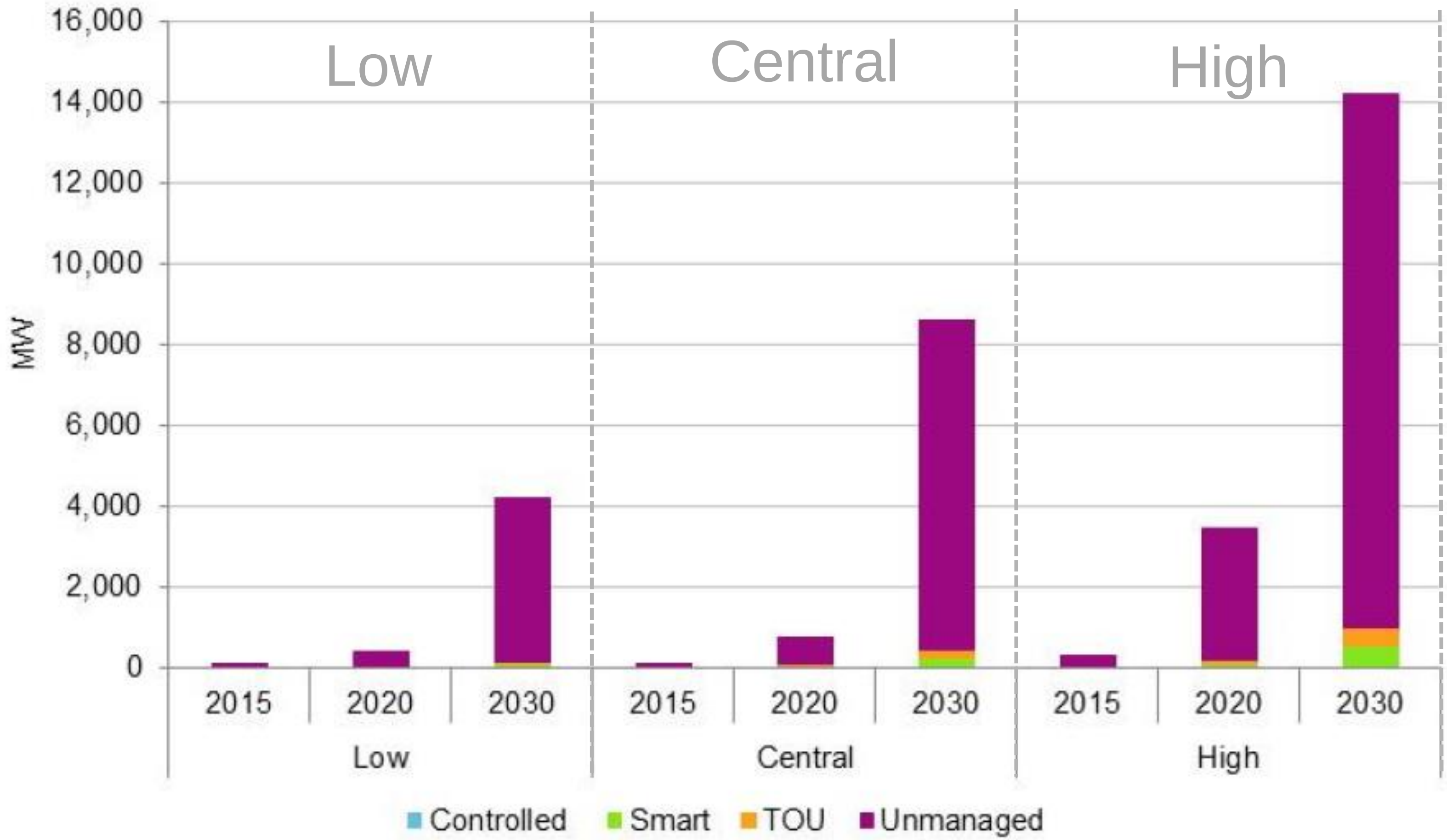
Impact on electricity sector

Maximum load days in 2010



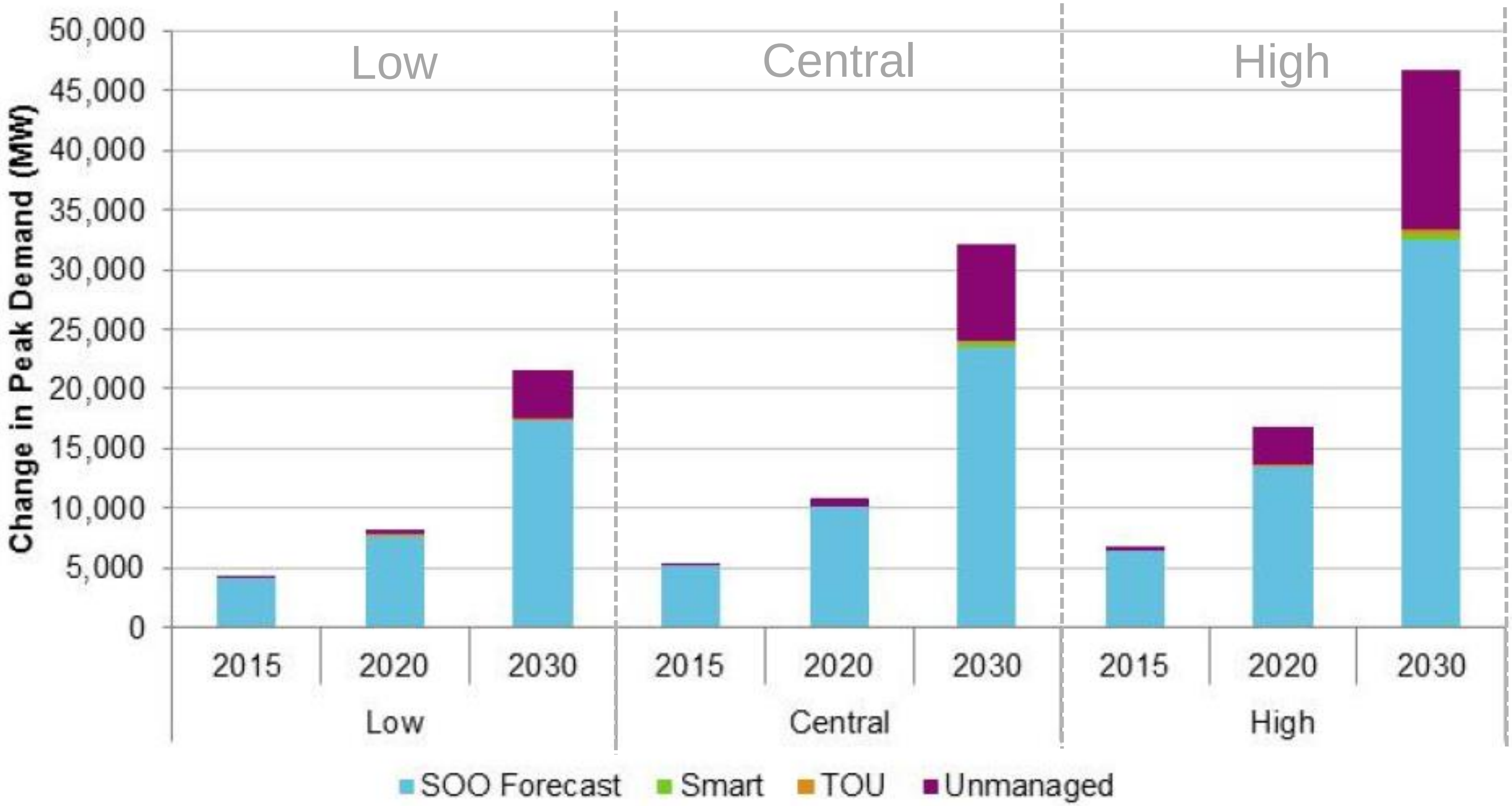
Source: Net System Load Profiles from AEMO (2011a).

