Electrified Transport Opportunities for Low Carbon Mobility in Australian Cities

Never Stand Still | Faculty of Engineering

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Introduction

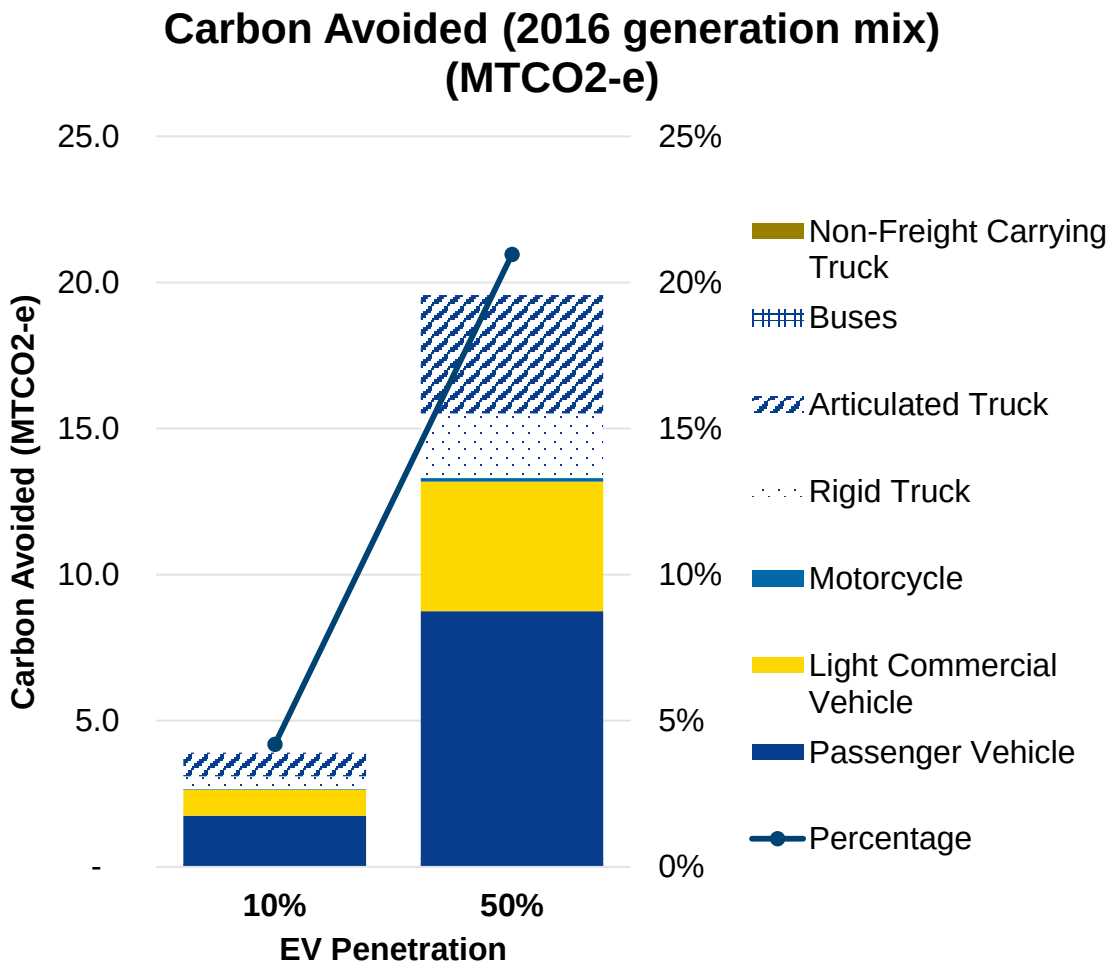
- EV uptake is growing across all modes but uptake remains relatively low in Australia
- High EV uptake in other countries linked to policy decisions[1]
- Many Australian groups / companies are calling for EV policy support[2]
- Most EV policy research & industry reports focus on e-cars.





