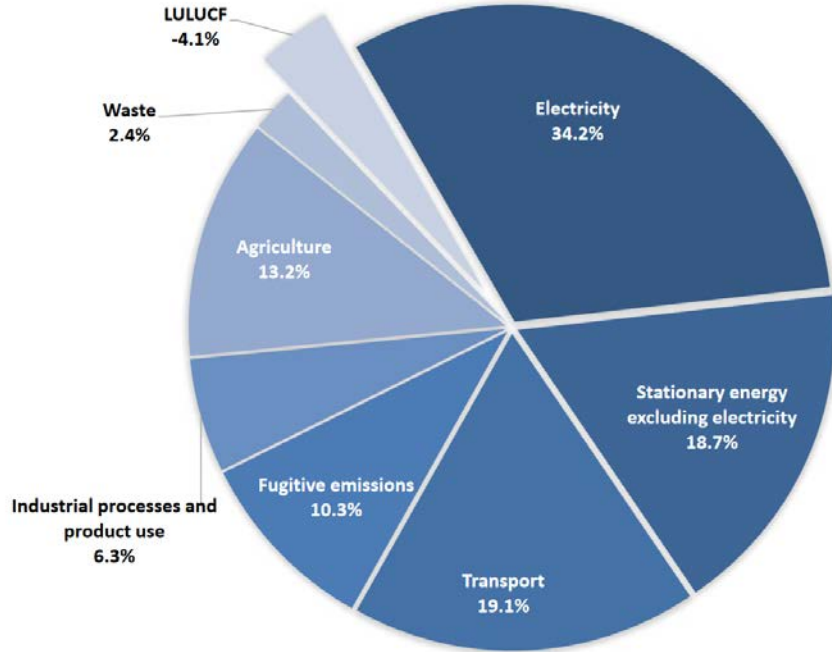


# GHG emissions



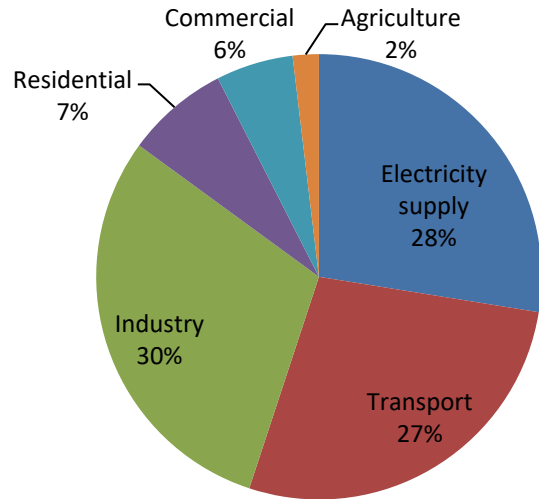
A lot of people think, OK, renewable energy, wind and solar, has gotten a lot cheaper, isn't that it? Well, electricity is only a quarter of the problem. In fact, we've got to solve the entire 100 percent. You know, unless somebody has the pie in their mind that, OK, electricity's 25 percent, agriculture's 24 percent, transport's 14 percent, unless they start with that, we're not really talking about the same problem.

## Source:

AXIOS <https://www.axios.com/bill-gates-climate-change-alarm-1227d57c-10ac-4e03-90d1-20e6097be21b.html>; <https://futurism.com/the-byte/bill-gates-climate-change-axios>  
Australian Department of the Environment and Energy <http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-national-greenhouse-gas-inventory-june-2018>

# Energy change

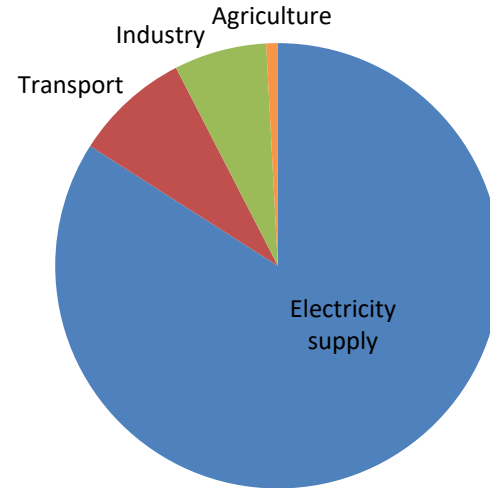
Climate Change is the challenge. Energy Change is the key.



2016-17



– ANU Energy Change Institute



2030? 2050?