Additional peak demand (NEM)



Source: AECOM. Note: The above chart shows estimated additional peak demand, with increments attributable to each charging type. For example, under the central take up scenario, by 2030, with unmanaged charging 8,600 additional MW are required; for ToU charging this is 410MW and for smart charging an additional 205MW.

Additional peak demand (NEM)



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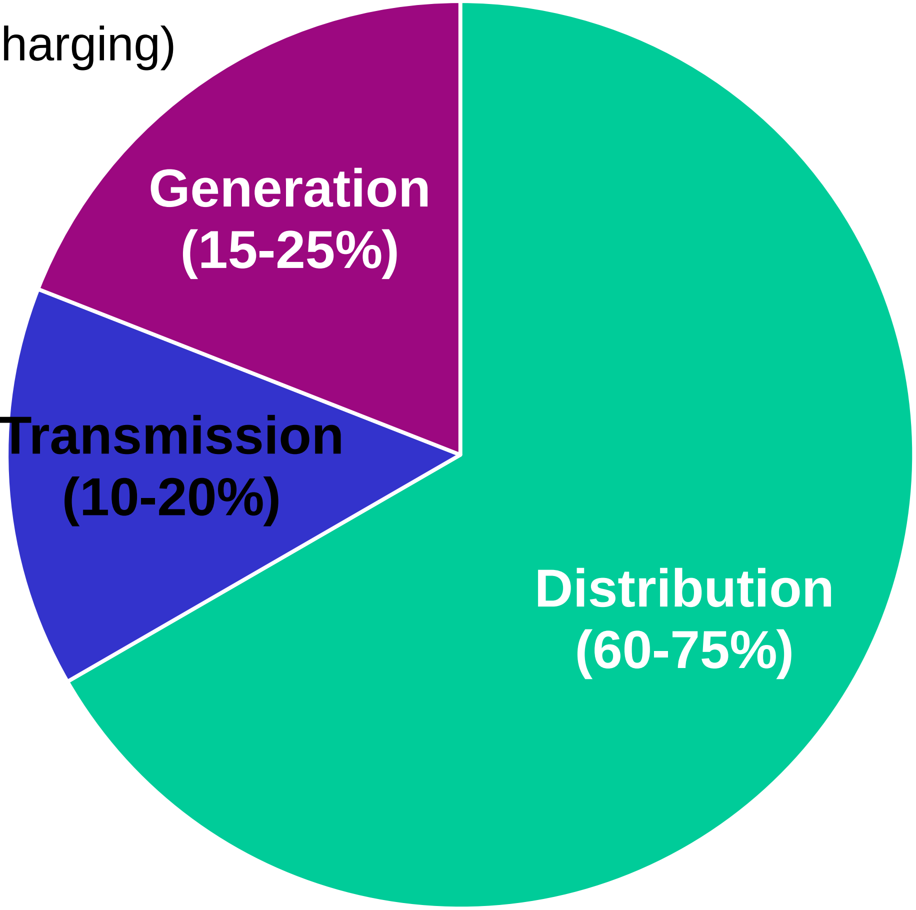
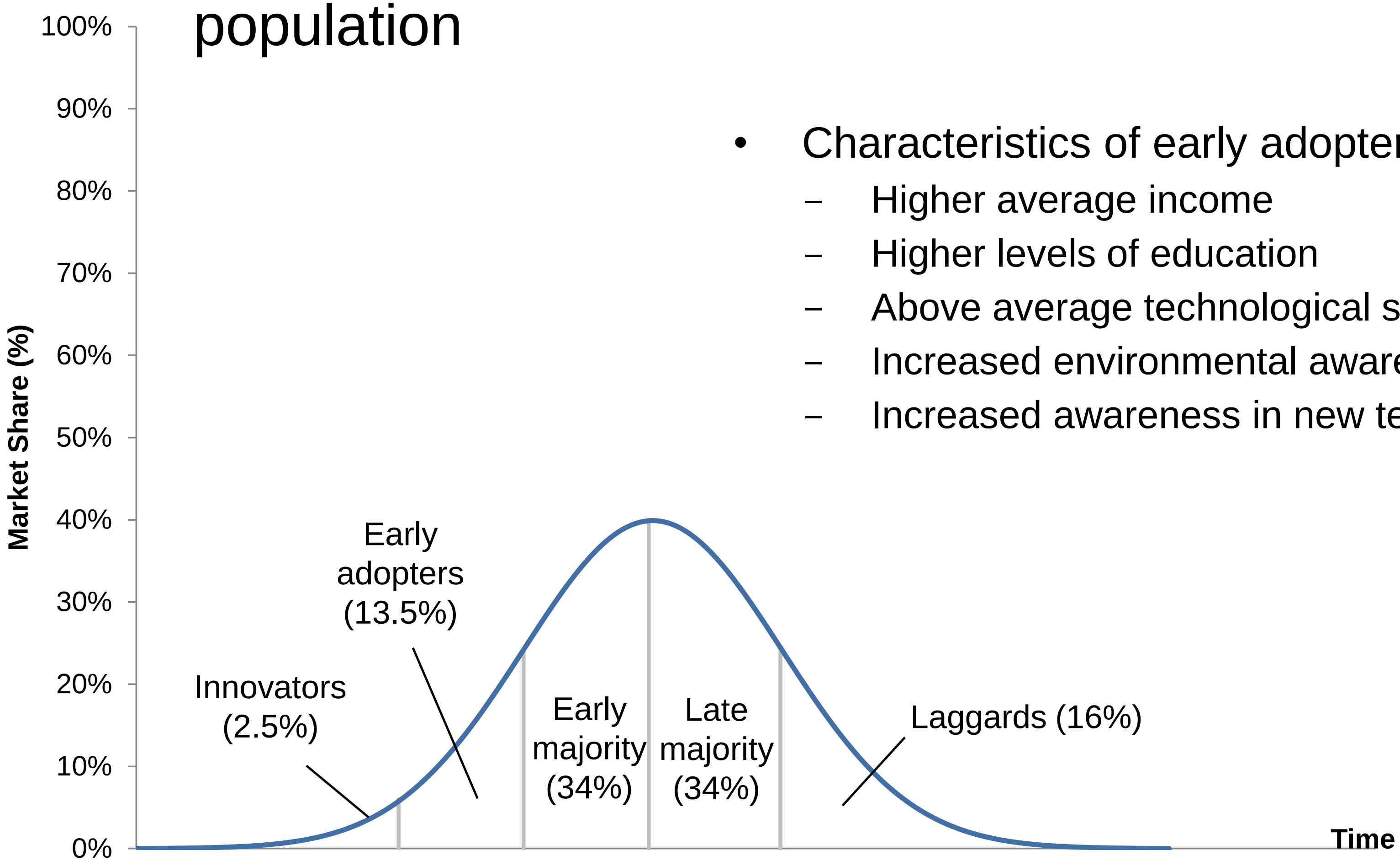
Additional costs

- $10,000 per EV
- (Central uptake, unmanaged charging)



