Australian National University

100% Renewable Electricity and Electrified Land Transport

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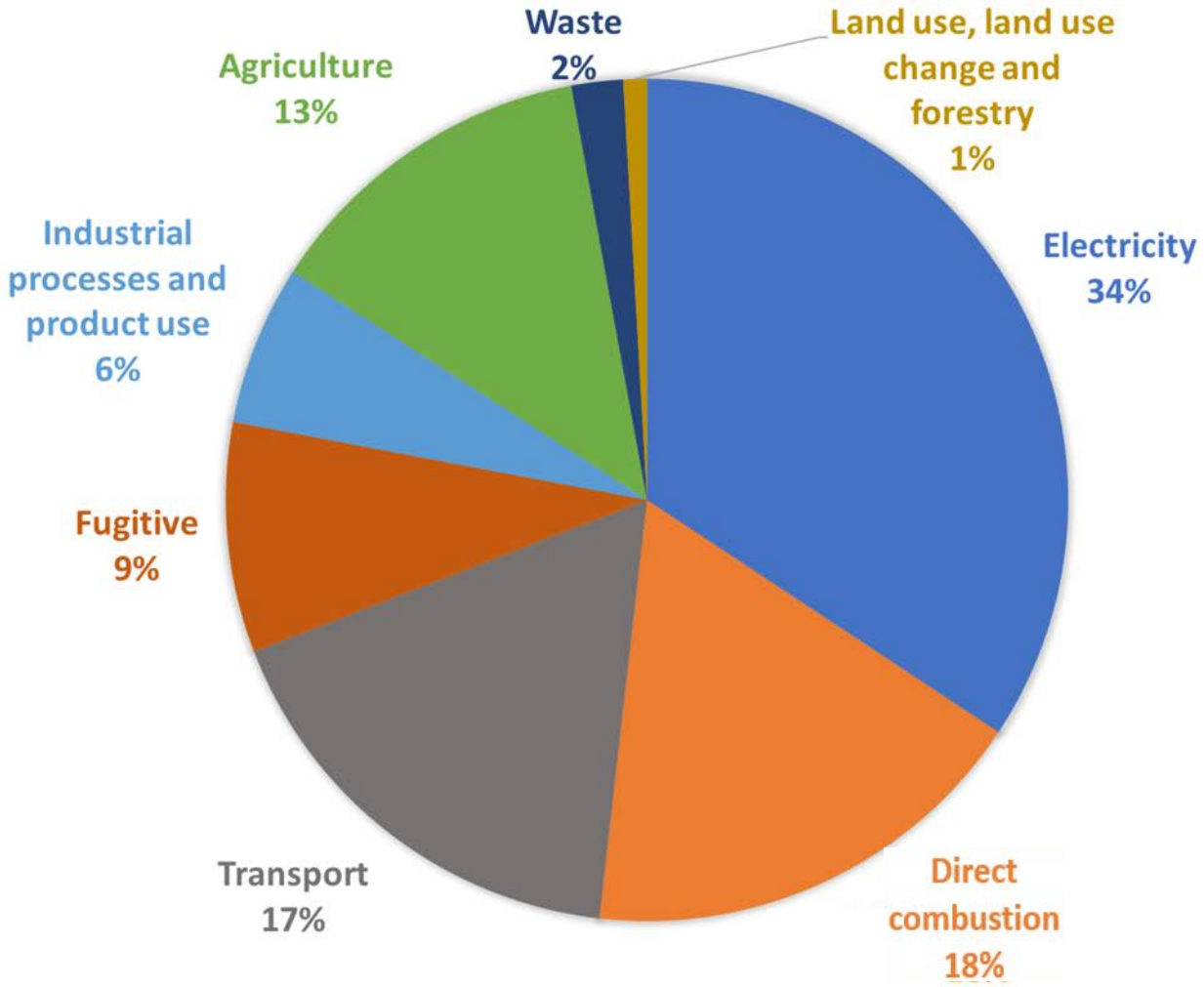
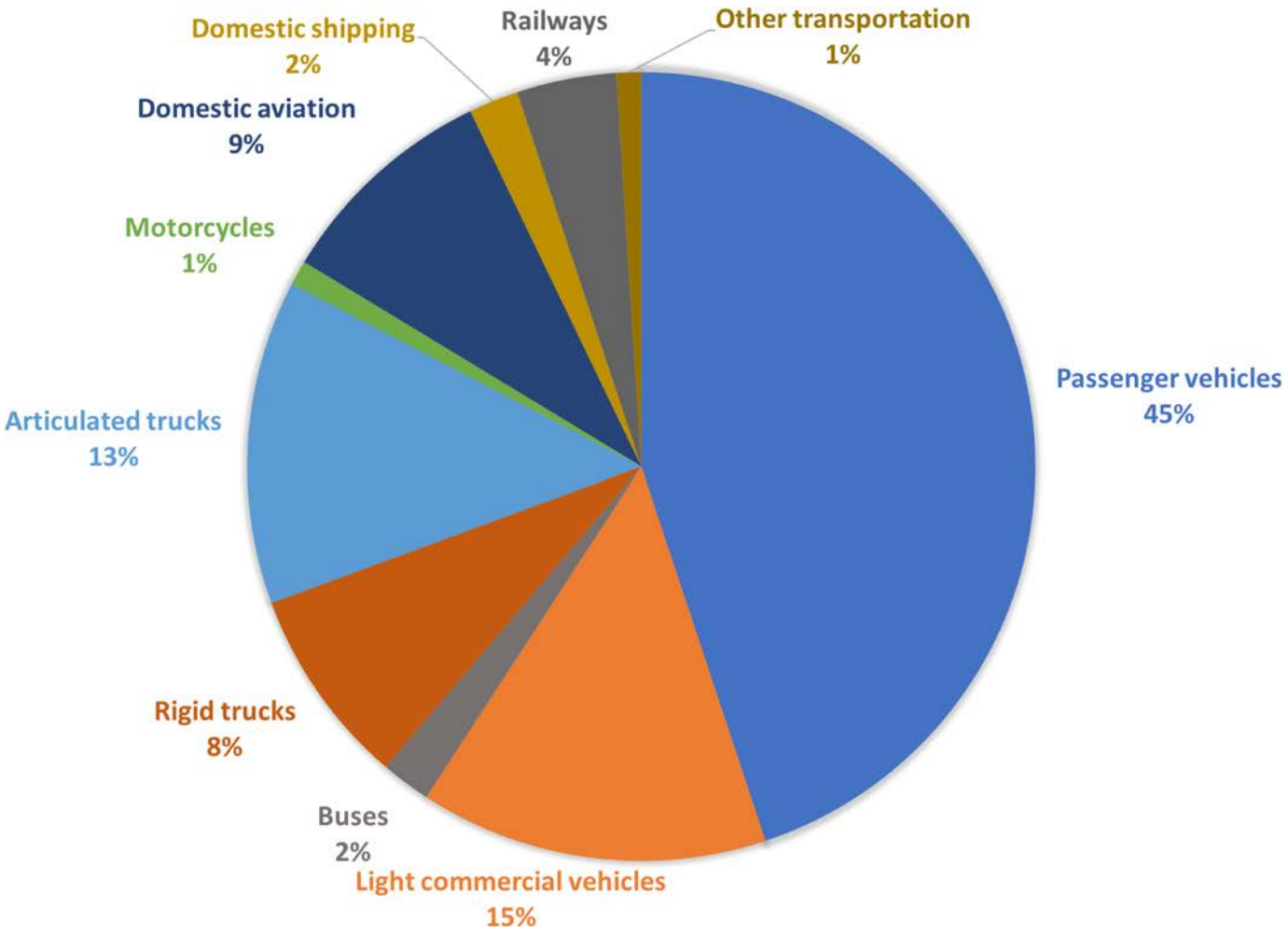
Australia's emissions by sector (2017)