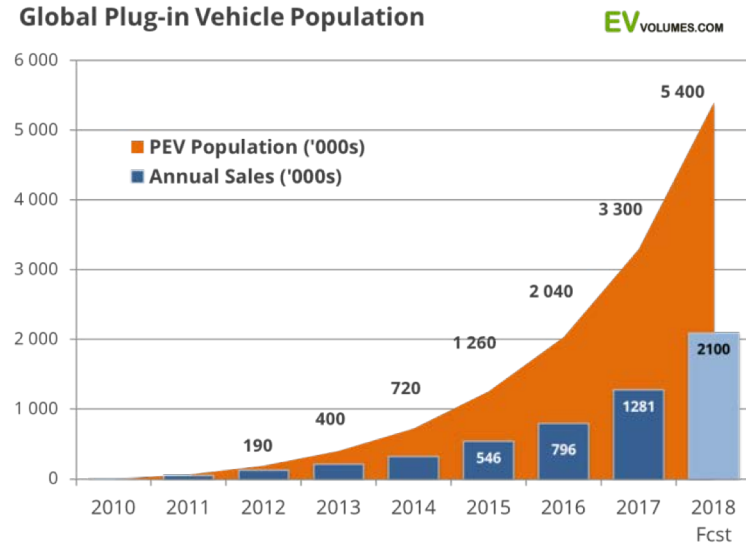
Note. Adapted from Ivor Frischknecht's presentation at the ACT/ANU Solar Oration 2018

Source:

Australian Department of the Environment and Energy <https://www.energy.gov.au/publications/australian-energy-update-2018>

# Electric vehicles

- > 2 million sales worldwide in 2018
- IEA Global EV Outlook 2018: 125-220 million by 2030

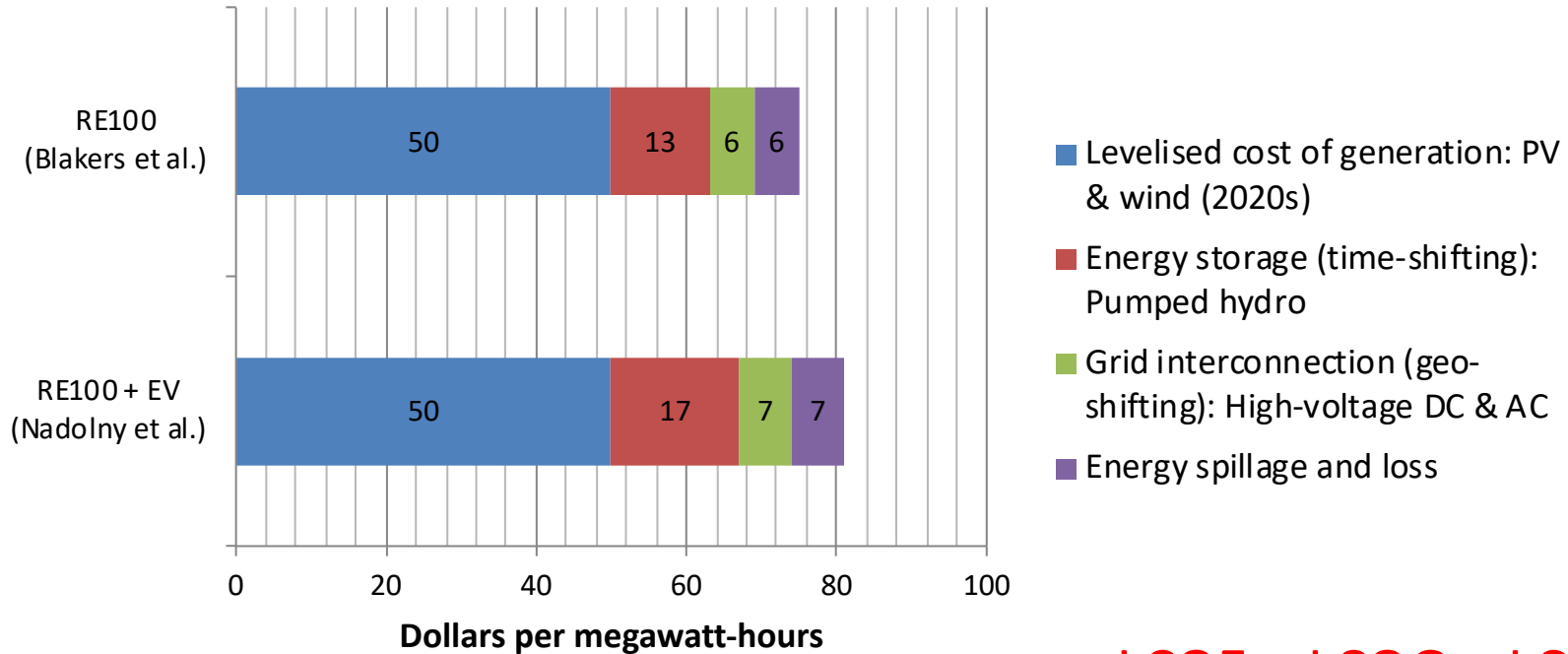


Source:

