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Electricity Generation

from Renewable Energy

Hugh Outhred

School of Electrical Engineering & Telecommunications
University of New South Wales

Tel: 02 9385 4035; Email: h.outhred@unsw.edu.au

www.ergo.ee.unsw.edu.au



Outline

- What are renewable energy resources?
- Why use them to generate electricity?
- Specific renewable energy resources for generating electricity
- Career opportunities for electrical engineers
- Conclusions



Energy resources used by humans

- Fossil fuels (coal, oil, natural gas):
 - Biomass converted & stored in geological formations
- Nuclear energy (fission & fusion):
 - Naturally occurring: geothermal & solar energy
 - Human-made: nuclear power & weapons
- Renewable energy resources:
 - Solar, biomass, wind, hydro, tidal, wave, ocean thermal, geothermal
 - Derived from natural nuclear & gravitational forces



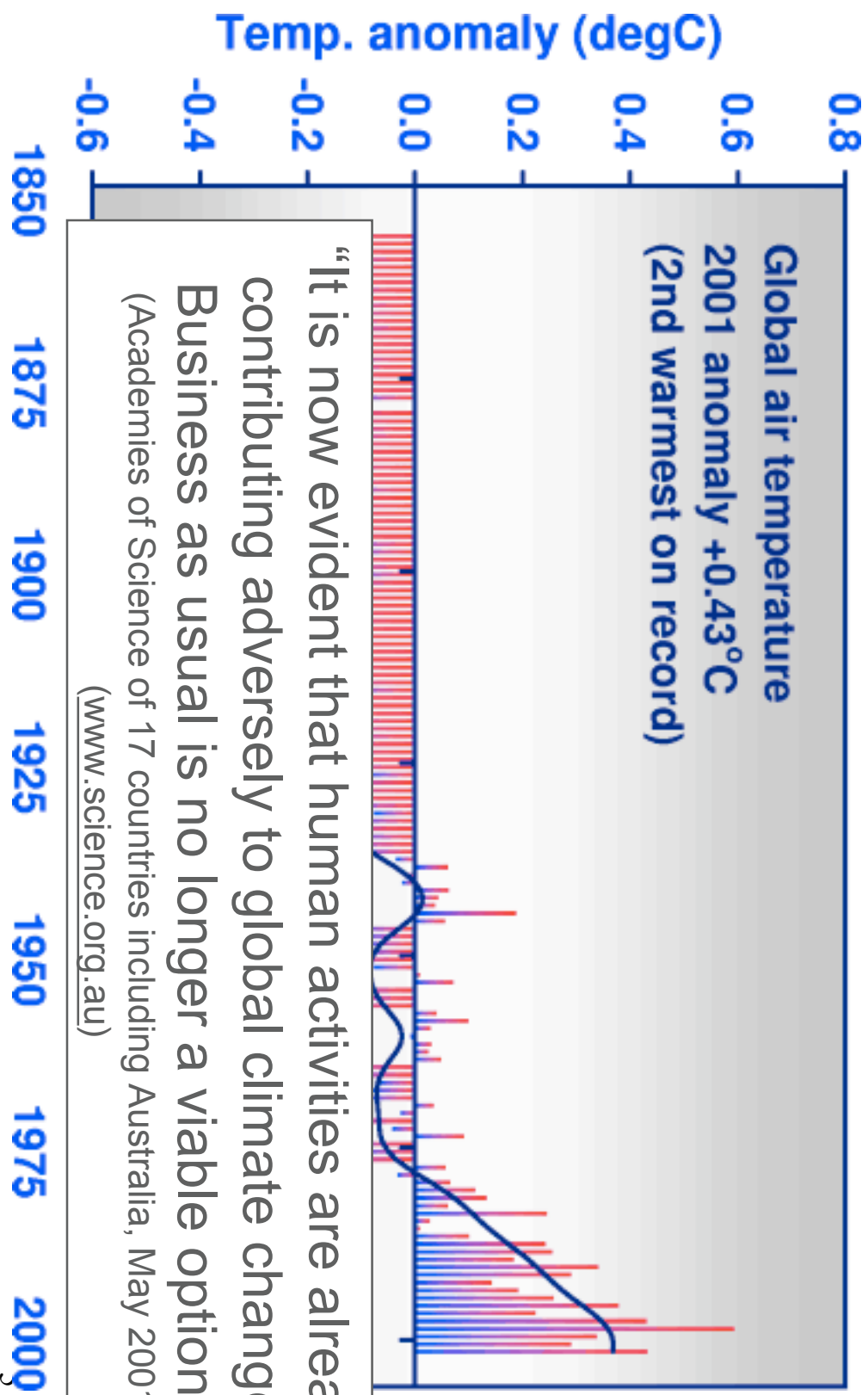
Why use renewable energy resources?