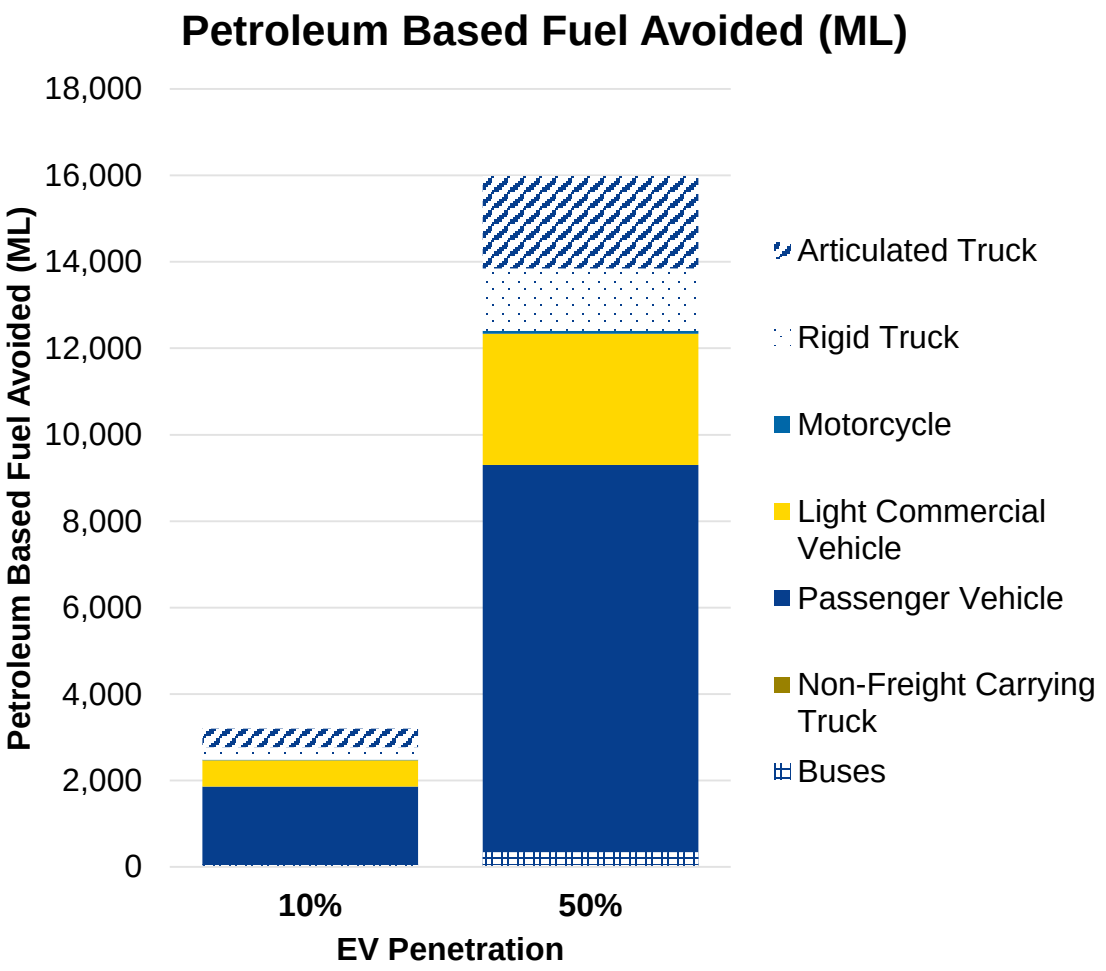

[1] To varying extents for various policy types. (APEC 2017), (IEA 2018)
[2] Such as (Energeia 2015), (Climate Works 2018), (Climate Change Authority 2018)

