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ENERGY Research Institute

# *Disruptive energy technologies*

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# Overview

- What do we mean by disruptive technology
- Some examples
- What are the emerging energy technologies
- How might they become disruptive?
- Integration of different technologies

# What is a disruptive technology?

- Coined by Bower and Christensen (1995) to refer to when a new technology replaces another
- One that significantly changes the way we live our lives
  - Increased quality of life
    - Improved health/reduced pollution
    - Equity
    - Freedom
  - Increased productivity
    - Work fewer hours/week
    - Less labour intensive
    - Generates more wealth

# Examples (not exhaustive)

- Domestication of animals/plants (~10000 BC)
- Writing (~8000BC)
- Forging steel (2000BC-1850)
- Steam engine (Newcomen 1712, Watt 1765)
- Electricity/electric motor (Ampere 1820, Faraday 1821)
- Internal combustion engine (Carnot 1824)
- Sewerage systems (i.e. London 1860)
- Telephone (Bell 1876)
- Radio transmitter (Marconi 1901)
- Assembly line manufacturing and private car ownership (~1870-1900)
- Vaccinations (1800), Penicillin (1928)
- Jet engine (1921)
- Transistor (1947)
- Personal computers/email/ internet/smart phones (1976-about 5 minutes ago)
- CFCs and Montreal Protocol
- Contraceptive pill



All technologies/inventions build on previous ideas – nothing is 100% original

**"I think there is a world market for maybe five computers."**
*Thomas Watson, president of IBM, 1943*

- **"There is no reason anyone would want a computer in their home."**
- *Ken Olsen, founder of Digital Equipment Corporation, 1977*

**People are naturally conservative, new ideas take some time to catch on but then rapidly expand**

# Drivers of disruptive innovation

- Necessity
- Serendipity
- Financial
- Social/political

## But it's not all good…

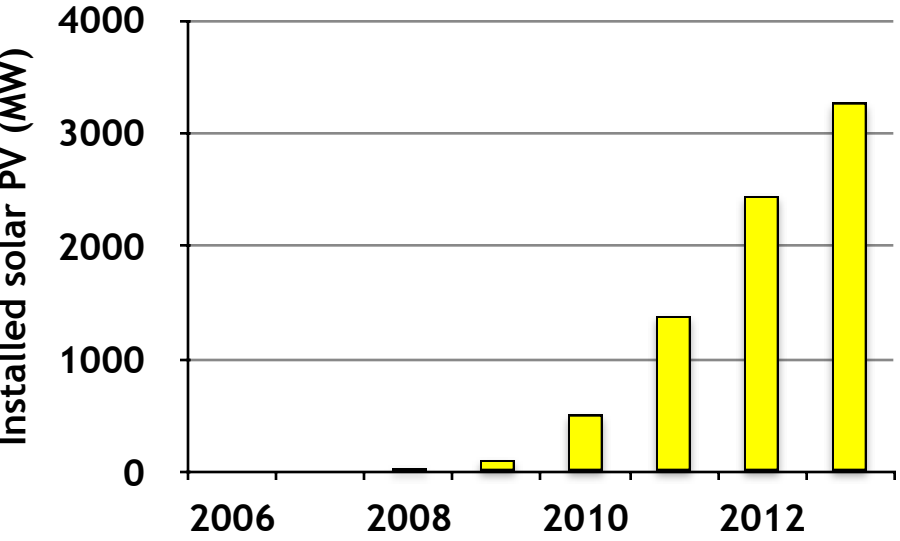
- fossil fuels
- nuclear technology

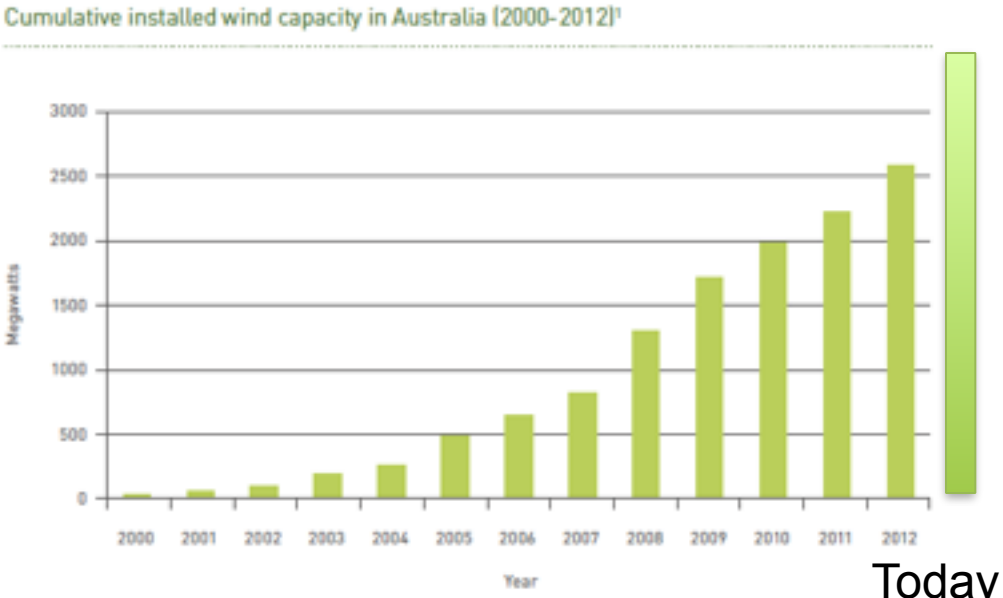
# Disruptive technologies in the energy sector