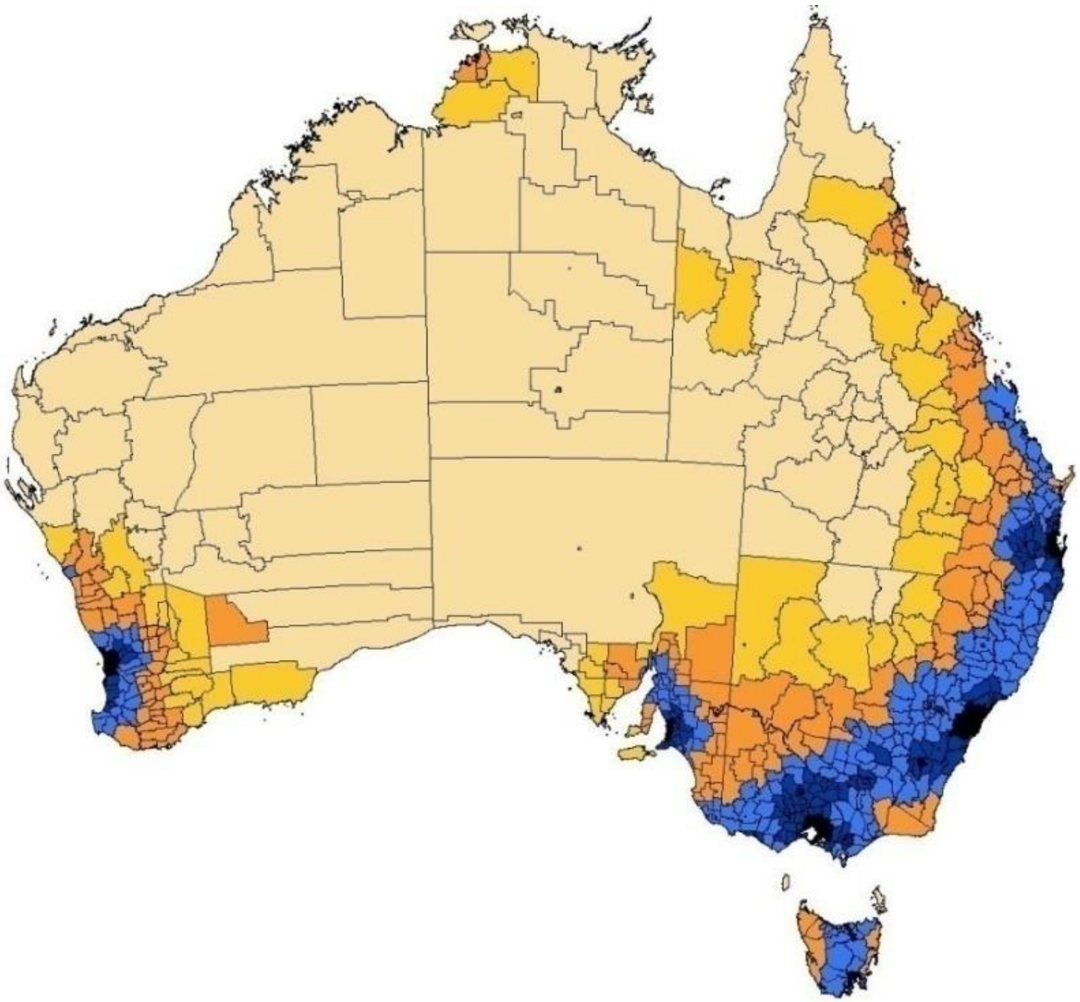
Early adopter clusters?

– Uptake of a new technology will vary across the population



- Characteristics of early adopters
  - Higher average income
  - Higher levels of education
  - Above average technological skills
  - Increased environmental awareness
  - Increased awareness in new technology

Spatial clustering



Some parts of the grid will experience strong uptake, earlier

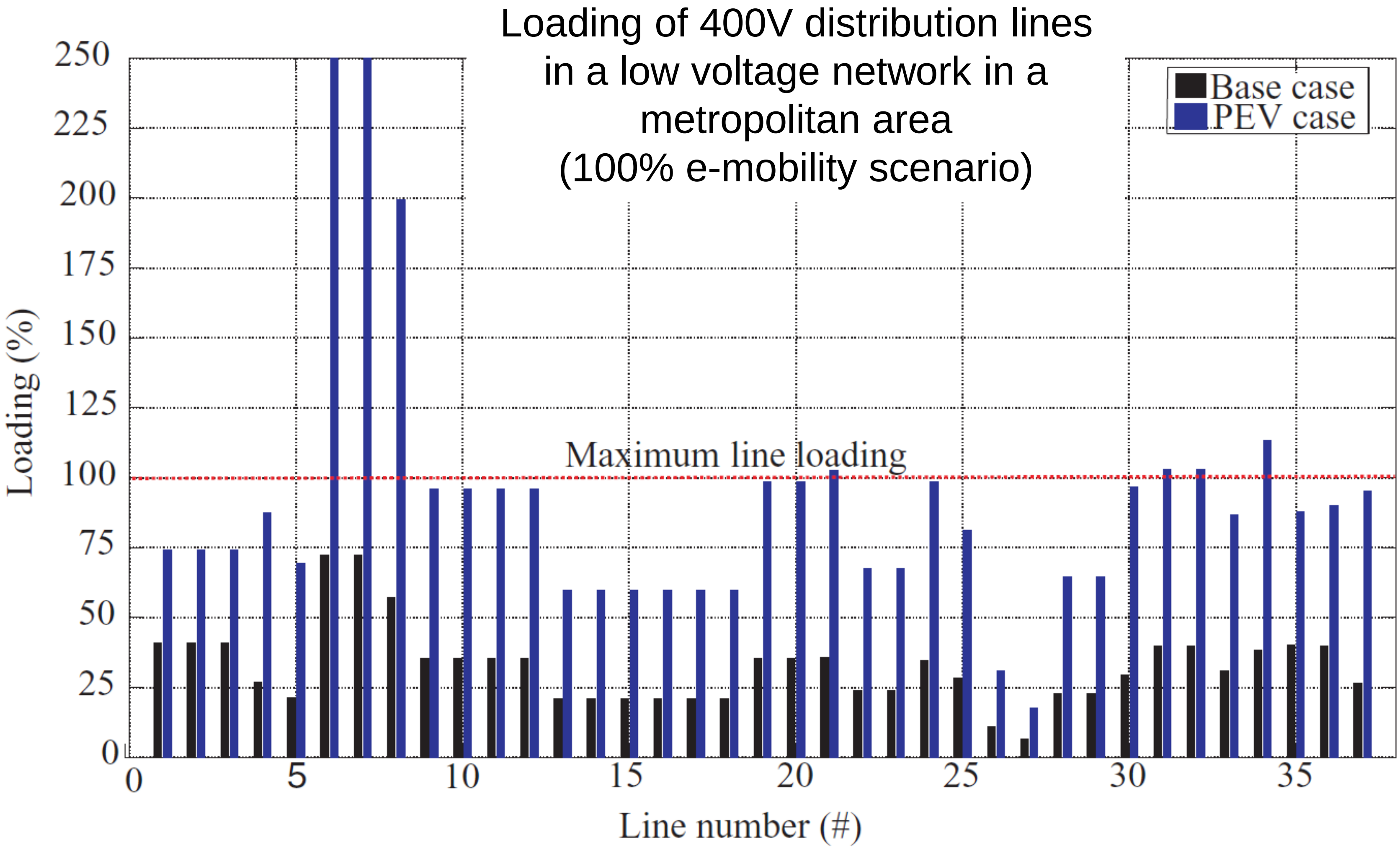
Additional challenges

What if Level 2 chargers become standard in-home?

Can distribution networks supply this demand (even off-peak?)