EV Benefits to Society



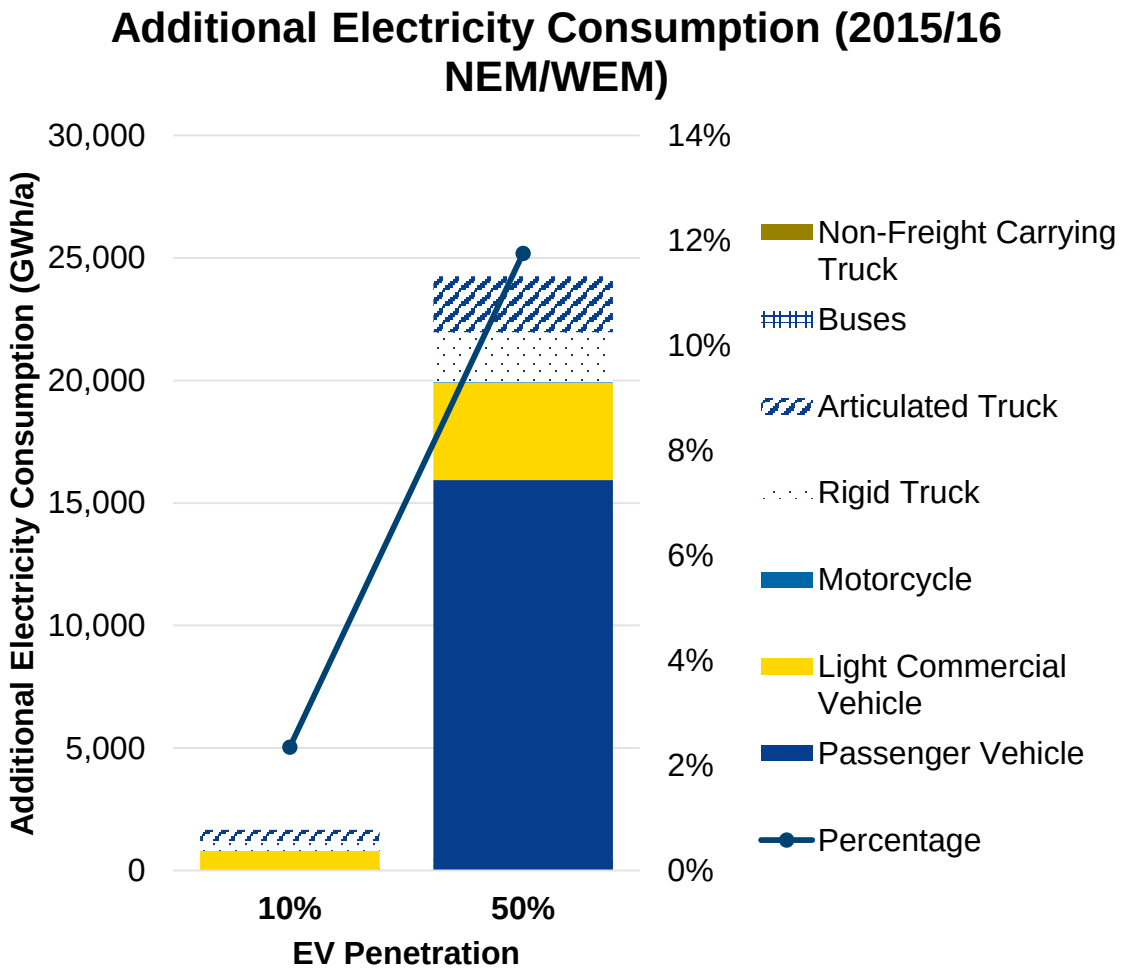
- *Average BEV energy intensity figures per mode* (Mellino, Petrillo et al. 2017)
- *Australian Emission factors (Australian wide)* (DOEE 2016)
  - *Scope 1 factors for gasoline, diesel and LNG and Scope 2 factors for electricity.*
- *Total domestic transport emissions of 96MTCO2 in 2017* (Commonwealth of Australia 2017)