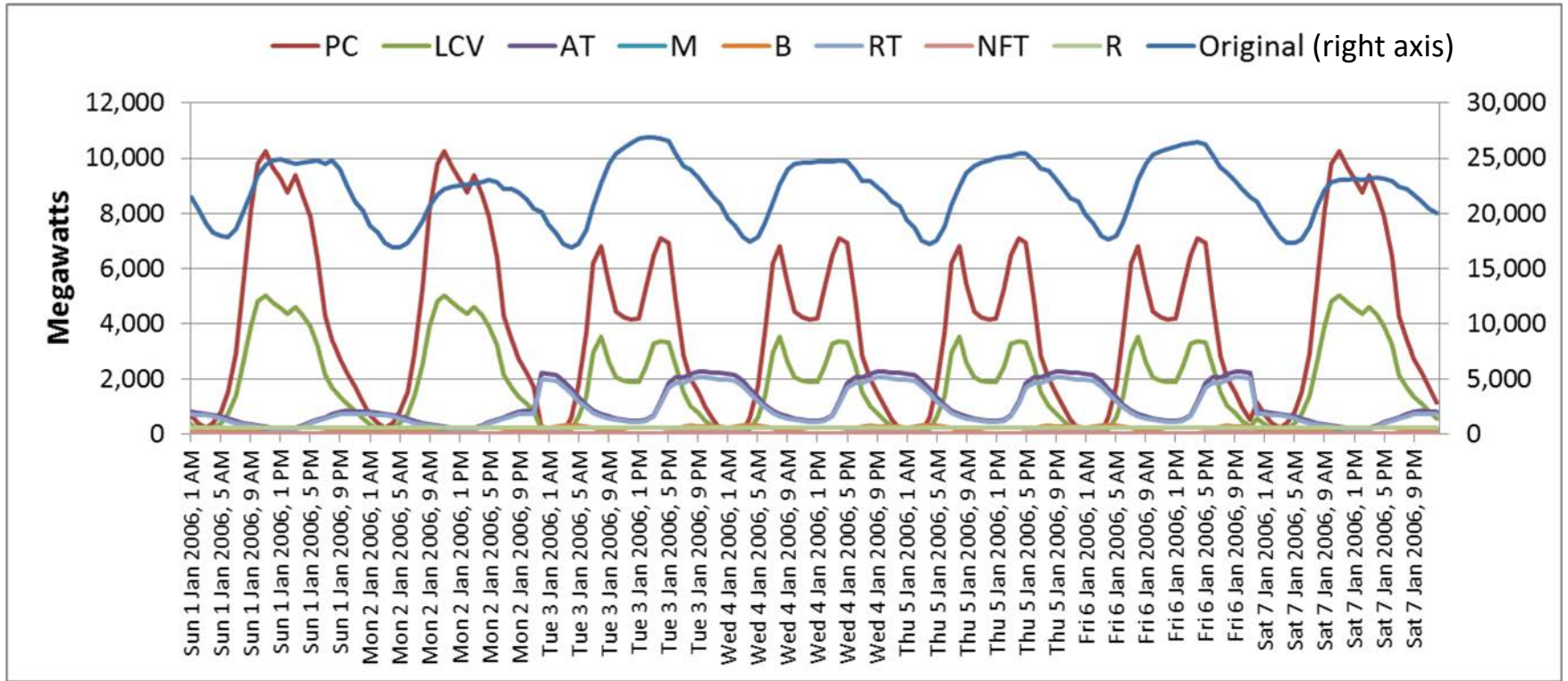
EV-Volumes.com <http://www.ev-volumes.com/>

International Energy Agency <https://www.iea.org/gevo2018/>

# 100% renewable electricity + electrified land transport in Australia



$$\text{LCOE} = \text{LCOG} + \text{LCOB}$$



## Electrification of land transport:

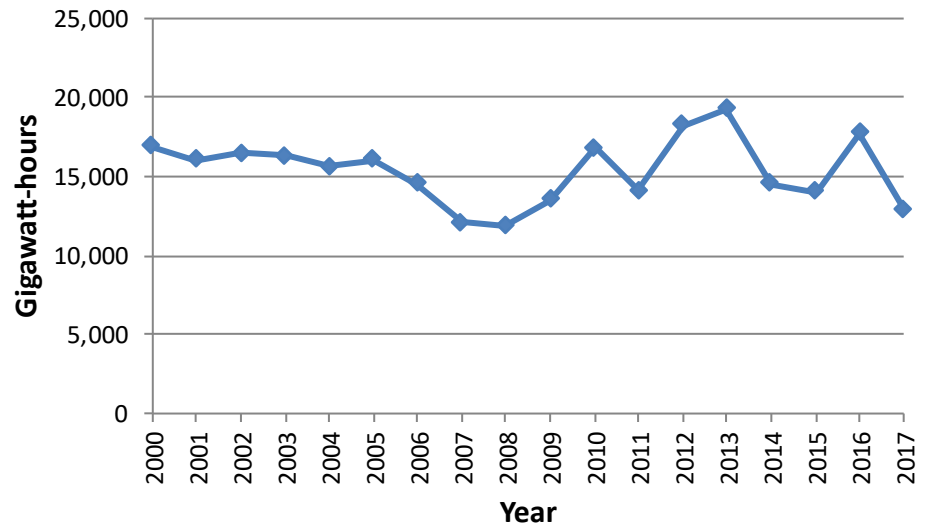
- Adds **38%** electricity consumption in the National Electricity Market
- Adds **44%** maximum peak demand

# Hydro energy resource

- Hydropower contributed 12-19 TWh p.a. since 2000
- Constrained by resource availability

“Hydroelectricity generation is projected to remain broadly unchanged in Australia due to the limited availability of suitable locations for the expansion of capacity and water supply constraints.”