- Fossil fuels:
 - Release oxides of carbon (climate change), nitrogen & sulphur into the atmosphere
 - Mining impacts; uneven human access
- Nuclear energy (human created):
 - Concerns about accidents; long-term storage of nuclear waste; nuclear weapons
- Renewable energy *may* be more benign:
 - All electricity generation has adverse impacts



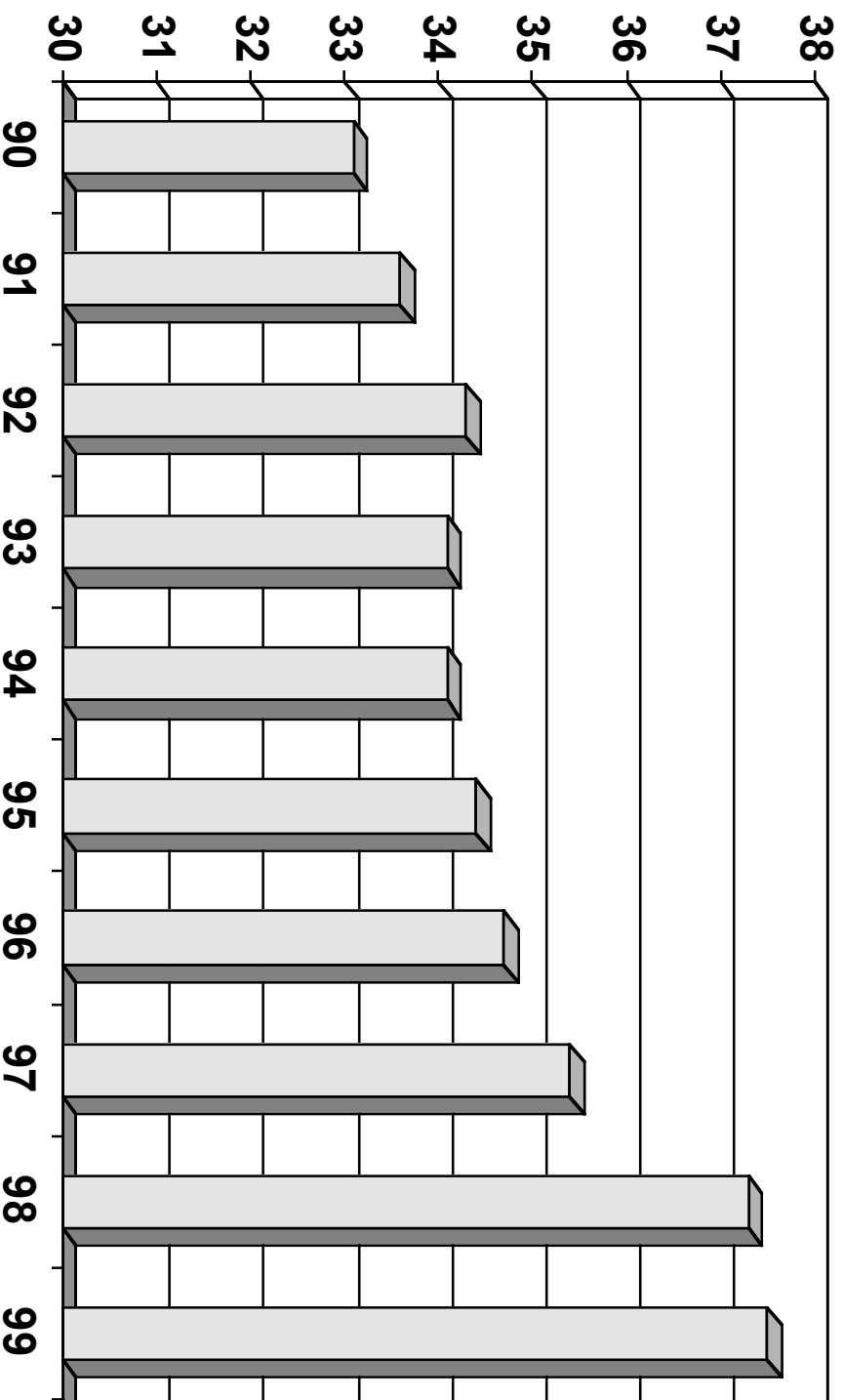
Global air temperature records

(<http://www.cru.uea.ac.uk/cru/info/warming/>)





Electricity contribution to Australian greenhouse emissions (%)



Source: www.greenhouse.gov.au/inventory, 2001