EV Benefits to Society



- *Total domestic crude oil consumption in 2015 57,966 ML crude oil* (DOEE 2017)
- *Vehicle petroleum-based fuel consumption is calculated using vehicle numbers, distances and fuel consumptions per year from ABS Survey of Motor Vehicle Use, Australia in 2017 based on 2015/16 data* (ABS 2017)

EV Benefits to Society



- *Total electricity consumption from EVs includes vehicles in all states*
- *% is calculated as a proportion of NEM (191,777GWh, 2016) and WEM (18,895GWh, 2015/16* (AEMO 2017)*) demand only and excludes all other electricity demand.*

Contents

1. Uptake of EV (multi-modal)
2. Drivers & Barriers for EV uptake in Australia
3. Considerations for designing multi-modal policy
4. Global policy examples

n.b. No policy recommendations.

Method

Literature review

- Academic
- Industrial

- **Senate Select Committee on Electric Vehicles 2018:**
  - 136 stakeholder submissions
  - Report due 4 Dec
  - LCV, Bus, Bicycle, Car, Motorcycle
  - Grid, Transport & Planning sectors

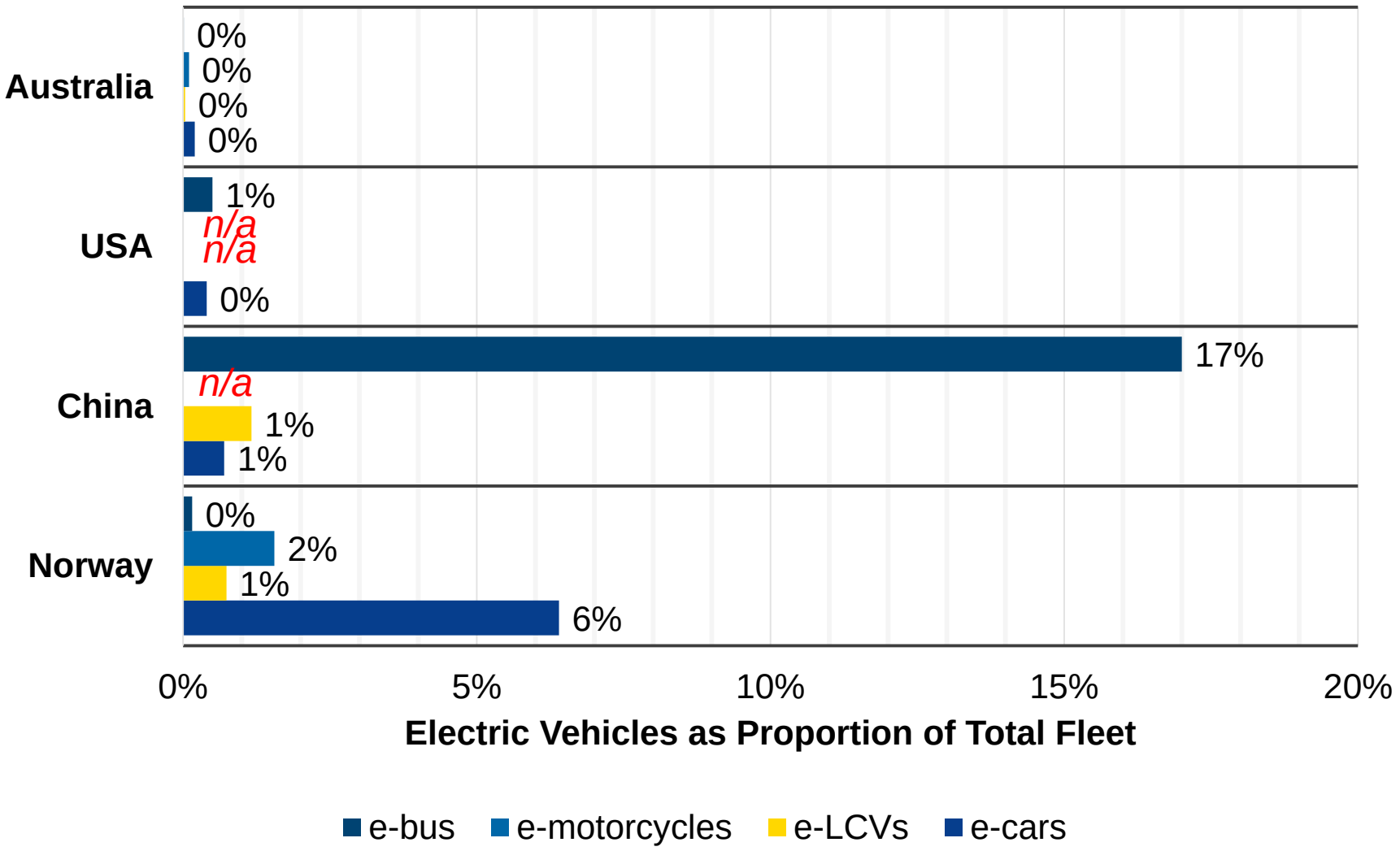
(see paper for sources)