– *Australian Energy Resource Assessment 2014*

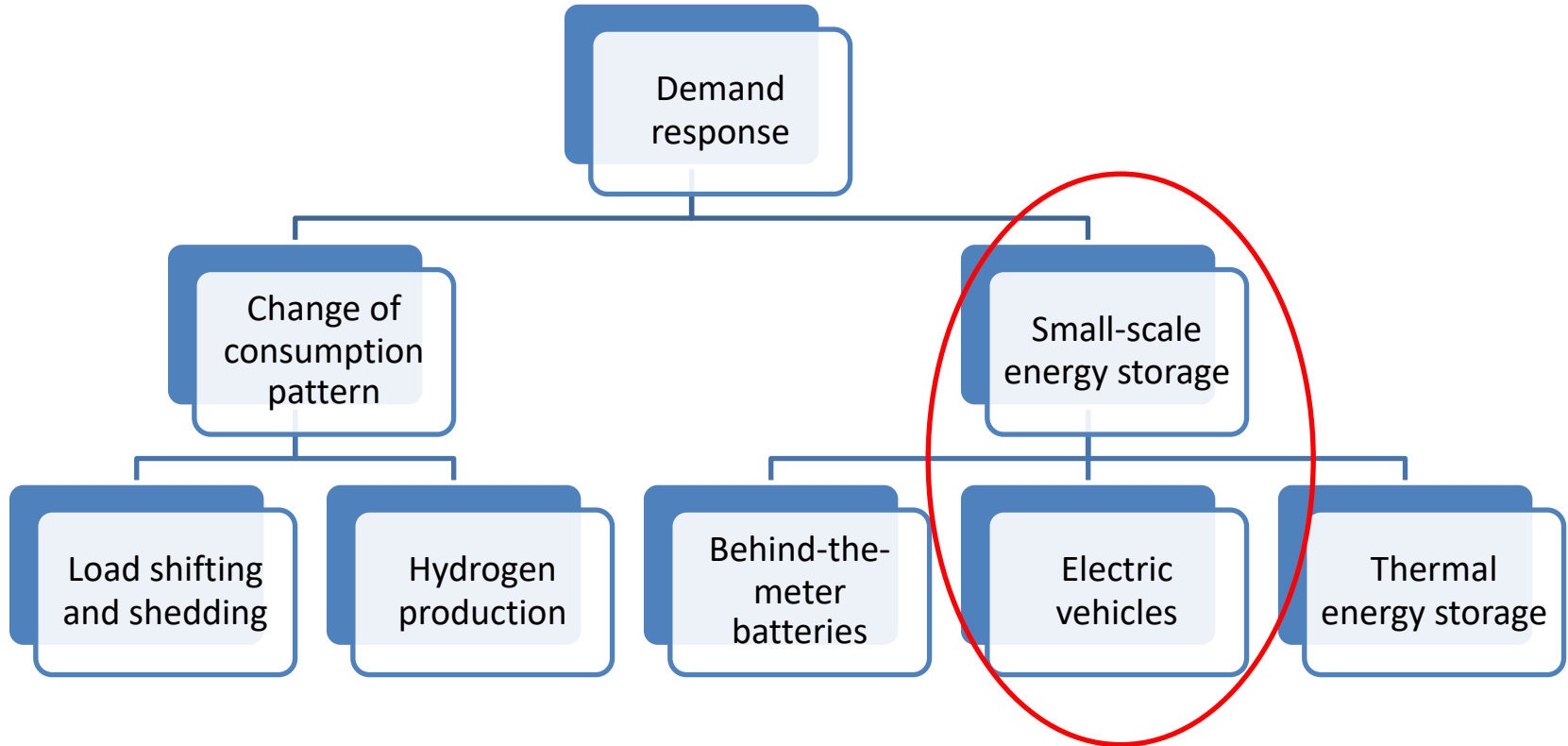


**Source:**

Clean Energy Australia Report 2016-2018 <https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html>

Australian Energy Statistics 2016 <https://archive.industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Australian-energy-statistics.aspx#>