- Currently in need of an energy revolution
  - Reduce emissions by 50-80% by 2050 to avoid 2°C
- Might proceed in a number of ways
  - Generation side, invisible to 'normal' consumers
  - Demand side
    - People understand their energy use
    - Generate their own energy (PV)
    - Manage energy use (batteries, demand management, Virtual Power Station)
- Which one will win?

# Possible disruptive energy technologies

- Generation side:
  - Biomass
  - Geothermal
  - Carbon Capture and Storage
  - Concentrating solar thermal
  - Utility scale solar PV
  - Gen IV Nuclear
  - Large scale energy storage
    - Pumped hydro
    - Liquid air energy storage
- Demand side
  - Building integrated PV
  - Smart Meters
  - Battery storage (Lead acid/ lithium ion)
  - Electric vehicles
  - Energy management systems
  - Virtual Power Station




Today

- Solar and wind power have grown spectacularly in the last few years
- Couple of small utility scale PV
- Cost of PV has dropped dramatically
- Wind facing challenges – regulation (noise).

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# PV cost curve

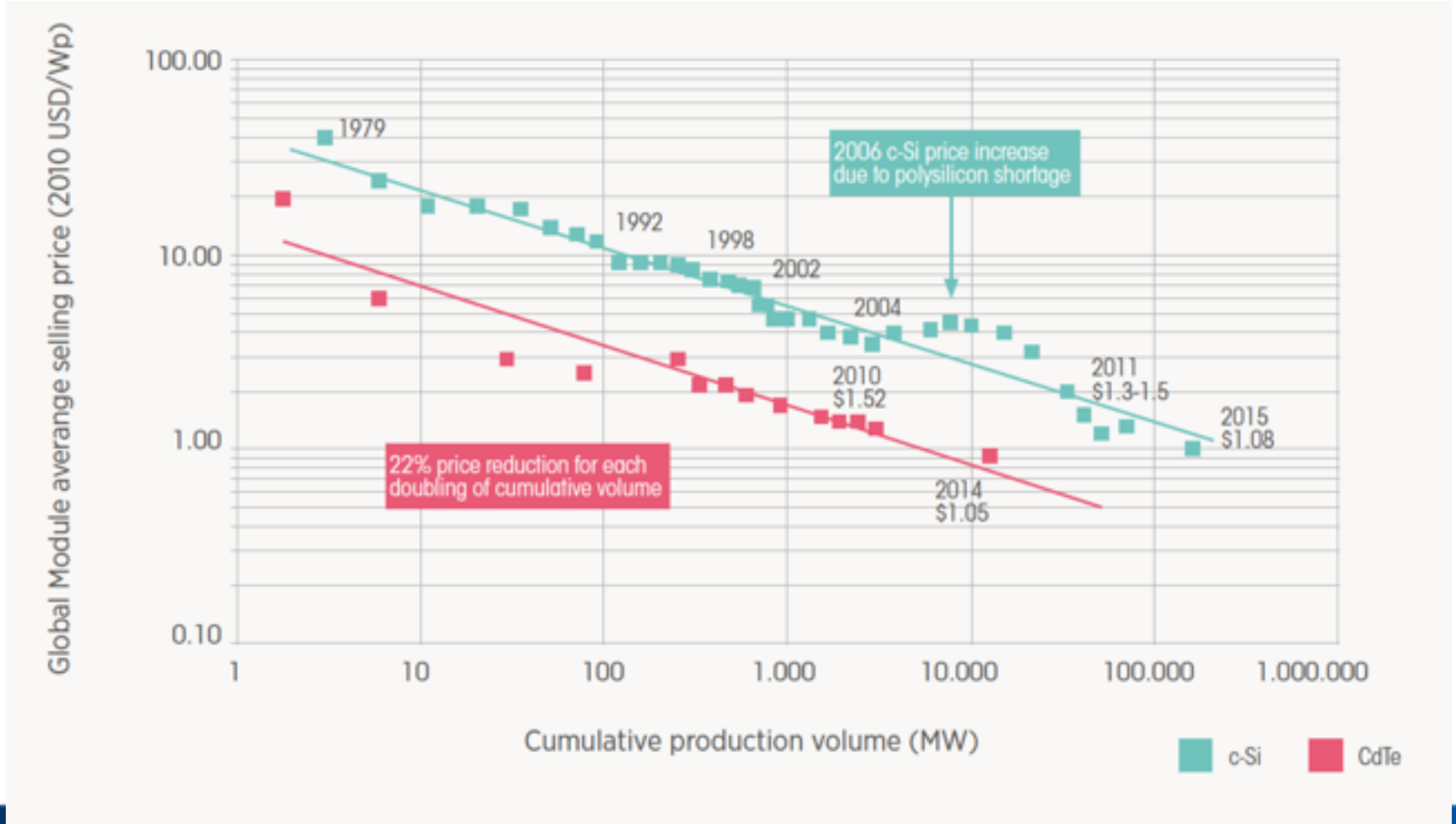



FIGURE 4.1 THE GLOBAL PV MODULE PRICE LEARNING CURVE FOR C-SI WAFER-BASED AND CDTE MODULES, 1979 TO 2015

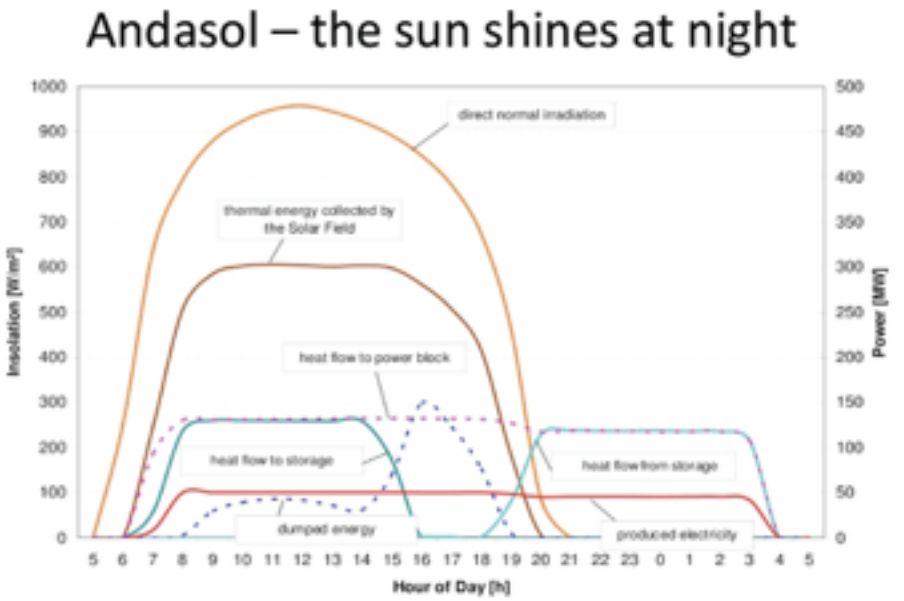
*Sources: based on data from EPIA and Photovoltaic Technology Platform, 2010 and Liebreich, 2011.*