High-level analysis

- International EV reports
- Country vehicle registration data
- Census data
- Average fuel intensity (kWh/km)
- Average costs (electricity, petrol, diesel)

(See paper for more detail)

EV Uptake



Estimates only and derived from numerous sources including (IEA 2018), (BNEF 2018), (ABS 2017), (Statistics Norway 2018), (National Bureau of Statistics of China 2018) and (U.S. Department of Transportation 2017)

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E-mobility Drivers for the Consumer

Financial

- **Maintenance Cost Reductions**
- **Fuel Cost Savings *(all)***
  - *Fuel efficiency (L/km or kWh/km)*
  - *Fuel prices ($/kWh or $/L)*
  - *Driving distance*

Non-Financial (not directly)

- **Noise reduction *(buses, LCVs)***
  - Potential to avoid noise curfews
    - *"could be a game changer for supermarket operators who are currently restricted from accessing some stores with heavy vehicles at night due to curfews"* [1]
- **Environmental *(all)***
  - Key reason to purchase for Australian bicycle first adopters [2]
  - ACCUs in ERF
  - "Green marketing"

[1] (ALC 2018); [2] (Johnson and Rose 2013)

E-Mobility Barriers for the Consumer

1. **Purchase Costs**
   - Purchase cost are typically be 1-3 times that of an ICE for most modes
     - *"35 per cent would be willing to buy an electric vehicle if it were at price parity with similar petrol or diesel options"* [1]

	ICE ('000 $)	EV ('000$)	Cost Prem.	EV Model
Car (small)	$13- $65 (Mirage-AudiS3)	$27-$69	1-3	Chevrolet Spark Nissan Leaf Renault Zoe BMW i3
Bicycle (road)	$0.3-$10	$1.5-10+	1-3	Velectrix Urban2 – premium
Van	$29 - $40	$40-$52	1-1.8	ACE Cargo Van Renault Kangoo ZE
Bus	$280	$300-$400	1.5-2[6]	BYD Blu Bus (*speculated*)

2. **Other Costs**
   - Skilled drivers *(buses, LCVs)* [2]
   - Maintenance & replacement procurement time *(buses, LCVs)* [2]
   - Redesigned facilities & timetabling *(buses, LCVs)* [3]
   - Increased weight class penalties (*buses, LCVs)* [4]
   - Reduced payload capacity [5]

[1] (Climate Works 2018) [2] (Margaritis, Anagnostopoulou et al. 2016) [3] (Quak, Nesterova et al. 2016), [4] (Fairweather 2018) & (Humphries 2018) , [5] (ALC 2018), [6] (MRCagney 2017)

E-Mobility Barriers for the Consumer

3. Range Anxiety

- Public charging may be required especially for commercial vehicles
- Queuing Anxiety *(taxis, LCVs)* [1]

	Battery Range (km)	Ave. Daily Distance (km) **
Car	40 – 350	35
Bicycle	15 – 65	2[5]
Motorcycle	40 – 300	25
Van	100 - 400	200[3]
Bus	90 - 300	80
Taxi	40 – 350	310[4]

*** Ave. daily driving distance taken from census data unless otherwise noted*

4. Grid Augmentation

- Centralised charging for fleets
- Principle agent problem *(buses, LCVs, cars, taxis)* [2]
- Grid study waiting times etc.

