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 2.4 percent, transport’s 14 percent, unless they start with that, we’re not really talking about the same problem.

Source:
Energy change

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

Source:

Note. Adapted from Ivor Frischknecht’s presentation at the ACT/ANU Solar Oration 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/
100% renewable electricity + electrified land transport in Australia

**Levelised cost of generation:**
- **PV & wind (2020s):** 50 dollars per megawatt-hours
- **Energy storage (time-shifting):** Pumped hydro
- **Grid interconnection (geoshifting):** High-voltage DC & AC
- **Energy spillage and loss:**

\[
\text{LCOE} = \text{LCOG} + \text{LCOB}
\]
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:
Demand flexibility

- Demand response
  - Change of consumption pattern
    - Load shifting and shedding
    - Hydrogen production
  - Small-scale energy storage
    - Electric vehicles
    - Thermal energy storage
    - Behind-the-meter batteries
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
Power deficiency

Energy deficiency
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

Replaced by electric cooking appliances (electric cooktops, electric ovens)

Replaced by air-source heat pumps (ASHP)

Source: [1]
Electrification of low temperature heating

- Cut Australia’s emission by 7% (40 Mt CO2-e)
- Significant increase in energy efficiency:
  - Water heating: 67%
  - Space heating: 75% - 90%
  - Cooking: 40%

Estimated load profile (unregulated)

Flexible load

69%  2%  2%  1%  13%  13%
Estimated load profile (controlled)

Daytime charging

Night charging

Electric Load (MW)

Fixed load  Flexible load

Fixed load  Flexible load
References