Source: [1]

Transport emissions by mode



Source: [1]

Battery capacity, consumption & range

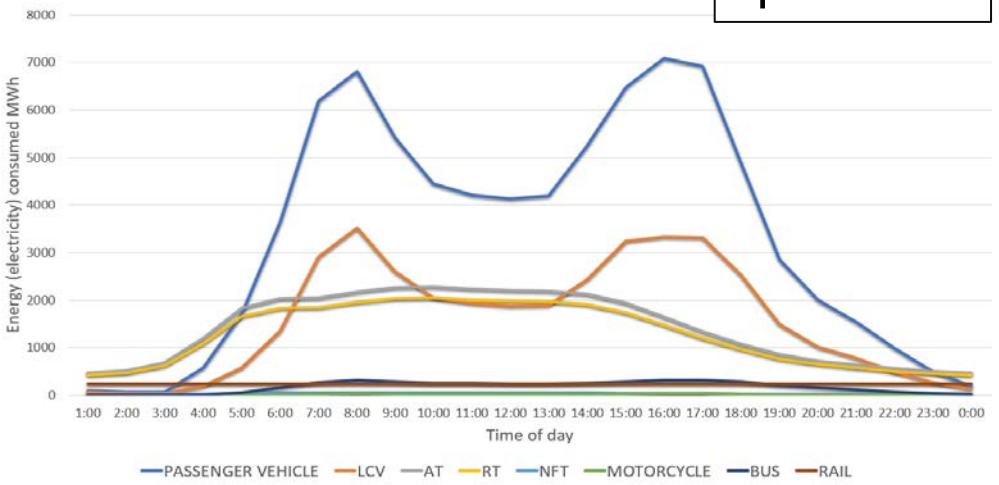
Class of vehicle	Average nominal battery capacity (kWh)	Average energy consumption (kWh/km)	Average maximum range (km)
Passenger EVs	77	0.17	450
Light commercial vehicles	60	0.4	150
Articulated trucks	800	1.4	570
Buses	100	1.1	91
Rigid trucks	100	1	100
Motorcycles	15	0.06	250
Non-freight carrying trucks	100	0.7	140