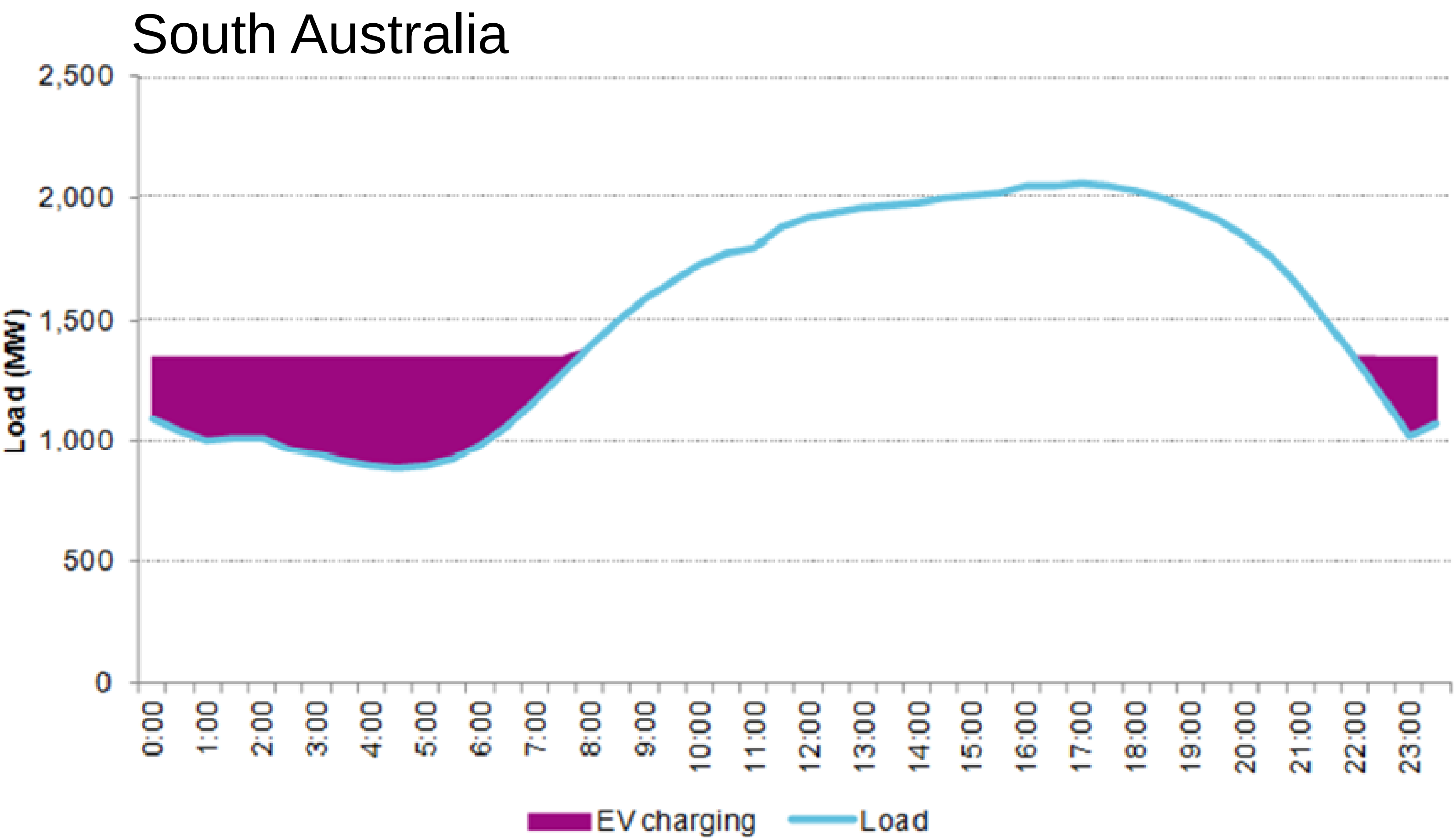
Upgrades can be expensive! (particularly in communities with underground lines)

Distribution lines overloaded



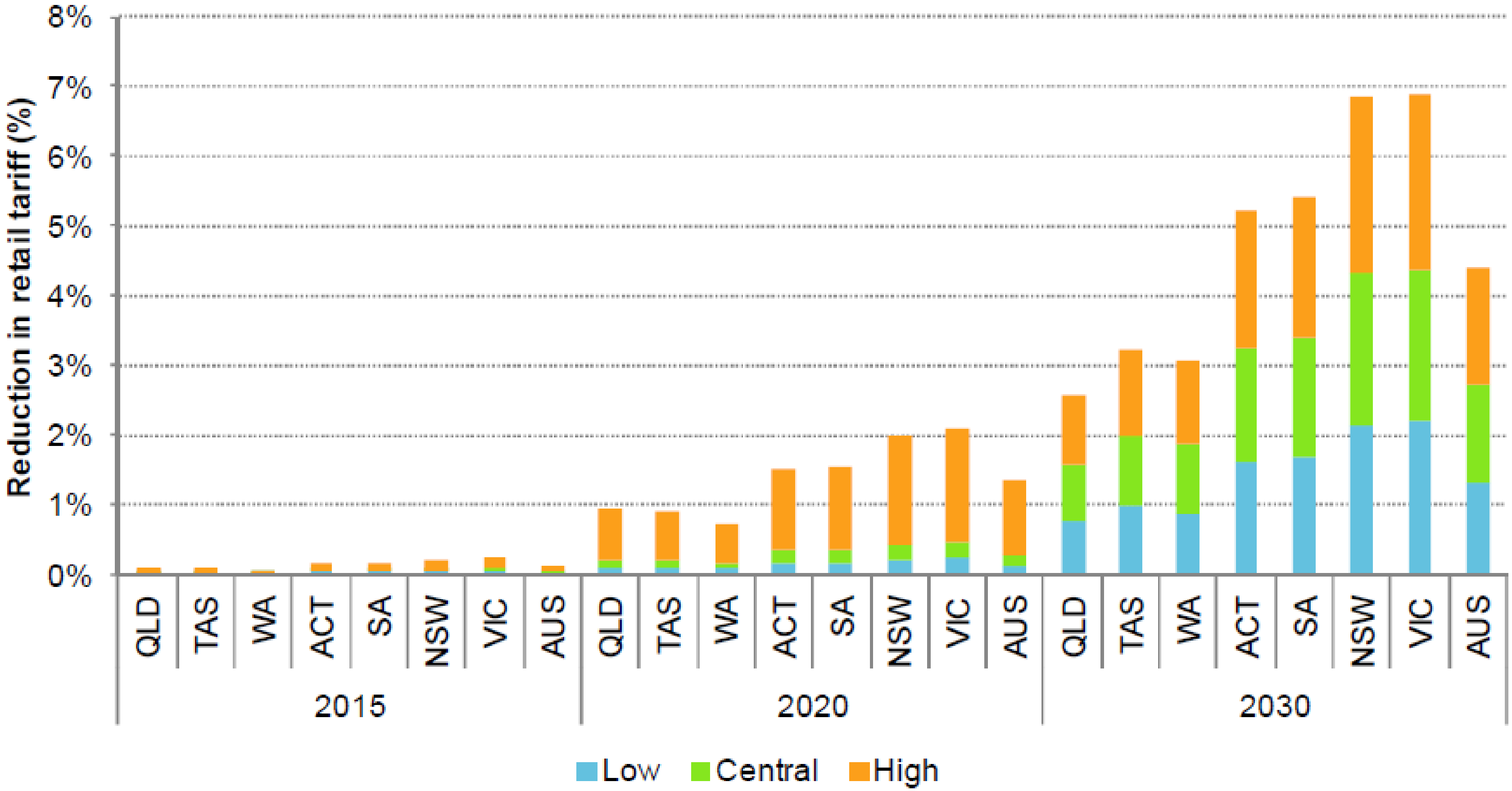
Galus, M. D., Vaya, M. G., Krause, T., Andersson, G. "The role of electric vehicles in smart grids", WIREs Energy Environ 2013, 2:384-400

Can the off-peak charging be accommodated?