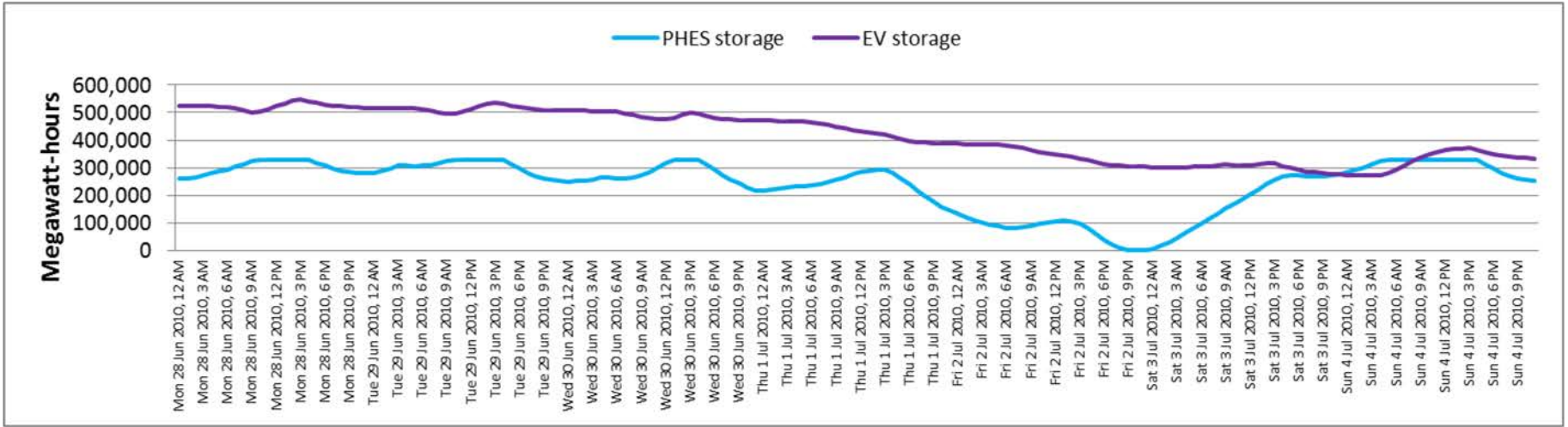
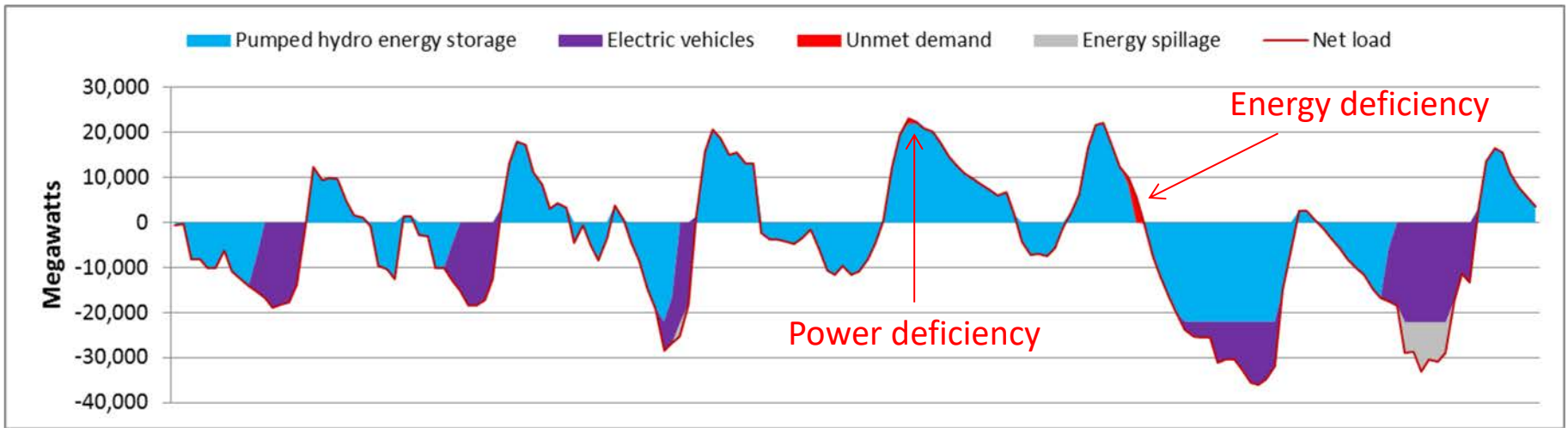
# Demand flexibility



# Modelling

- Generation, storage and transmission
  - Power generation: PV, wind, existing hydro & bio
  - Energy storage: Pumped hydro and **battery**
  - Electricity transmission: High-voltage DC & AC
- Energy balance modelling 2006-2010
- Dynamic electric vehicles charging
  - Flexible: 75% passenger cars + 50% light commercial vehicles + 25% trucks
  - **Contributes > 20 GW, > 500 GWh flexibility**