Source: [2] – [20]

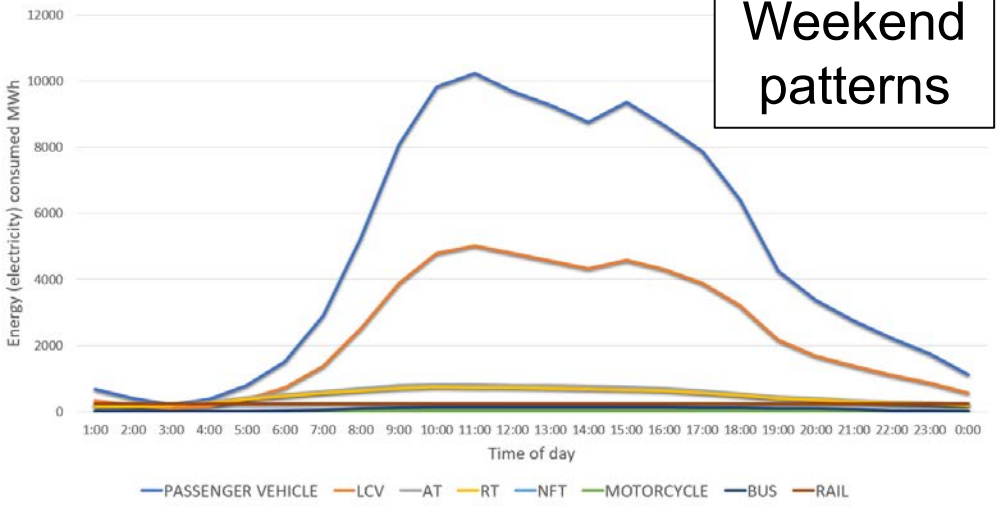
Travel patterns

- Survey of Motor Vehicle Use from the Australian Bureau of Statistics (ABS)
- Historical data from the Sydney Greater Metropolitan Region (GMR) Household Transport Survey (HTS)
- Bus timetables
- Heavy vehicles traffic volume data from NSW Roads and Maritime Services