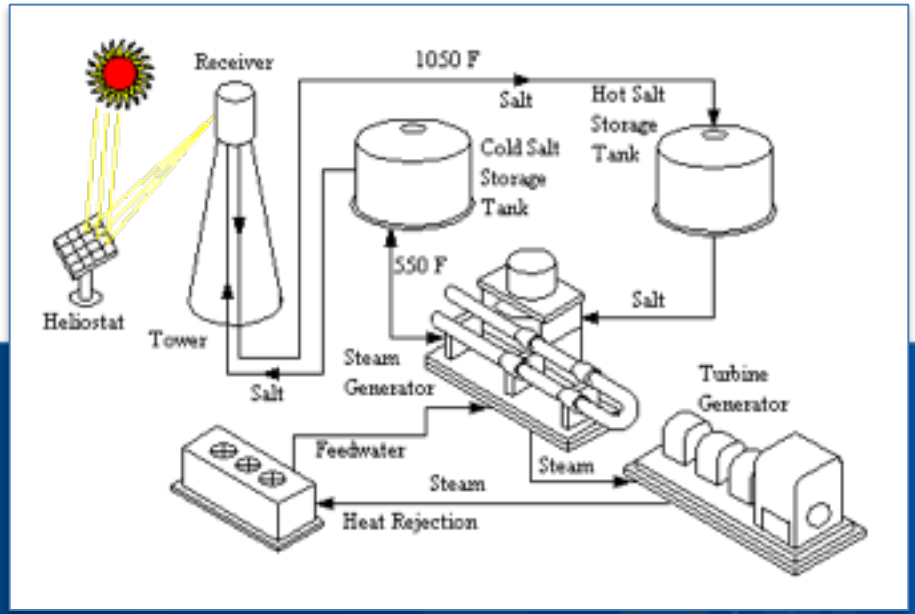


http://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-SOLAR_PV.pdf

# Solar Tower

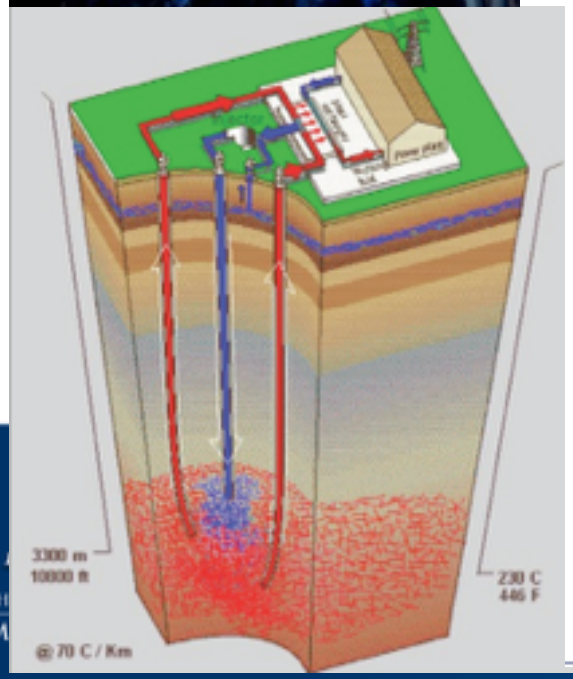
- Large field of solar-tracking mirrors concentrate solar energy onto central tower
- Working fluid (molten salt) transfers heat to stream to drive a turbine
- Energy storage potential