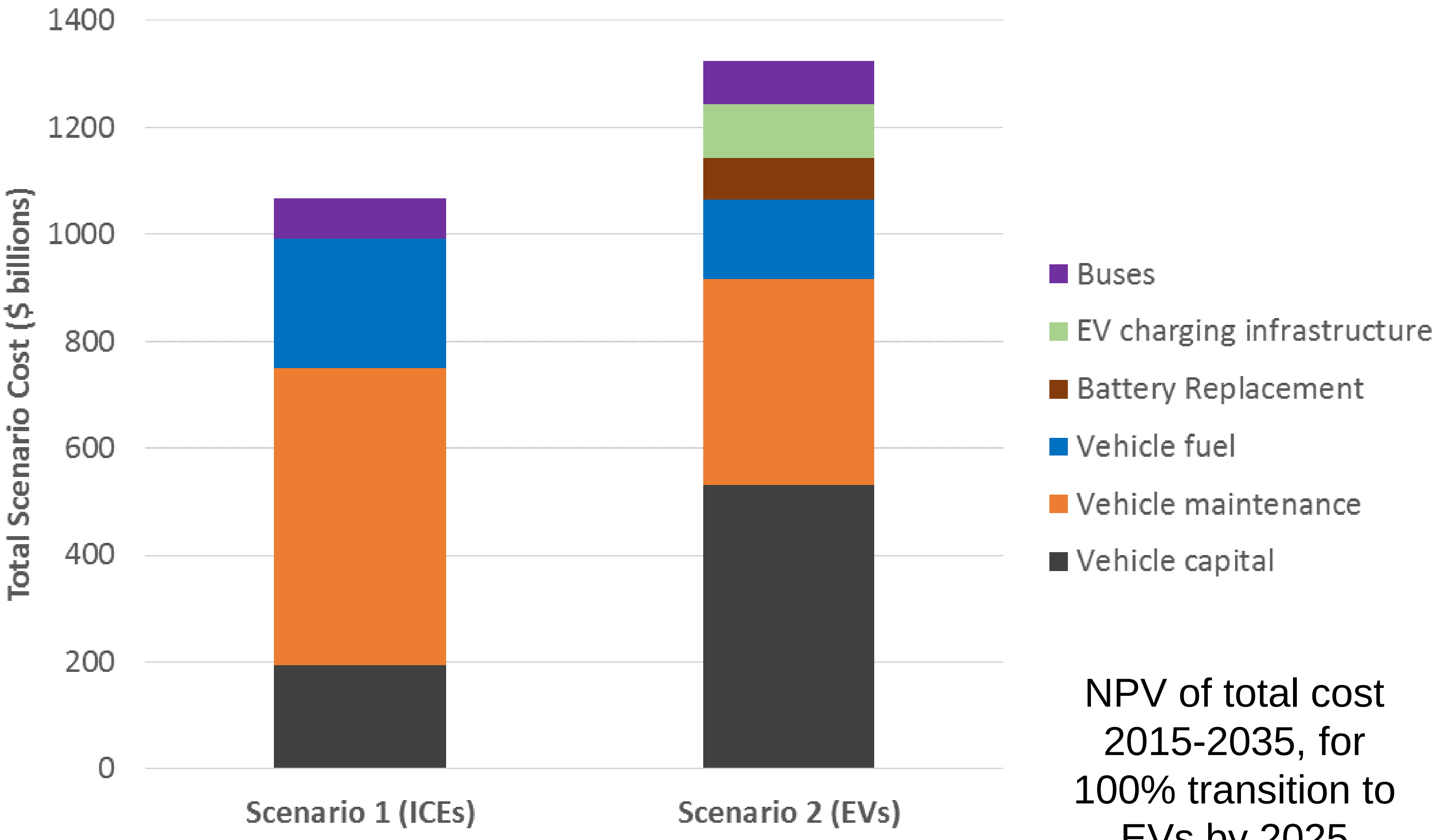
Source: Net System Load Profiles from AEMO (2011a), EV charging AECOM

Improved load factor



ONLY if charging is managed

What if we moved to 100% EVs?



NPV of total cost 2015-2035, for 100% transition to EVs by 2025

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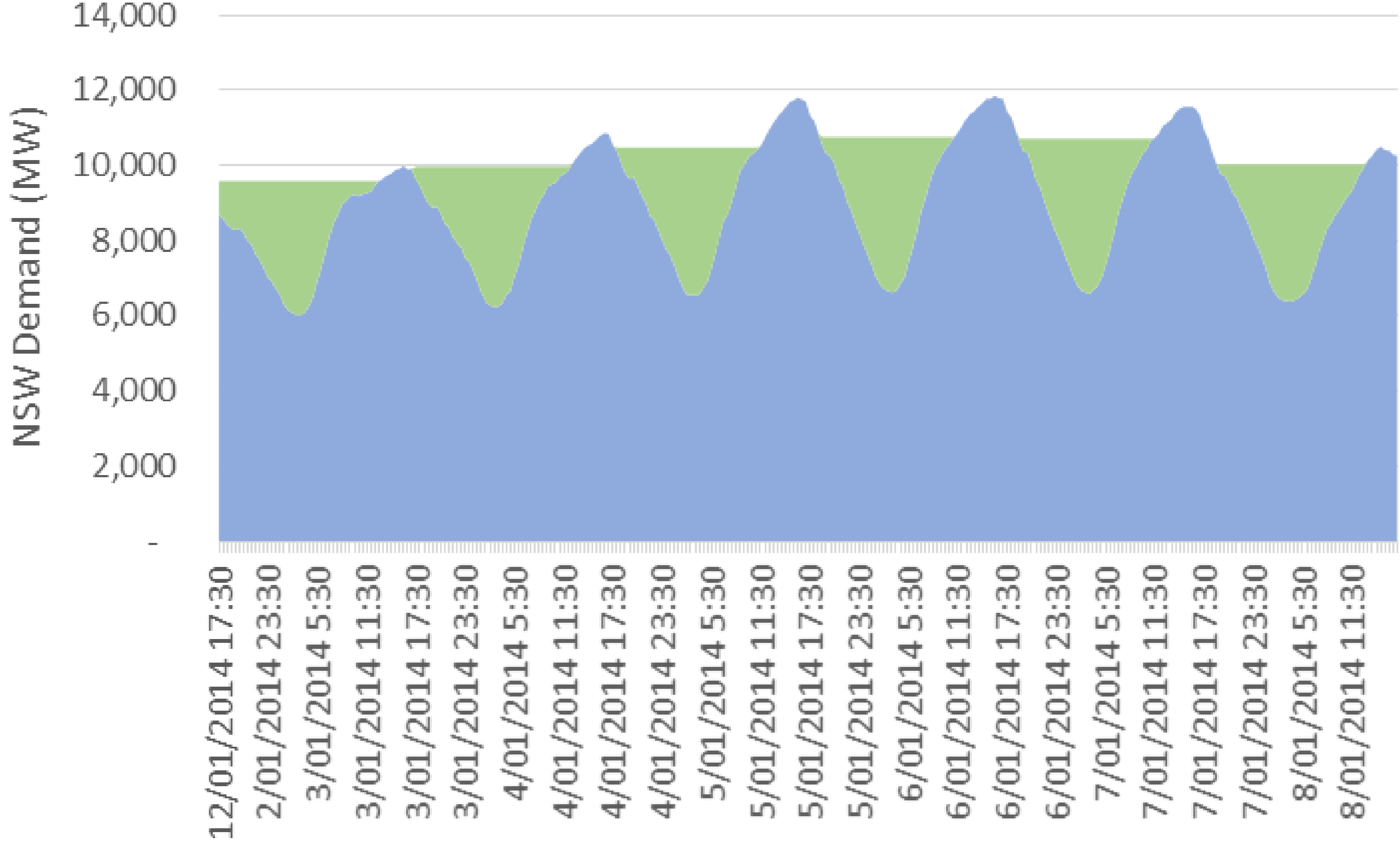
100% EVs

Significant additional demand, but with managed charging should increase network utilisation