Weekday patterns

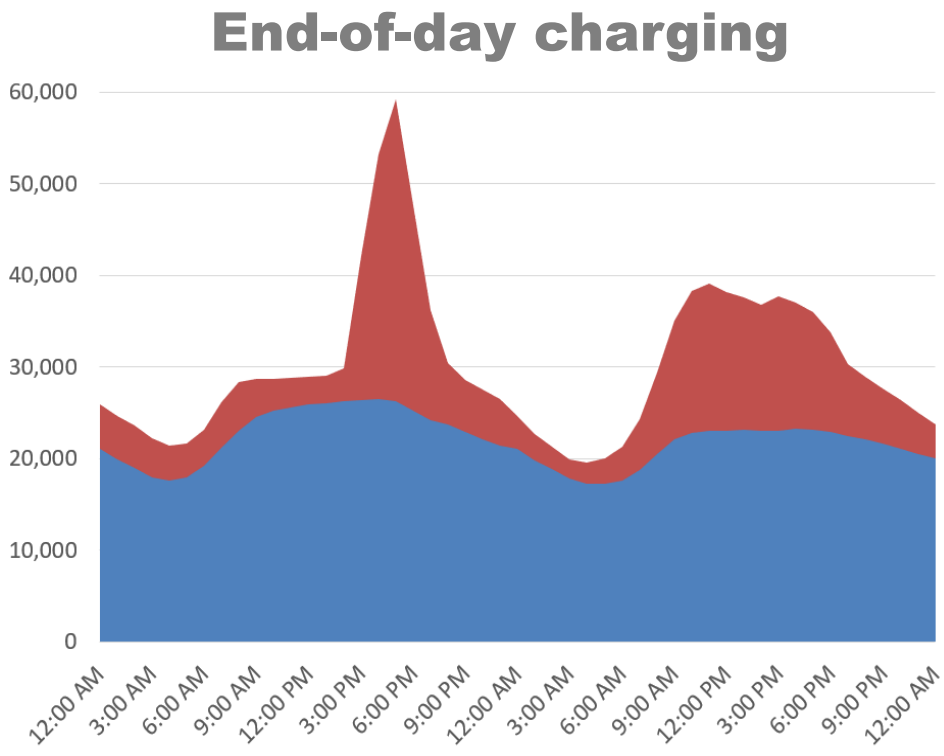


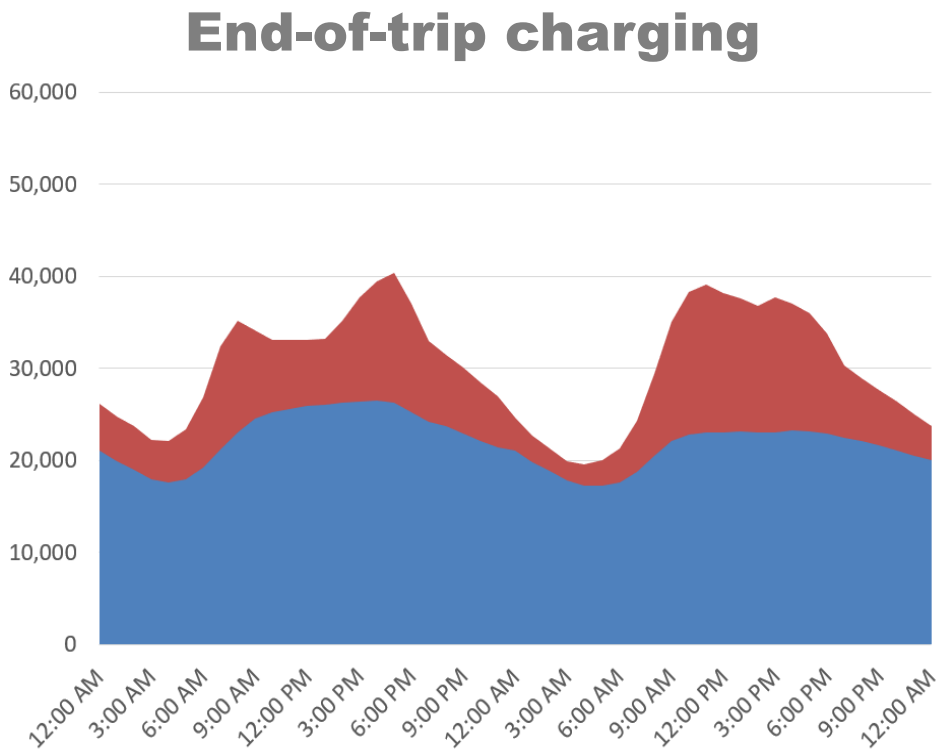
Weekend patterns



Charging profiles

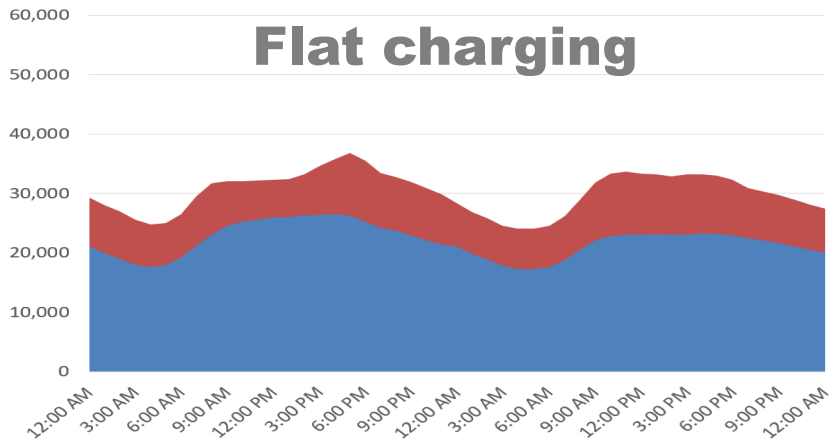
- Electric demand from EV + historic NEM demand data
- Unregulated scenarios:

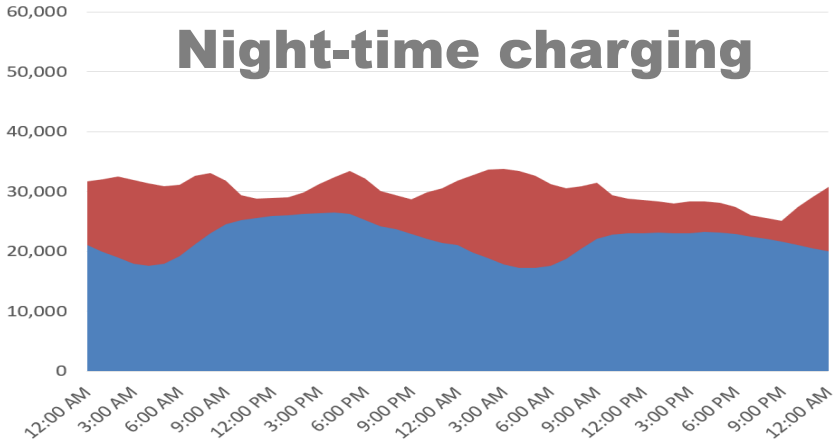


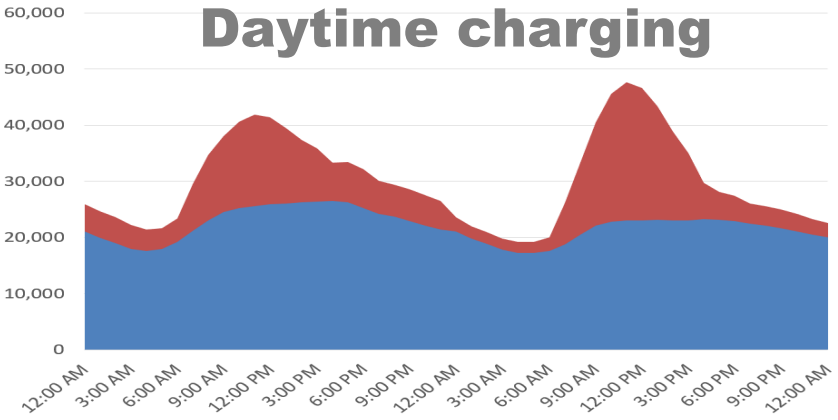


Charging profiles

- Controlled scenarios - only passenger EV charging regimes were tested





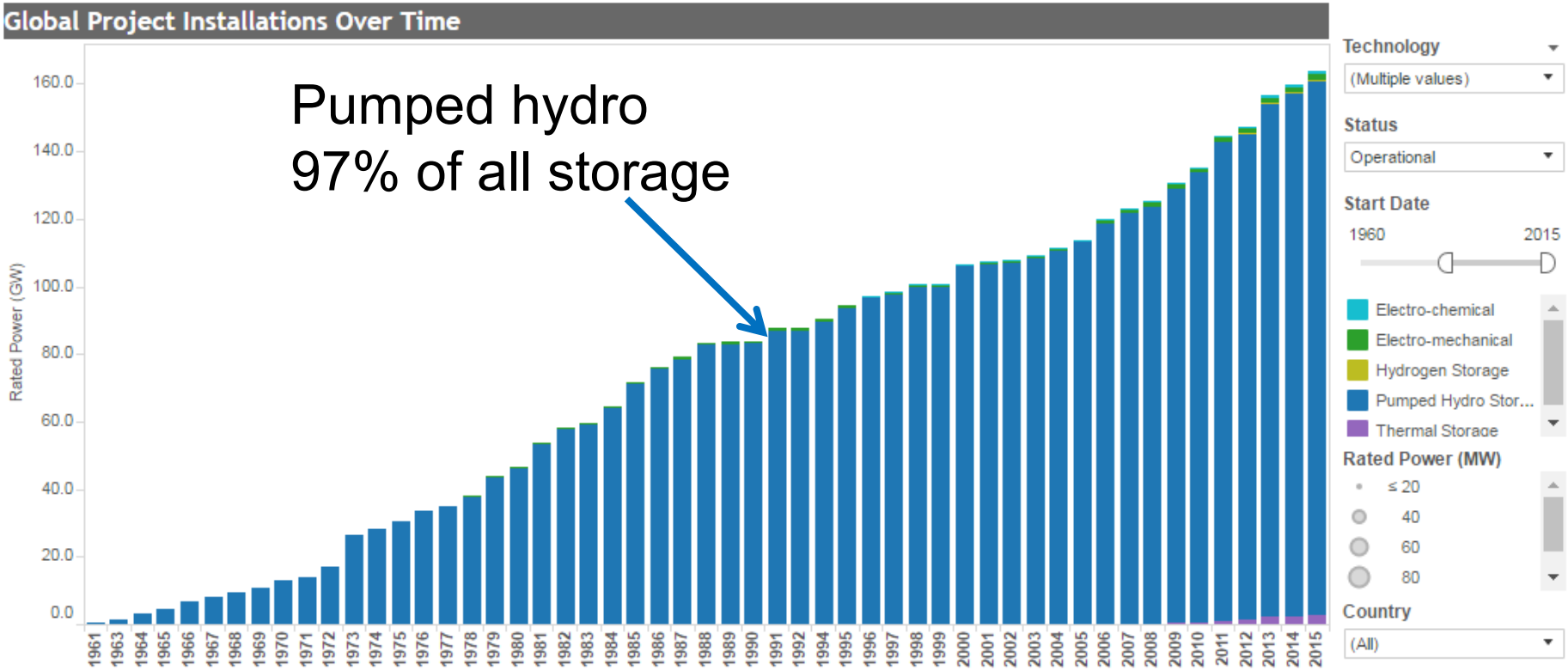


Energy balance modelling (hourly)

- A modified and extended version of the National Electricity Market Optimiser (NEMO) model
- Over 90% PV + Wind
  - Historic weather (wind and insolation data)
  - Retain existing hydro and biomass generation (7%)
- Off-river pumped hydro energy storage (PHES)
- High Voltage DC/AC Transmission (HVDC/AC)
- The NEM standard for unmet energy demand (0.002%) is applied
- Least-cost solution