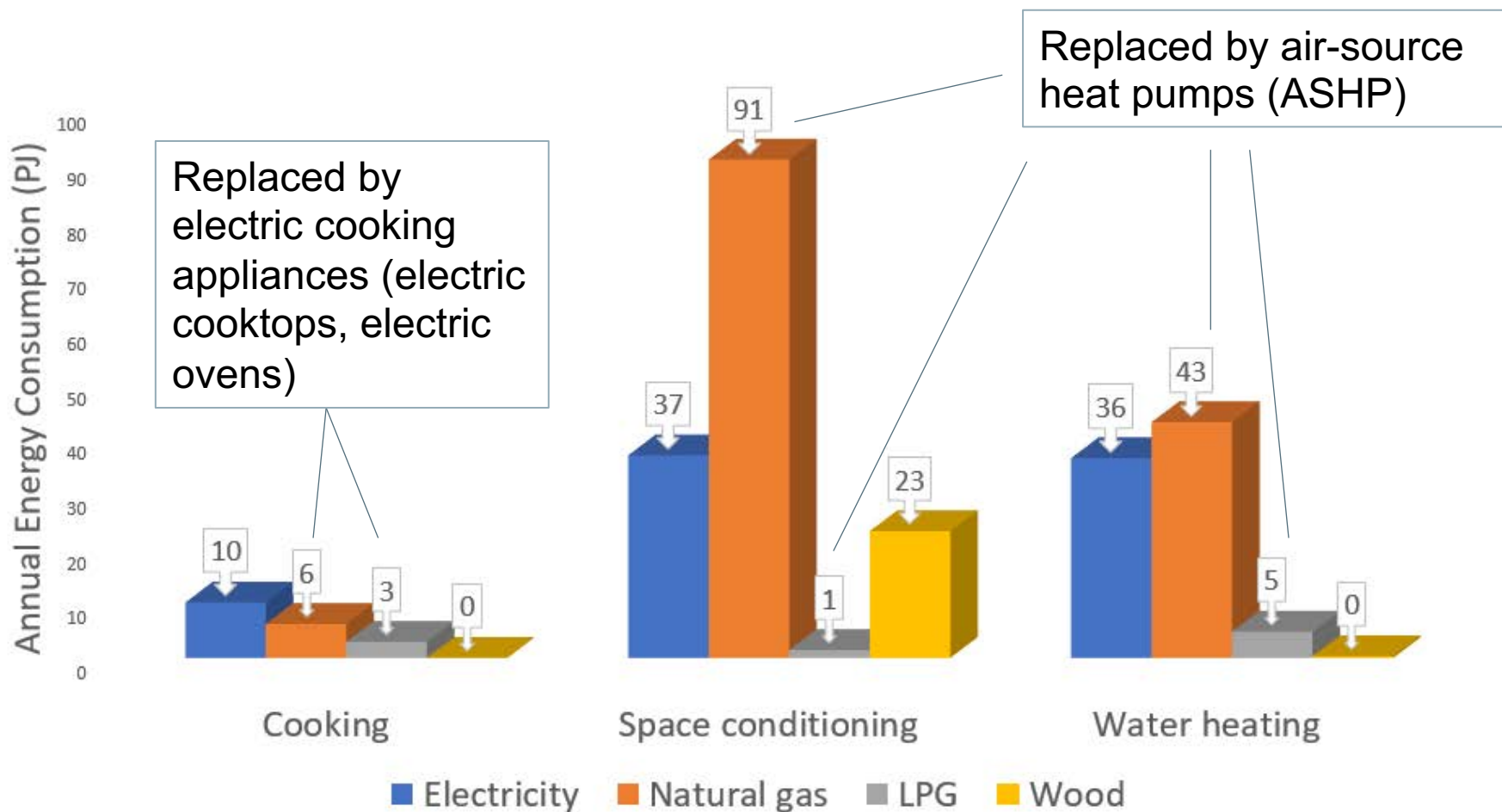




# Summary

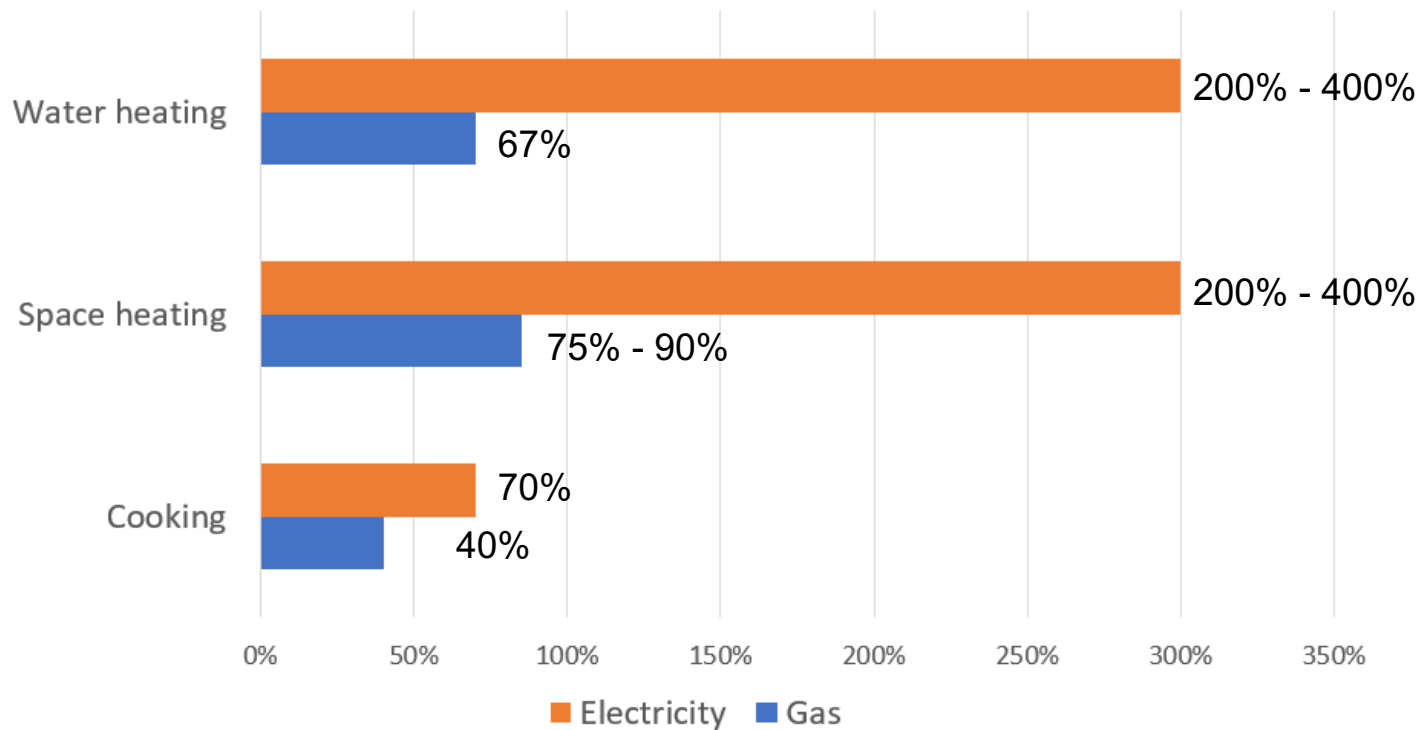
- Meets the NEM reliability standard 0.002%
- Levelised cost of electricity/balancing reduced by \$8/MWh equivalent to \$2 billion (10%) savings p.a.
- Storage requirements:
  - RE100: 500 GWh (Blakers et al.)
  - RE100 + EV unregulated: 800 GWh (Nadolny et al.)
  - RE100 + EV flexible: 330 GWh – 22 GW, 15 h
- Pumped hydro energy storage, Vehicle-to-Grid (optional) fill the gaps