POWER OF CHOICE REVIEW

AEMC RESPONSE TO EVS

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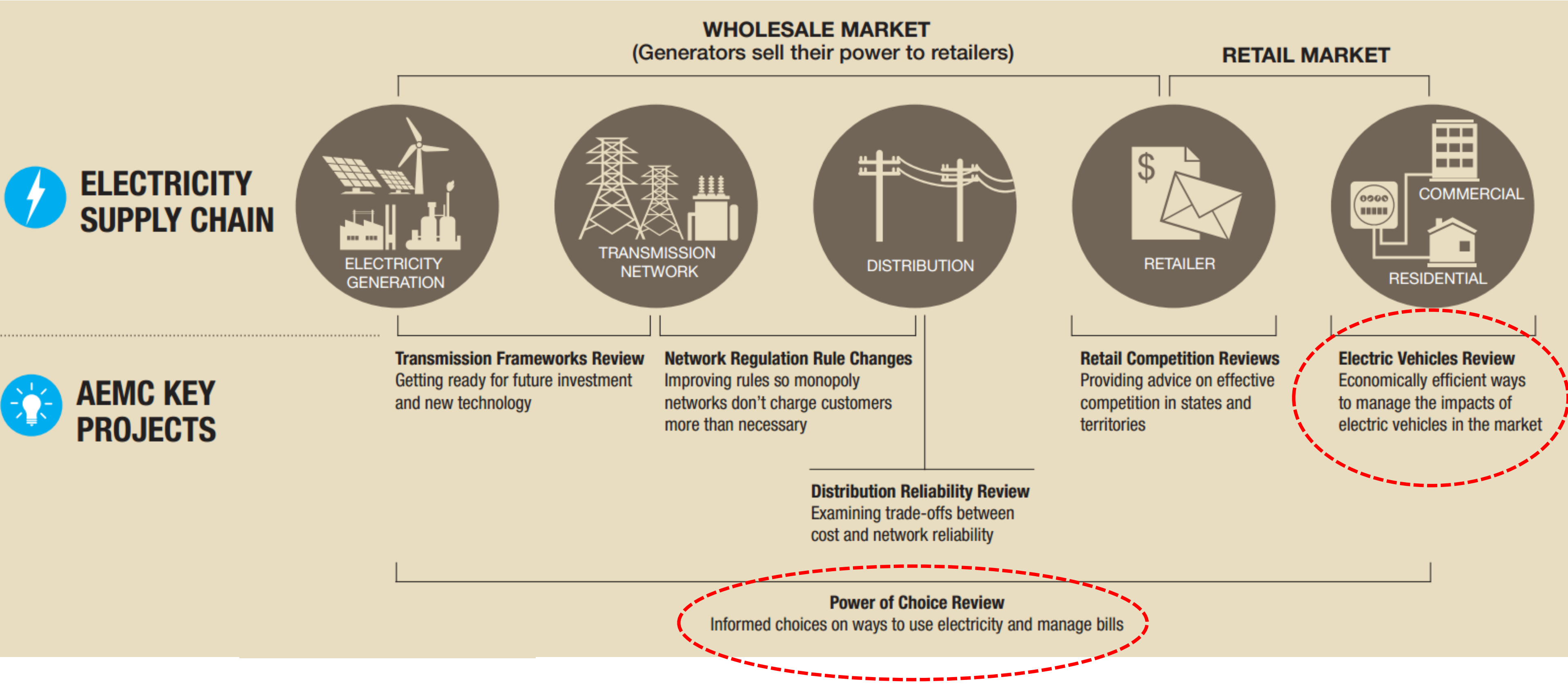
AEMC response to EVs

- EVs are just a potential form of Demand Response
- Prefer technology neutrality
- Consider under Power of Choice Review

AEMC Key Projects



Arguably highest priority
(defined by MCE)

Proposals in Power of Choice:

Time varying network tariffs

New DSP mechanism

- DSP can directly participate in the wholesale market and receive the spot price

New categories of market participant

- Allowing consumers to engage with multiple different parties for different services

Distribution network incentives

- Making DSP a part of network planning
- Improve framework for how distribution network tariffs are determined

Enabling technology (metering)

- Overarching framework to encourage commercial investment in better metering

Access to consumption information

- Better access for customers

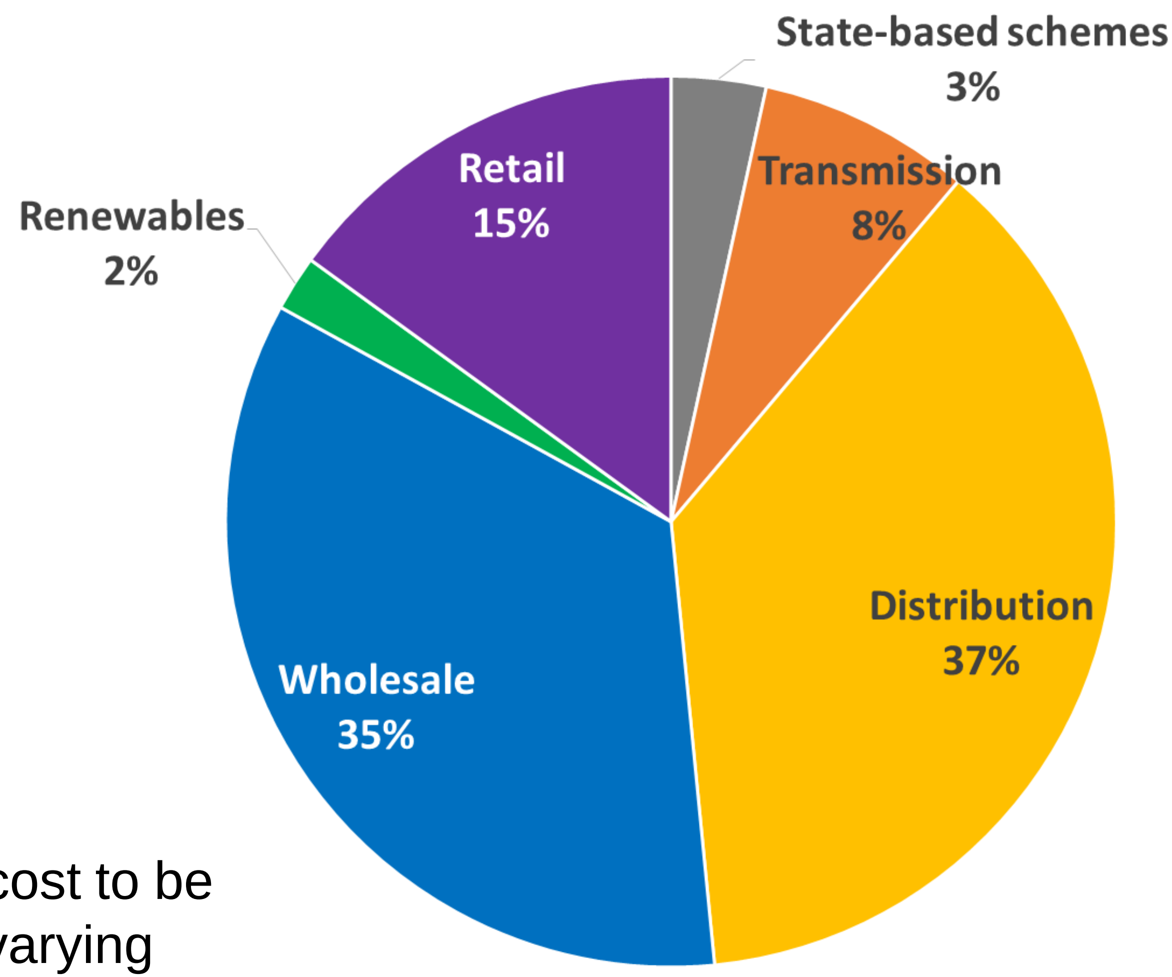
Energy efficiency measures and policies

- Greater coordination between measures and policies for EE and DSP

Time varying network tariffs

- Mandate time varying tariffs for network components of consumer bills
  - More cost reflective
  - Most cost related to peak demand periods
  - Encourage customers/retailers to respond appropriately
- Retailers remain free to decide how to include in retail offers