	Demand (kW)		
	Slow	Mid	Fast (DC)
Car	3-7	22	40-120 (350)
Bicycle	0.25	n/a	n/a
Motorcycle	3.3	n/a	n/a
Van	3-7	22	40-120 (350)
Bus	15-22	22-50	50-300
Taxi	3-7	22	40-120 (350)

[1] (Morganti and Browne 2018), [2] (Quak, Nesterova et al. 2016), [3] https://reneweconomy.com.au/first-all-electric-delivery-van-available-to-aussie-freight-operators-70082/ ; [4] (CIE and IPART 2017), [5](Arundell 2007)

Summary: Drivers & Barriers of E-Mobility to Consumer

	e-cars	e-bicycle	e-motorcycle	e-taxi	e-LCV	e-bus
Drivers						
Reduced operating costs						
Reduced local emissions						
Reduced carbon emissions						
“Green” marketing						
Silent operation						
Barriers						
Insufficient range						
High upfront cost						
Access to public charging						
Limited model availability						
Grid infrastructure augmentation						
Weight restrictions & capacity						
Queuing risk						

Where **white** = not significant / relevant, **light** = somewhat significant, **dark** = significant

E-Mobility Policy

Policy Category	Policy Instrument	e-car	e-bike	e-motorcycle	e-taxi	e-LCV	e-bus
Regulatory	Vehicle Emission Standards						
	Standardisation of Infrastructure						
	Weight class exceptions						
Road Related Taxes and Charges	Luxury Car Tax						
	Import Tax						
	Stamp Duty / Registration fees						
Financial Benefits at Purchase	Subsidies, Rebates & Grants						
Other benefits for Owner / Operators	**Priority (Bus / HOV) Lane Use**						
	Toll Road Exemption						
	Free / Designated Parking						
	Relaxed parking rules						
	Priority public charging access						
	EV electricity tariffs						
Infrastructure	Infrastructure (charging) support						
	Infrastructure (grid upgrades) support						
Market Creation	Demonstration Projects / Trials						
	Government Fleet Procurement Policy						

Where **green** = relevant and used; **yellow** = could be used; **white** = not relevant

Multi-Modal EV Policy Evaluation & Design

(IRENA, 2014) – policy evaluation indicators:

1. Effectiveness *(does it work?)*
2. Efficiency *(does the outcome warrant the cost?)*
3. Equity *(does it disadvantage anyone?)*
4. Feasibility *(will it be politically and technically viable?)*
5. **Complementarity**
   - » Consider both the transport sector and electricity sector
   - » *Are the policies aligning with each sectors goals?*
   - » *What are the consequences in both sectors?*
6. **Technological neutrality**
   - Vehicles modes
   - Ownership types (private vs business etc.)

Priority (Bus / HOV) Access

- Common for E-cars (New Zealand, Norway etc.)
  - *Used in ACT for e-LCVs*

- Creates new driver:
  - High for car purchasers [1]
  - Unknown for most modes

- **Technologically neutral**?
- **Complimentary** to transport sector goals?