# Electrification of low temperature heating



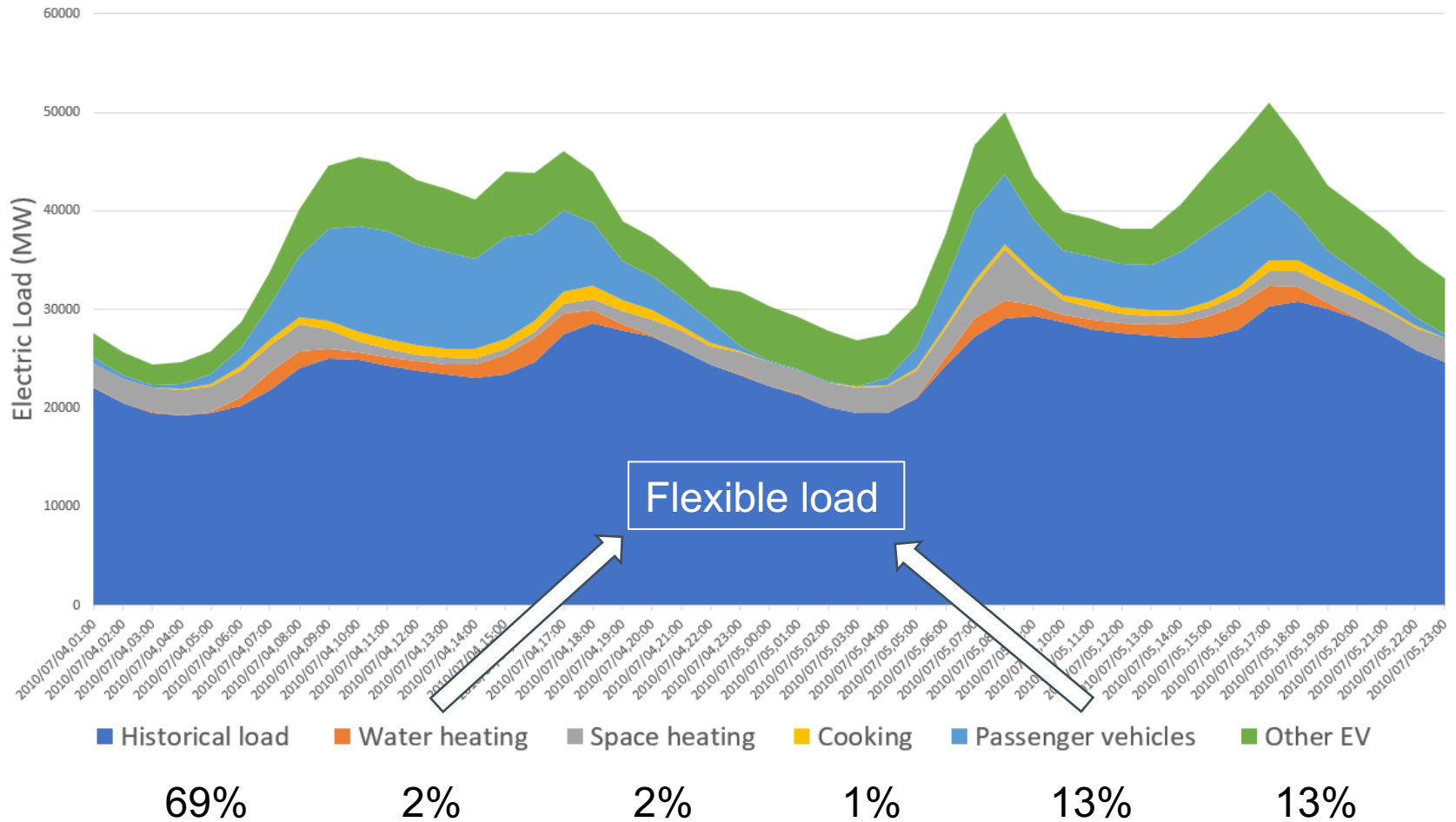
# Electrification of low temperature heating