Why do we use electrical energy?

- Readily produced from most primary energy forms (fossil, nuclear, renewable)
- Readily delivered from point of generation to point of end-use
- Readily used to deliver most highly valued stationary end-use energy services, eg:
 - Lighting, heating, cooling, electronics, motive power
- But:- high quality, hard-to-store energy form:
 - Expensive to make in terms of thermodynamics & external impacts (& not easy to use for transport)
 - Expensive when supply is interrupted



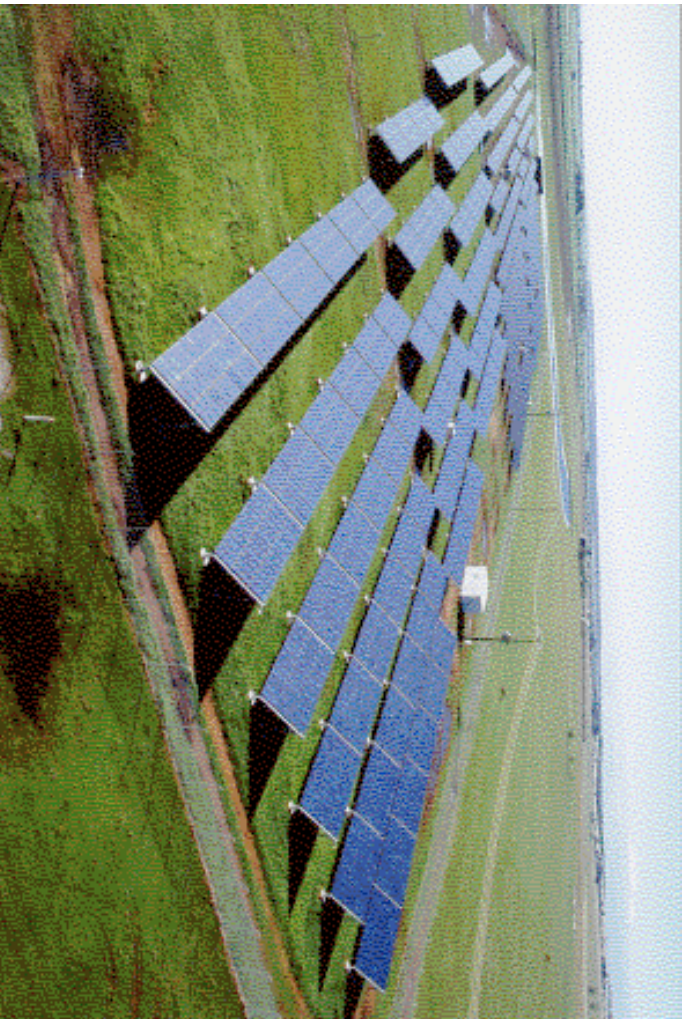
Generating electricity using renewable energy resources