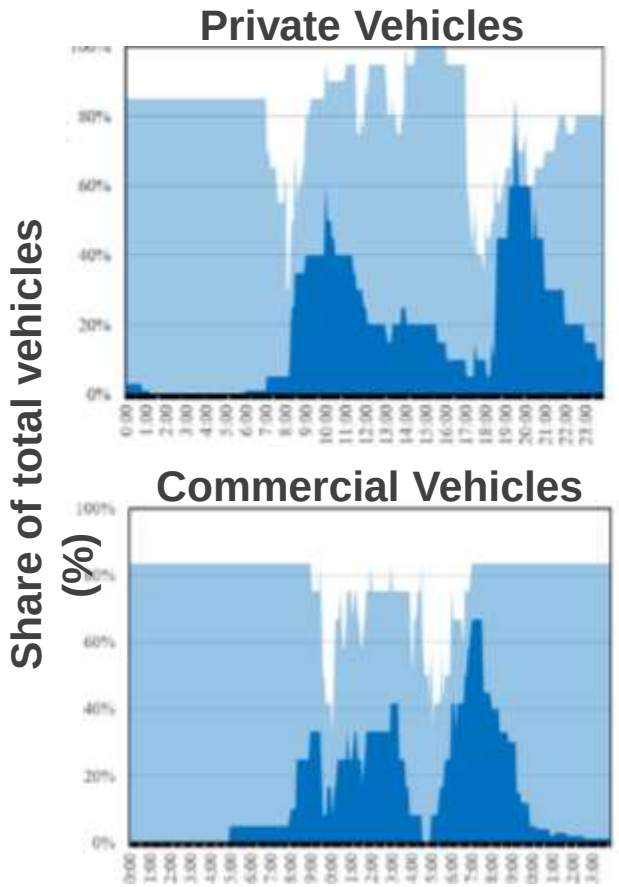
Drivers	e-cars	e-bicycle	e-motorcycle	e-taxi	e-LCV	e-bus
NEW: Avoid congestion						

[1](Cass and Grudnoff 2017)

EV Tariffs

- Different usage constraints per mode:
  - **LCVs:** *"fixed price, off-peak, per-unit charging costs"* SEA Electric[1]
  - **Buses**: *"demand charges can be prohibitively costly"* [2]

- **Complimentary** to electricity sector goals?



Drivers	e-cars	e-bicycle	e-motorcycle	e-taxi	e-LCV	e-bus
Reduced operating costs						

[1] (Fairweather 2018) & (Humphries 2018), [2] (Gallo 2016)
Graphs (right): (Jian, Yongqiang et al. 2018)

Conclusion

- Policy discussions shouldn't be limited to e-cars

- Common drivers and barriers to differing extents per mode

- Policy needs to be multi-modal in design:
  - **Technologically neutrality:**
    - To not disproportionally incentivize / disadvantage one mode
  - **Complementarity**
    - To support the goals of both the transport & electricity sectors

Questions?

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Images:

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Vehicle Comparison

	Range	Battery Capacity	Charge time			Demand		
	(km)	*(kWh)*	*Slow (hr)*	*Mid (hr)*	*Fast (hr)*	*Slow (kW)*	*Mid (kW)*	*Fast (kW) (DC)*
e-bike	16-64	1.5	4-6	n/a	n/a	0.25	n/a	n/a
e-motorcycle	40-300	3-14	3-10	2.5	n/a	3.3	n/a	n/a
e-car / e-taxi	40-350	16-90	8-10	4	0.3-1	3-7	22	40-120 (350 being developed)
E-LCV	100-270	-40	8-12	4	0.3-1			
E-bus	90-300	110-350	10	6	2	15-22	22-50	50-300

Charger Comparison

Mode	Charger Type	Charging Standards	Description	Power (kW)
E-bike; e-motorcycle; E-car; e-LCV; e-taxi	AC L1: Wall plug		Standard wall plug.	1-4
E-car; e-LCV; e-taxi	AC L2		Home, separate charger.	3-20
	DC Fast Charger	ChaDeMO	Japanese *(Kia, Mitsubishi, Nissan)*	20-50
		Combined Charging System (CCS)	European *(BMW, Chevy, Volkswagen)*	
		Supercharger	Tesla only	
	Induction			3-15
E-bus	Plug-in - slow		Separate charger	15-22
	- fast			22-50
	- rapid			50-120
	Pantograph		Roof mounted	150-300
	Induction		Wireless on road	< 200

CSIRO Uptake (2018)