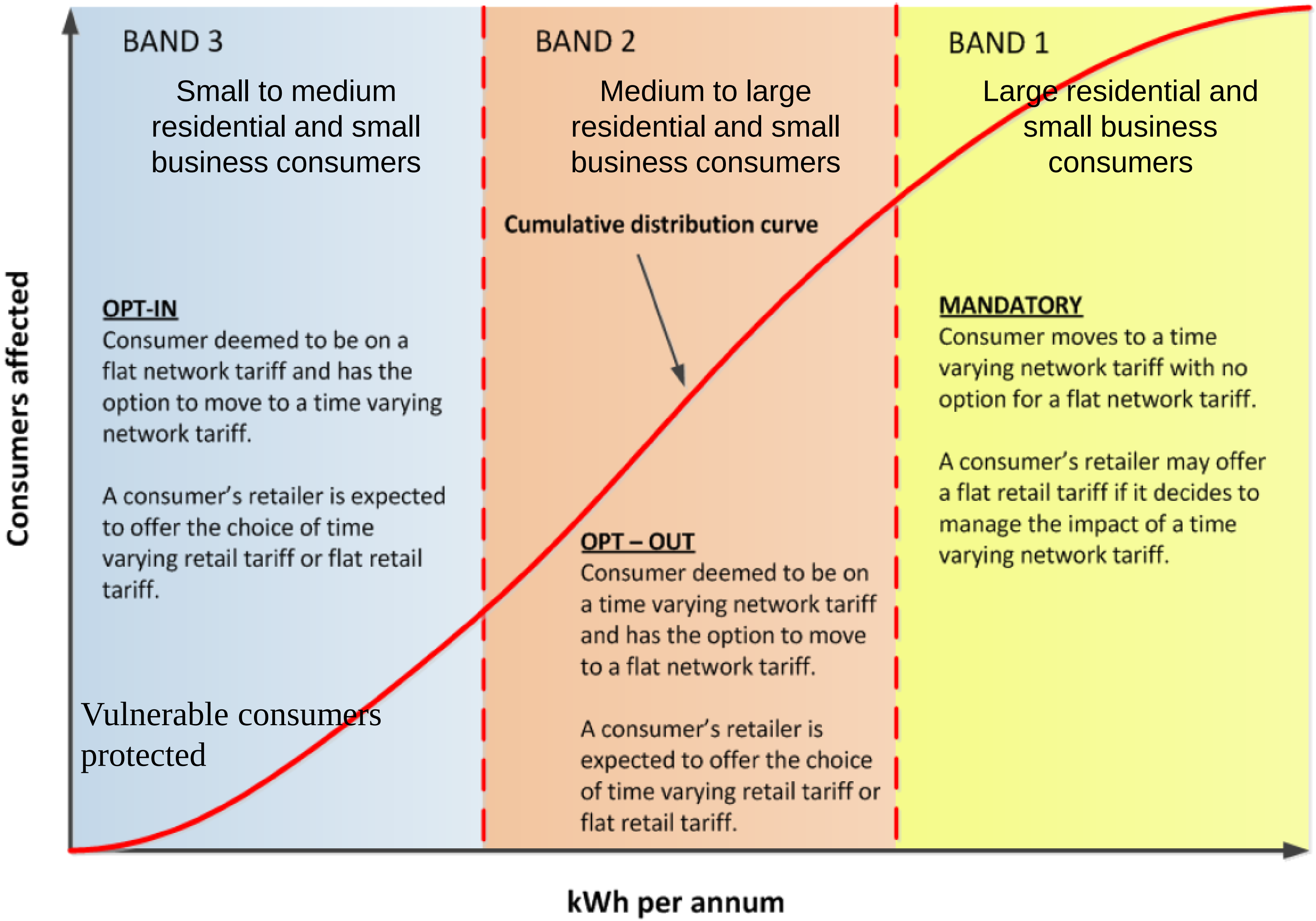
Components of retail electricity prices



80% of cost to be
time-varying

Source: AEMC, Possible Future Retail Electricity Price Movements: 1 July 2011 to 30 June 2014, Dec 2011

Introduce gradually to facilitate customer engagement



VEHICLE TO GRID (V2G)

POTENTIAL AND CHALLENGES

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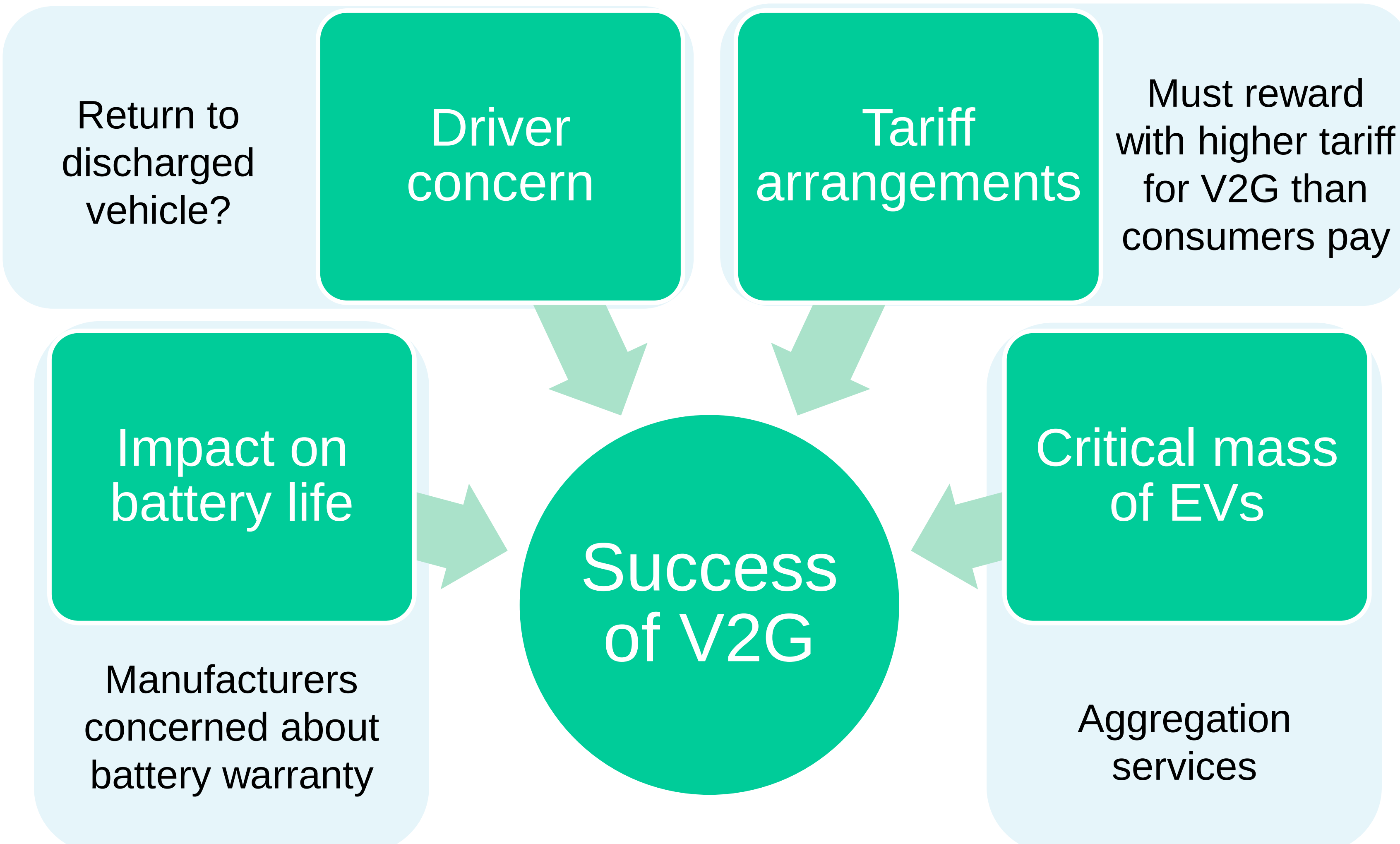
EVs as distributed storage

- Large number of grid connected batteries
- Use for distributed storage?
- Needed for integration of renewables?