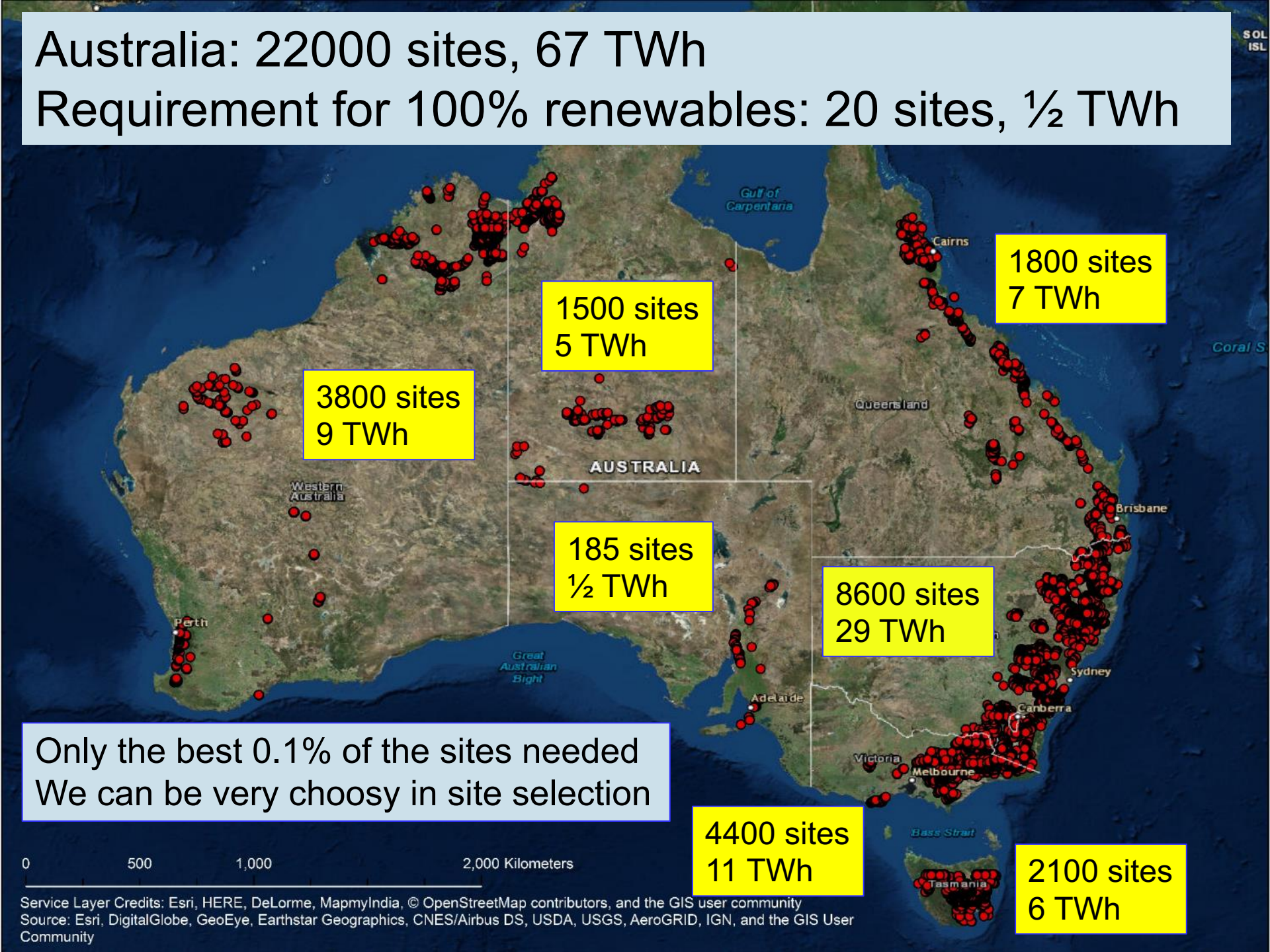
Pumped Hydro Energy Storage

- Lowest cost storage



Source: [21]