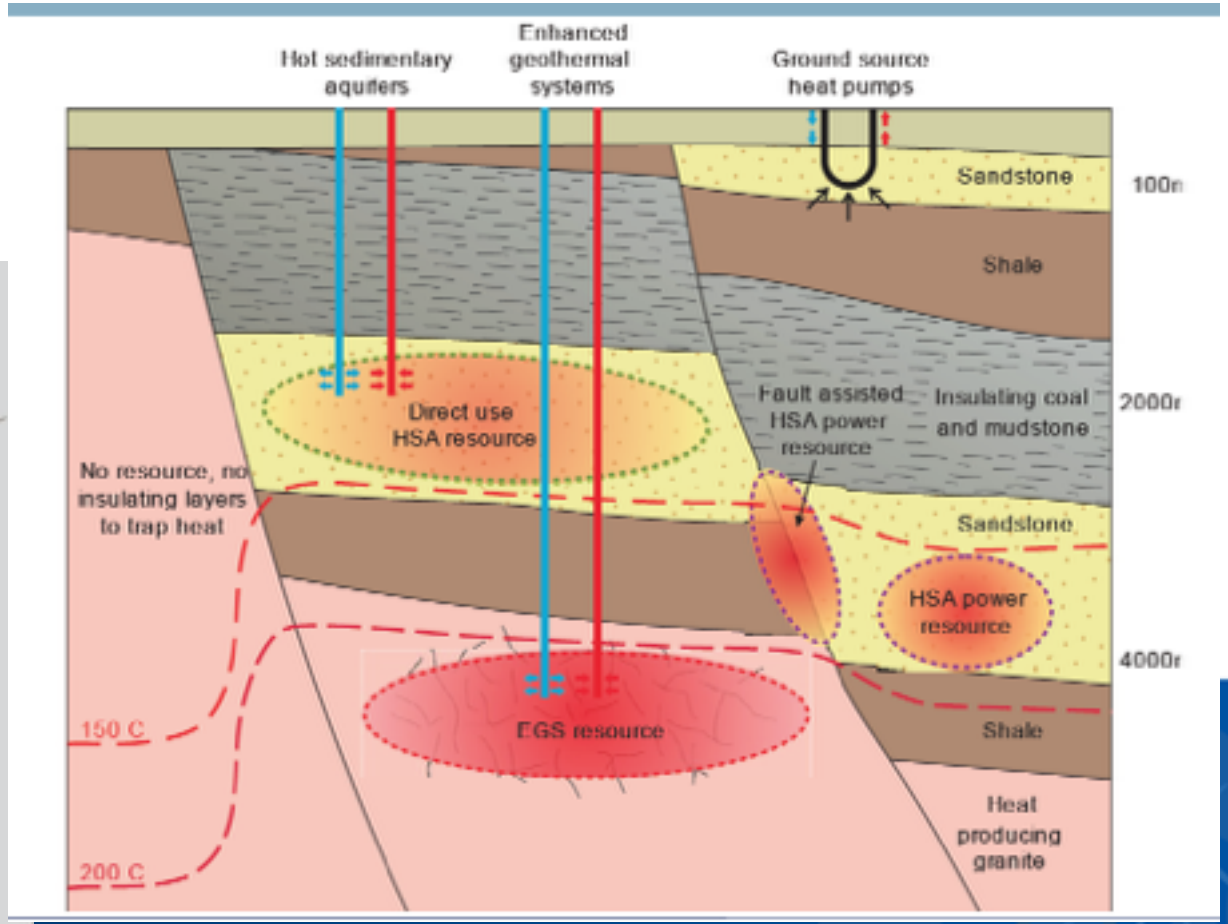


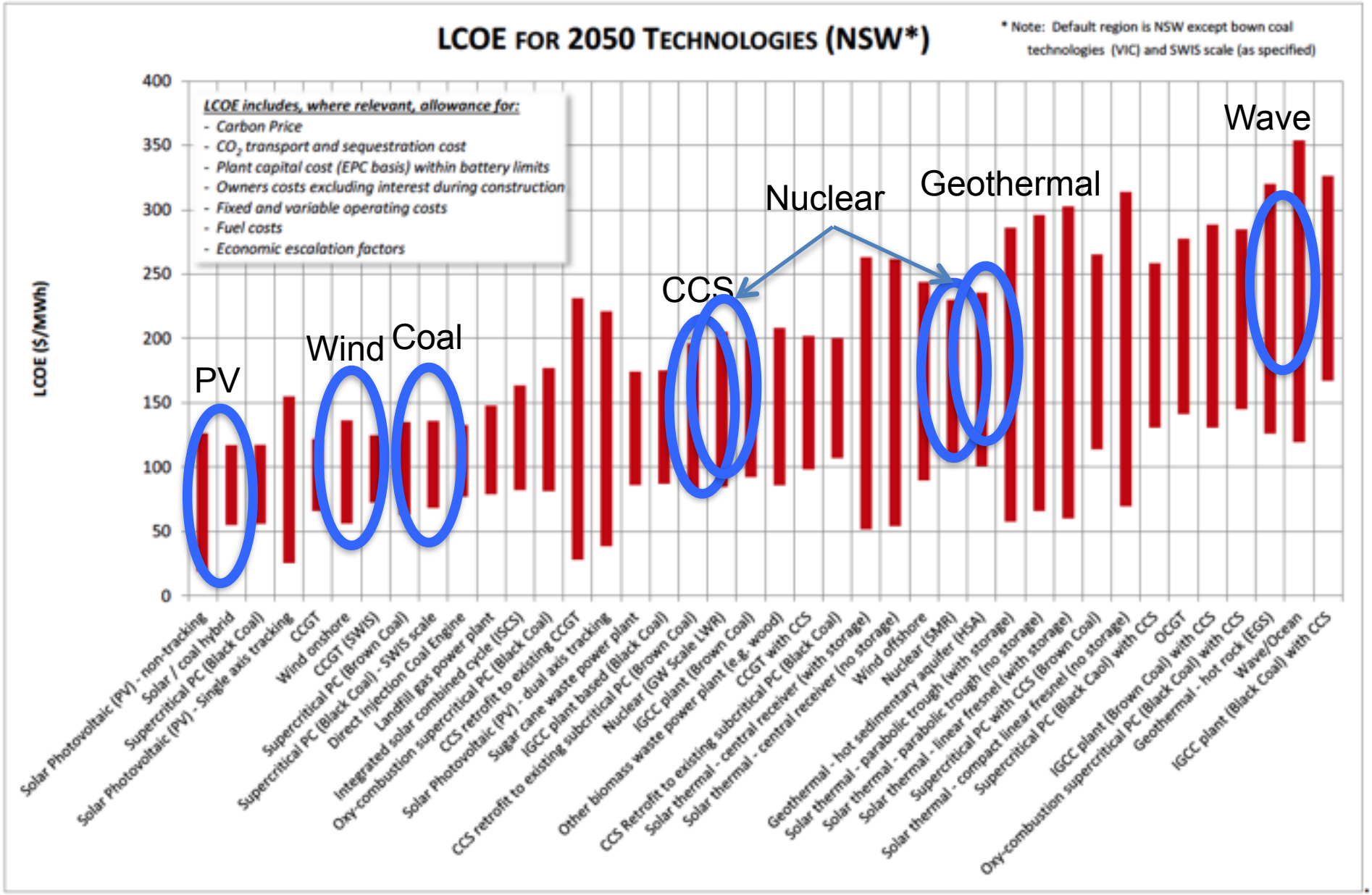



# Geothermal

- Uses natural heat in the crust
- Requires *very* deep drilling - expensive
- Can provide base-load power