- Cut Australia's emission by 7% (40 Mt CO<sub>2</sub>-e)
- Significant increase in energy efficiency:



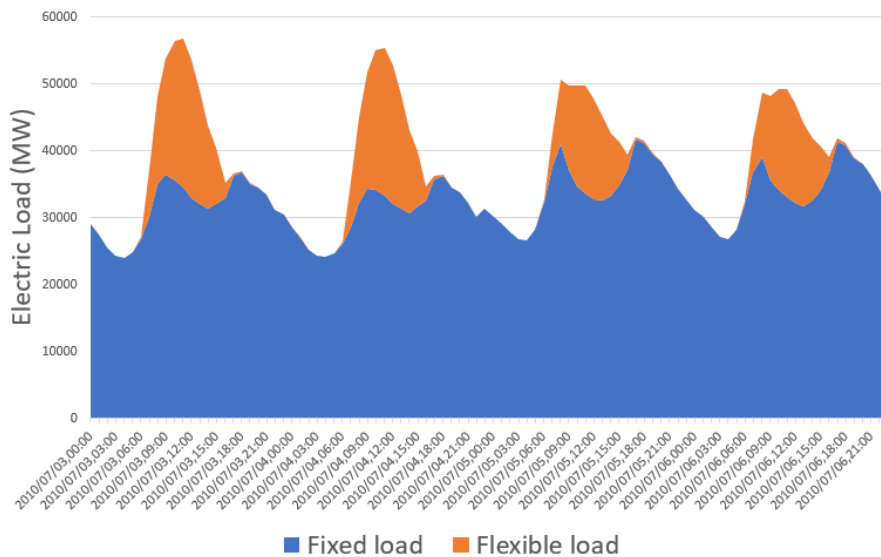


# Estimated load profile (unregulated)

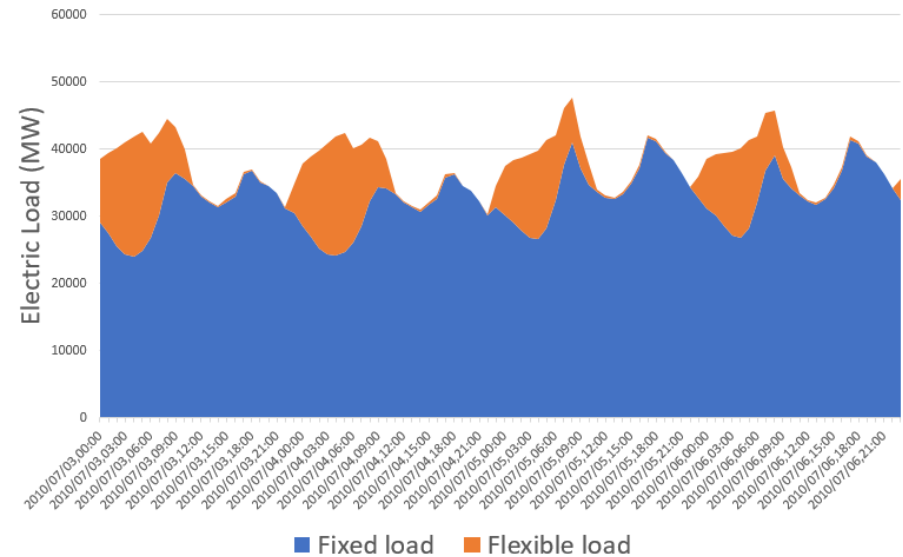


# Estimated load profile (controlled)

## Daytime charging



## Night charging



# References

- [1] EnergyConsult, “Residential Energy Baseline Study: Australia,” 2015.
- [2] DEPARTMENT OF ENERGY, “Energy Conservation Program: Test Procedures for Conventional Cooking Products,” 2014.
- [3] EnergyConsult, “Product Profile: Gas Space & Decorative (Fuel Effect) Heaters.” 2012.
- [4] G. Wilkenfeld, “Regulation Impact Statement : for Decision Specifying the Performance of Water Heaters for new Class 1 Buildings in the Building Code of Australia Prepared for the Department of the Environment , Water , Heritage and the Arts by George Wilkenfeld and Associates December 2009,” no. December, 2009.
- [5] Commonwealth of Australia, “Australia’s emissions projections 2017,” 2017.