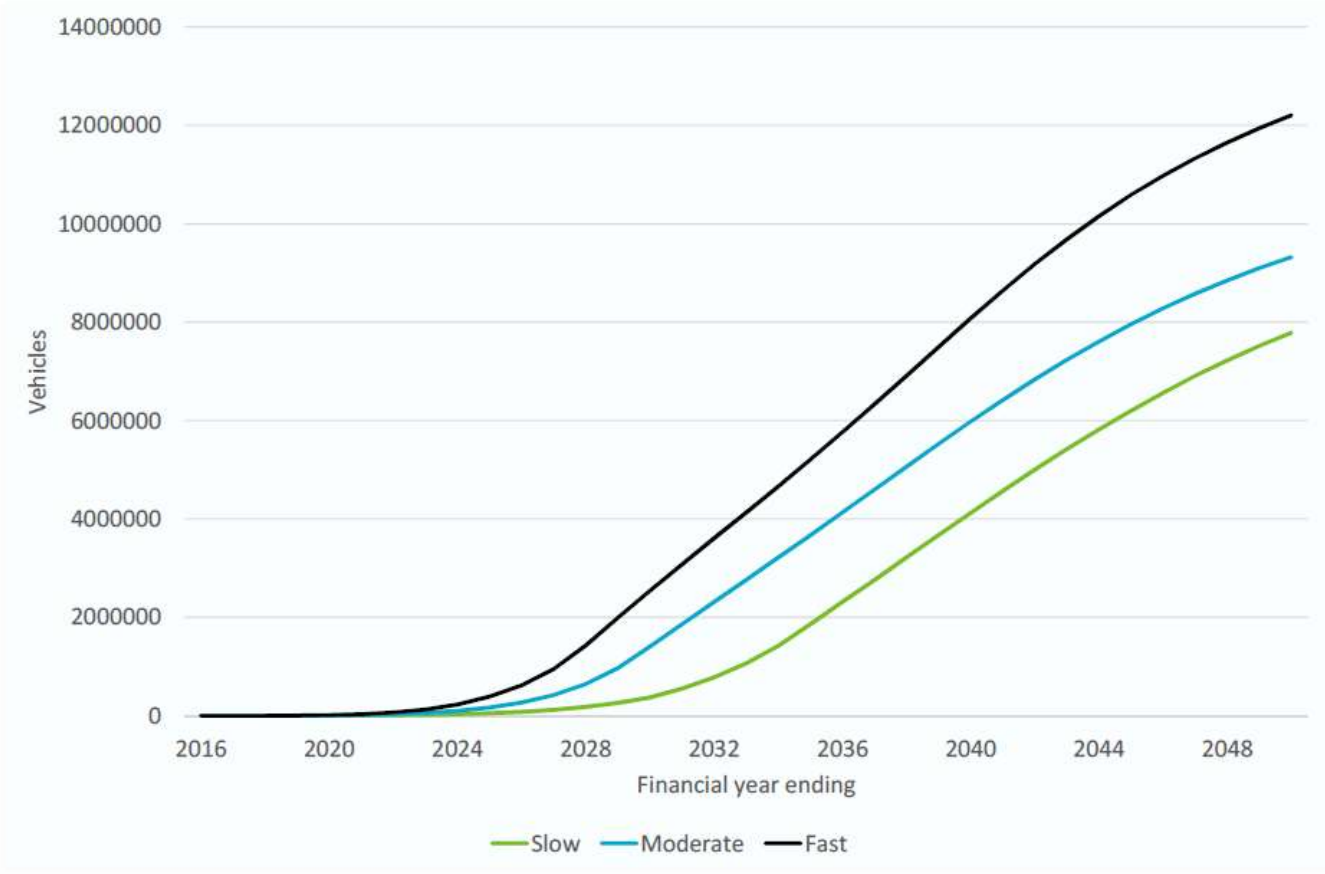

Figure 5-16: Projected total electric vehicle numbers, all vehicle types and all states/territories