Australia: 22000 sites, 67 TWh
Requirement for 100% renewables: 20 sites, ½ TWh



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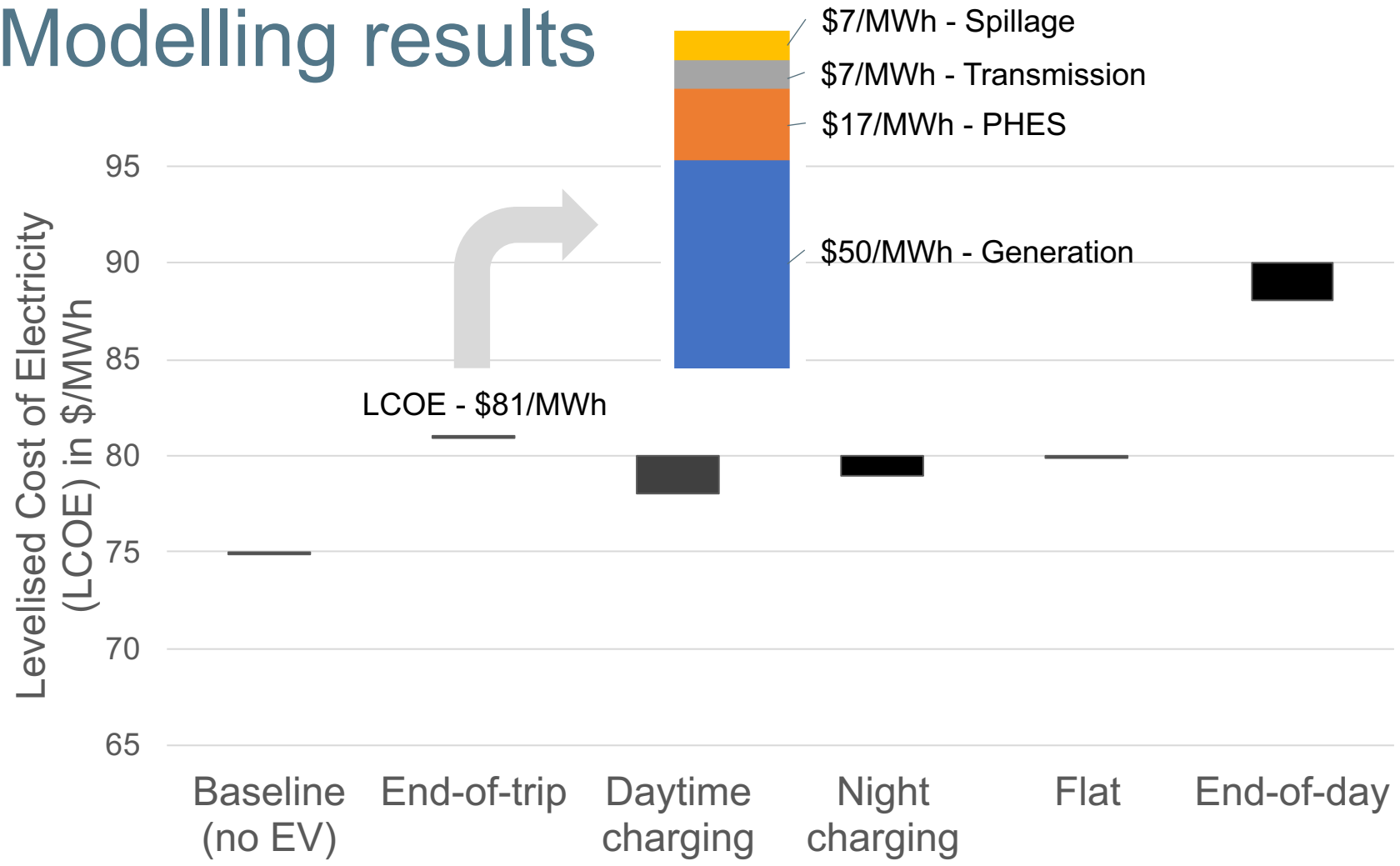
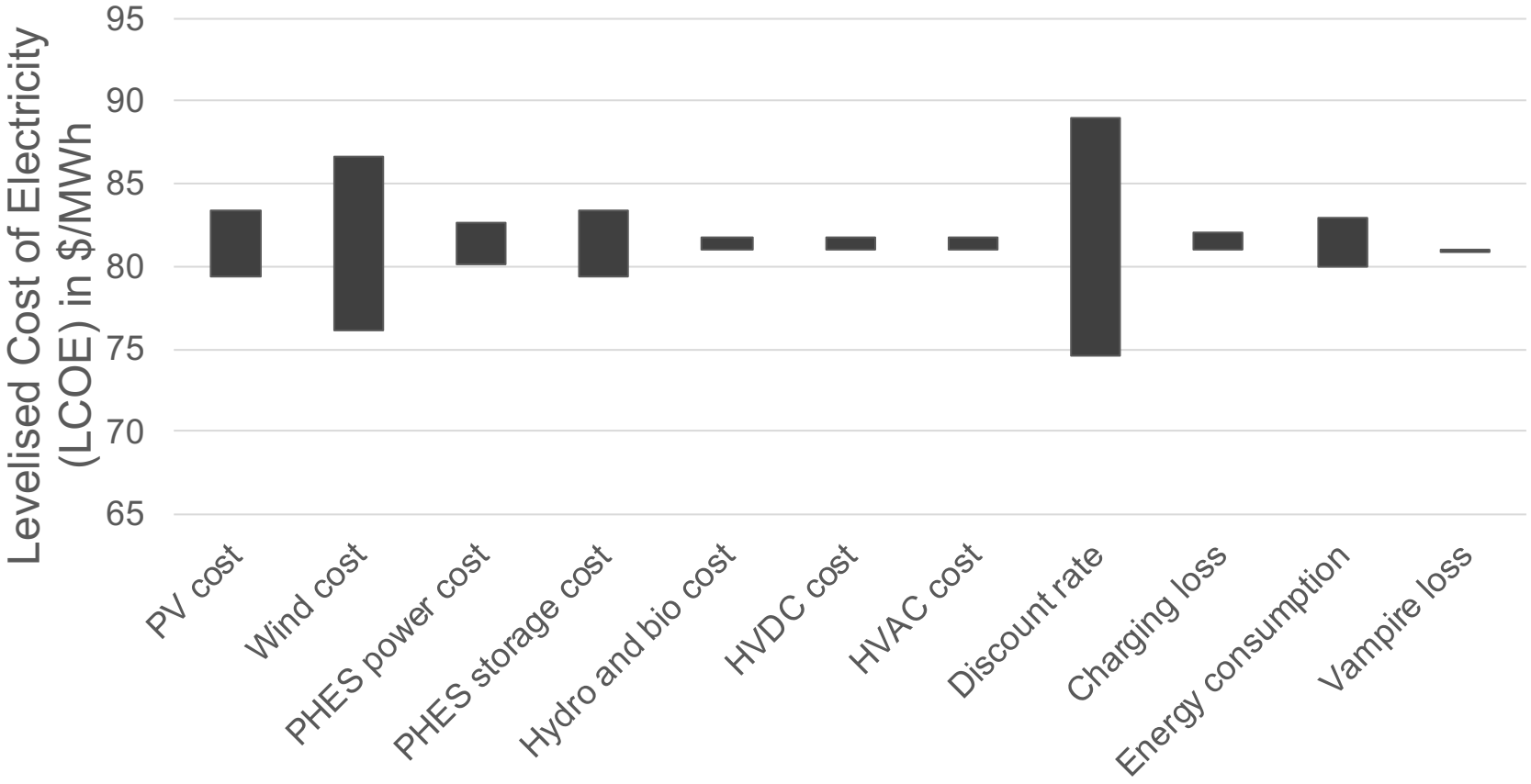
Economic parameters