Distinction between:

1. Managed charging (delay charging temporarily), and
2. V2G (supply energy back to grid)

Factors influencing success of V2G



Possible areas of value from storage

Price arbitrage

- But peak/off-peak price difference is usually not very large

Frequency Control Ancillary Services (FCAS)

- But FCAS is cheap in the NEM

Typically insufficient value to justify capex (battery) or inconvenience (EVs)

Defer network augmentation

- Most likely area of sufficient benefit to justify cost
- Largely unrelated to renewable integration!

EVs vs Large-scale battery storage

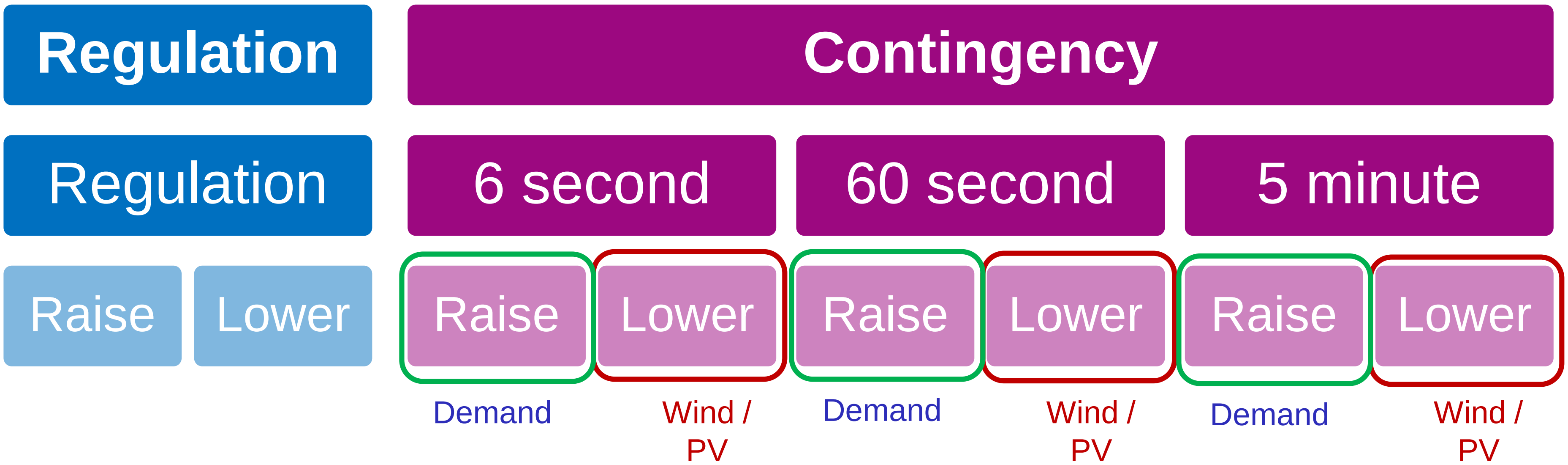
Large-scale batteries

- Significant up-front cost
- Installation justified mostly for network deferment
- Minimal operating cost
- Once installed, use for price arbitrage & FCAS also

EVs

- Minimal up-front cost
- Potentially high “inconvenience” cost
- Business case likely to be best for rare use in extreme circumstances (eg. Contingency ancillary services)

EVs providing contingency FCAS?



- EVs (and some other types of demand) may be well suited to contingency raise services:
  - Rarely called upon
  - Aggregate to provide large quantity provided
- Contingency services generally more expensive to provide at present (larger reserve capacity required)
  - Renewables and demand management may help reduce contingency FCAS costs

V2G options

Vehicle to Grid (V2G)

- Vehicle supplies to grid – technical challenges
- Tariff will need to be sufficiently high

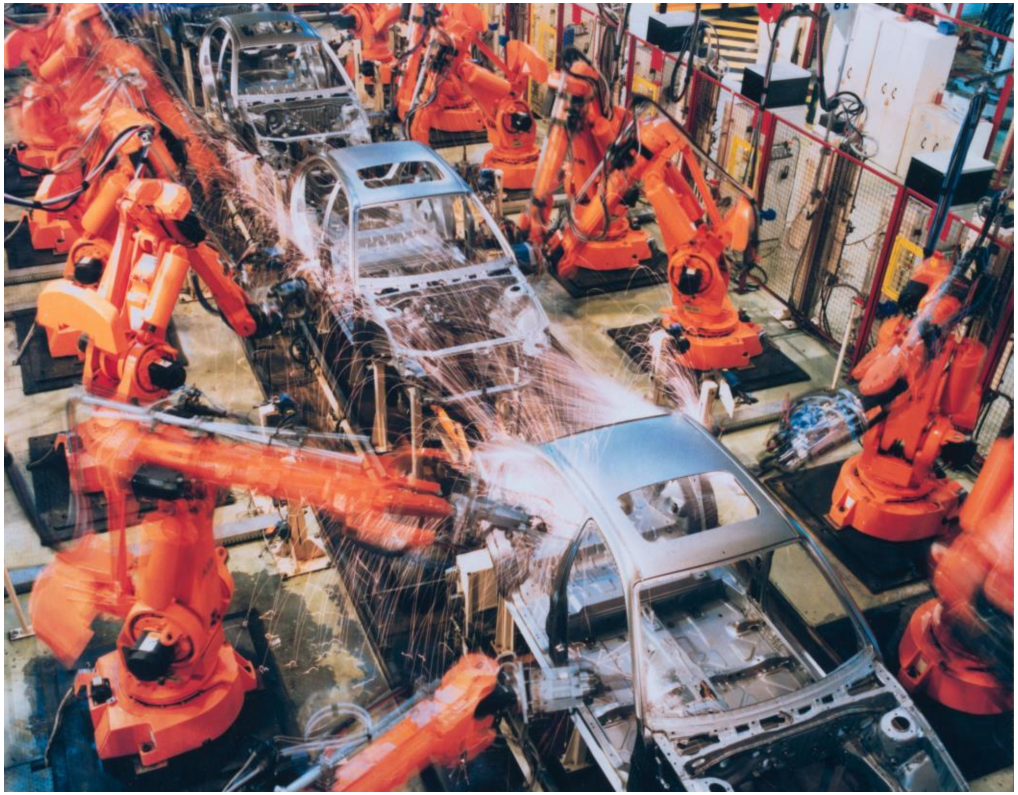
Vehicle to Home (V2H)

- No export to grid – technically simpler
- Only attractive where home is on strong ToU tariffs (CPP)

Managed charging may provide the vast majority of benefits, without most of the hassles!

Another way to contribute?

- Most significant contribution of EVs may be in mass production of batteries
- Stimulation of technology improvement
- Battery re-use?



Conclusions

- Transition to EVs is inevitable
  - Uncertainty around timing
- Incentives for charge management will be essential
  - Potentially very significant impacts on peak demand
  - Power of Choice Review
- Vehicle to Grid may have limited applications
  - Ideally available but called upon rarely

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