http://www.bree.gov.au/publications/australian-energy-technology-assessments

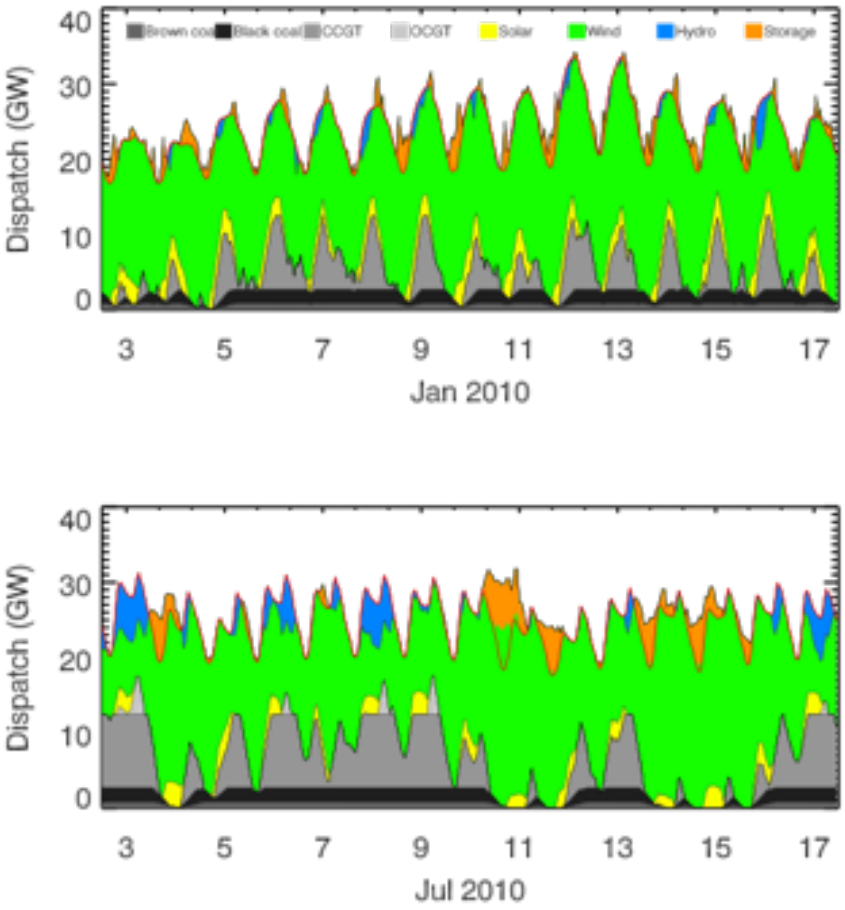
# How technologies integrate

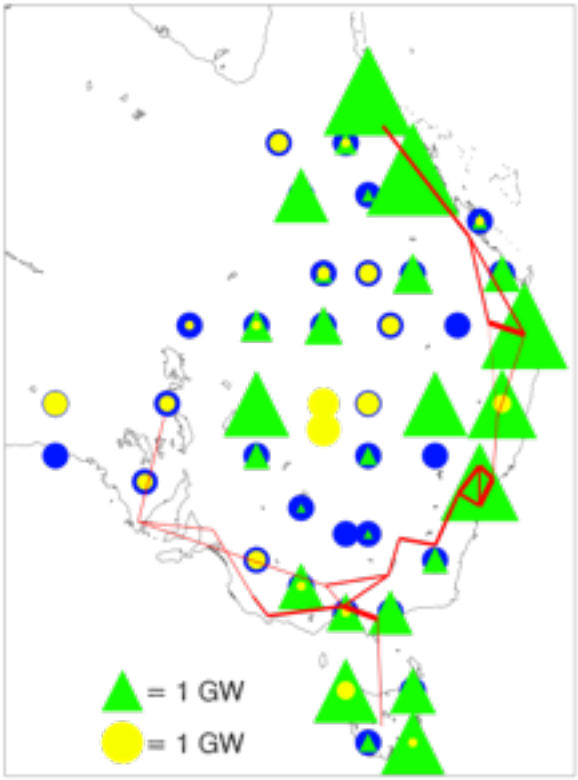
- Not simply a case of least cost wins
- Some renewables (wind, PV) are 'non-dispatchable'
  - Can't control the output – may not meet demand when required
- Require dispatchable capacity (biomass, geothermal, CSP, fossil, hydro)
- Demand-side management