- Future prices of PV & Wind - $50/MWh
- Purchase prices for existing hydro and bio - $50/MWh
- PHES – a private cost model
  http://re100.eng.anu.edu.au/research/re/phescost.php/
- High voltage transmission – data derived from similar projects

Modelling results



Sensitivity analysis for the end-of-trip scenario: +/- 20%



Opportunities and challenges

- Controlled charging can contribute to load-shedding and load-shifting
- Vehicle-to-grid (V2G)
- Charging infrastructure and distribution network

Summary

- 100% electrified land transport together with 100% renewable electricity (over 90% PV + wind) is technically feasible in Australia.
- The overall system cost ranges between $78/MWh - $90/MWh under different scenarios.
- A large fraction of the electric load from EV is flexible. The costs can be greatly reduced if active demand management is implemented.

Thanks!

- More – Bin Lu: “Modelling of Integration of Electric Vehicles and Heat Pumps in the Australian National Electricity Market”

References

- [1] Commonwealth of Australia. (2017). *Australia's emissions projections 2017*.\
- [2] Tesla, "Model S Design Studio," 2018. .
- [3] Tesla, "Model X Design Studio," 2018. .
- [4] A. Miles, "175 Miles In The '150-Mile' 2018 Nissan LEAF (#CleanTechnica Review)," *CleanTechnica*, 2018. .
- [5] Chevrolet, "Bolt EV," 2018. .
- [6] Nissan, "E-NV200 Range & Charging," 2018. .
- [7] F. Lambert, "A $52,000 plug-in electric pickup truck w/ range extender receives over 5,000 fleet orders, opens reservation to the public," *electrek*, Jan-2018.
- [8] M. Kane, "Ford, DHL Unveil StreetScooter WORK XL Electric Truck – Up To 90 kWh Batteries," *Inside EVs*, Aug-2017.
- [9] C. Hubbard, "Renault Master ZE large electric van review," *Parkers*, Sep-2018.
- [10] Tesla, "Tesla Semi," 2018. .
- [11] Proterra, "The Proterra Catalyst® 35-Foot Transit Vehicle," 2016. .
- [12] Proterra, "The Proterra Catalyst® 40-Foot Transit Vehicle," 2016. .
- [13] The Lion Electric Co., "eLionC." .
- [14] BYD Motors Inc, "K9 Electric Transit Bus," 2018. .
- [15] Daimler AG, "Electric Vision. The E-FUSO Vision One," 2018. .

References

- [16] F. Lambert, “Renault Trucks unveils new generation of all-electric trucks,” *electrek*, Jun-2018.
- [17] Daimler AG, “The Mercedes-Benz Electric Truck. Connectivity meets eMobility,” 2018. .
- [18] Zero Motorcycles Inc, “2017 Zero S,” 2018. .
- [19] Johammer e-mobility GmbH, “Johammer J1 Electric Motorcycle,” 2015. .
- [20] P. Ridden, “Europe’s first electric fire truck ready for rapid response,” *New Atlas*, 2018. [Online]. Available: https://newatlas.com/rosenbauer-linz-kreisel-electric-fire-truck/54088/. [Accessed: 20-Nov-2018].
- [21] Energystorageexchange.org, “Energy Storage Exchange,” *DOE Global Energy Storage Database*. [Online]. Available: https://energystorageexchange.org/projects/data_visualization. [Accessed: 03-Dec-2018].