# Interdependance

- Success or failure of one technology impacts on the others
  - Electric vehicles might allow more variable renewables
  - Cheap small scale batteries = more PV
  - Pumped hydro storage = more wind
  - Successful CCS/geothermal = less wind and PV

Carbon price = \$120/t $CO_2$

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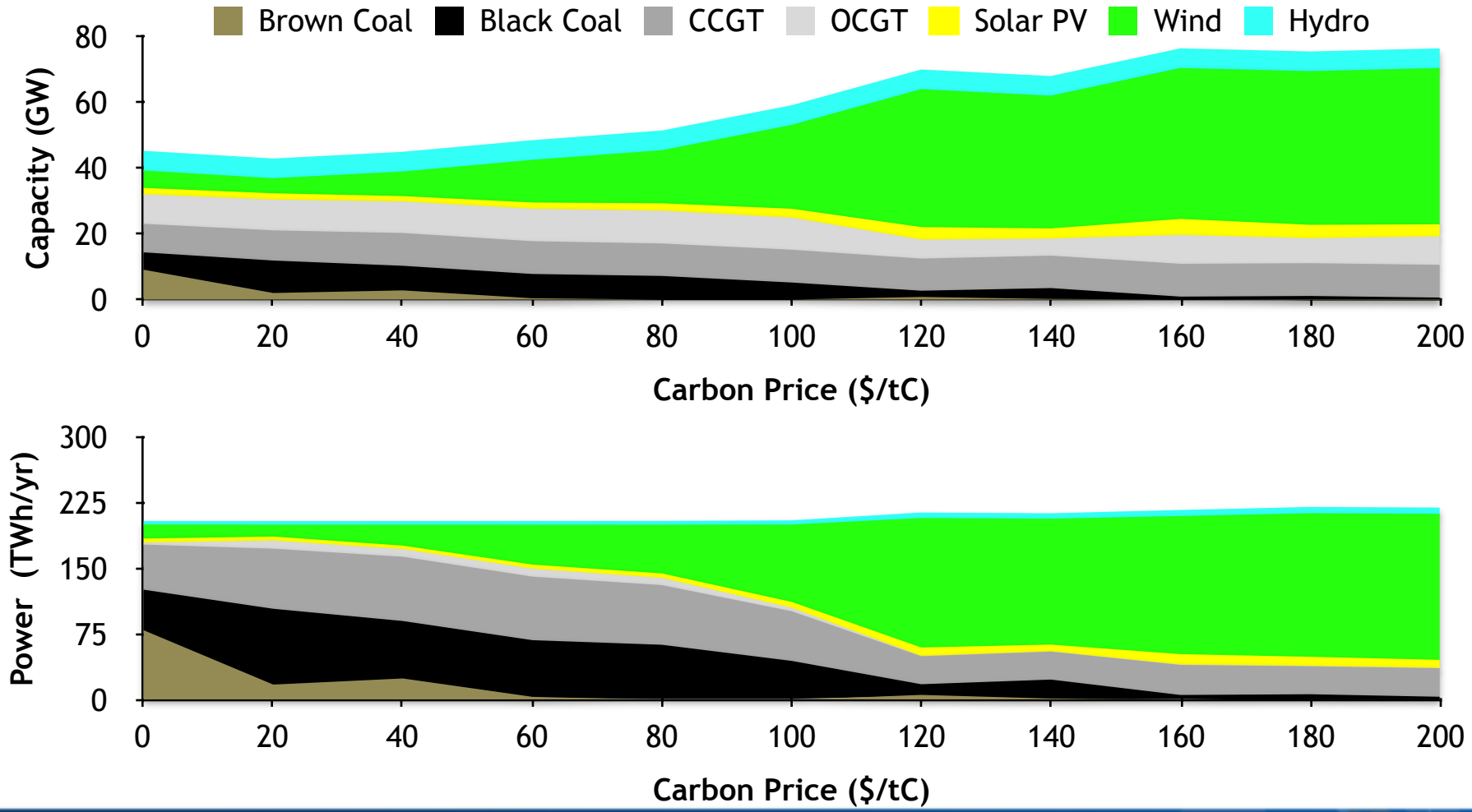
Results from Melbourne University Renewable Energy Integration Lab (MUREIL)

# Installed capacity (GW) and electricity generated (TWh/yr) (MUREIL)

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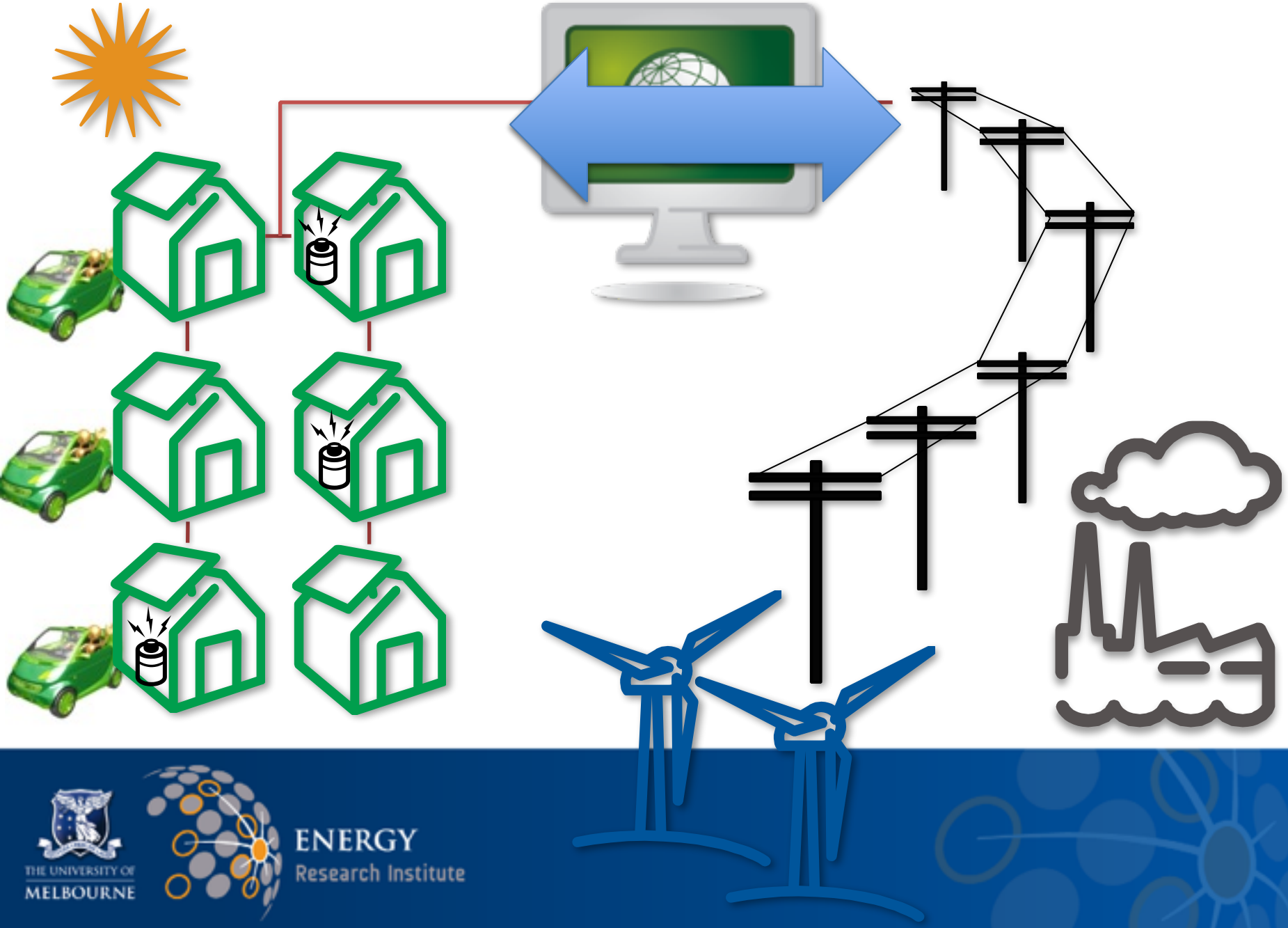
Model results highly dependent on cost predictions. Do not take into account other externalities (i.e. feed-in tariffs)

# Virtual Power Station

- Many individual prosumers interconnected and ‘controlled’ by an aggregator
  - Prosumer = consumer who also produces
  - PV, batteries, various loads (aircon, EVs etc)
  - Aggregator manages customers ‘dispatchability’ and makes it economically viable by economies of scale



Credit to Martin Wainstein (Aust. Germ. College)



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# What will the energy system of the future look like?

- Depends on success of various technologies
- Incumbents working hard to derail the revolution (Oreskes and Conway – Merchants of Doubt)
- Government and regulation
- Will of the people

# Summary

- Energy system of the future highly uncertain
- Important as infrastructure investments last decades
- Decisions over the next decade will set in place the trajectory for the future
- Will energy users become active participants?
  - Virtual power station may seem strange now, but so did so many of the technologies that are now mainstream