- Solar energy
- Biomass energy
- Wind energy
- Hydro energy
- Tidal energy
- Wave energy
- Ocean thermal energy
- Geothermal energy



Solar energy - photovoltaics

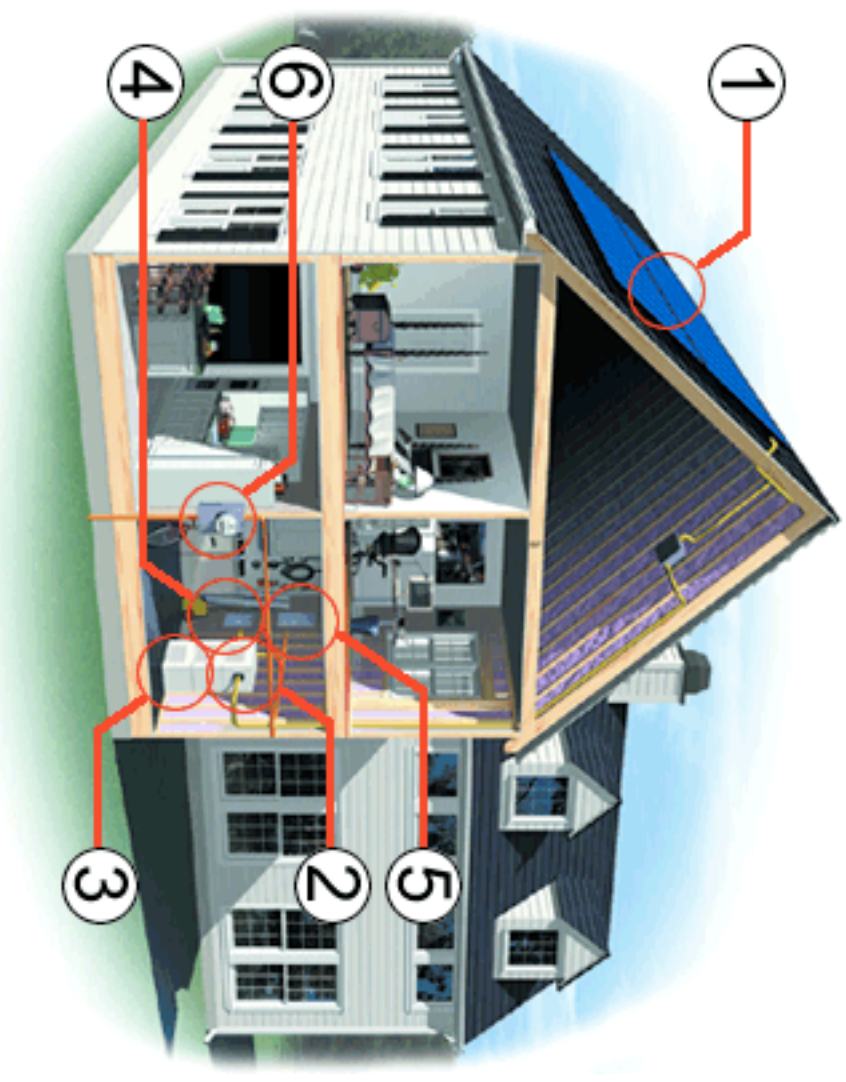
- PV cells convert solar energy directly to DC electricity
 - Use inverter to create AC
- Stand-alone or building integrated





AstroPower SunUPS™ Building-Integrated PV & UPS

1. PV Panel
2. Inverter (synchronised to the mains)
3. Battery for UPS function
4. Essential circuits supported by UPS
5. Low priority circuits not supported by UPS
6. Utility meter
7. *PV is proven but expensive technology*



(<http://www.astropower.com/sunups.htm>)



Solar energy - thermal electric

- Solar energy > thermal energy > electrical energy
 - Working fluid: steam, oil or (for high concentration) sodium
- *Still under development*

(www.greenhouse.gov.au)



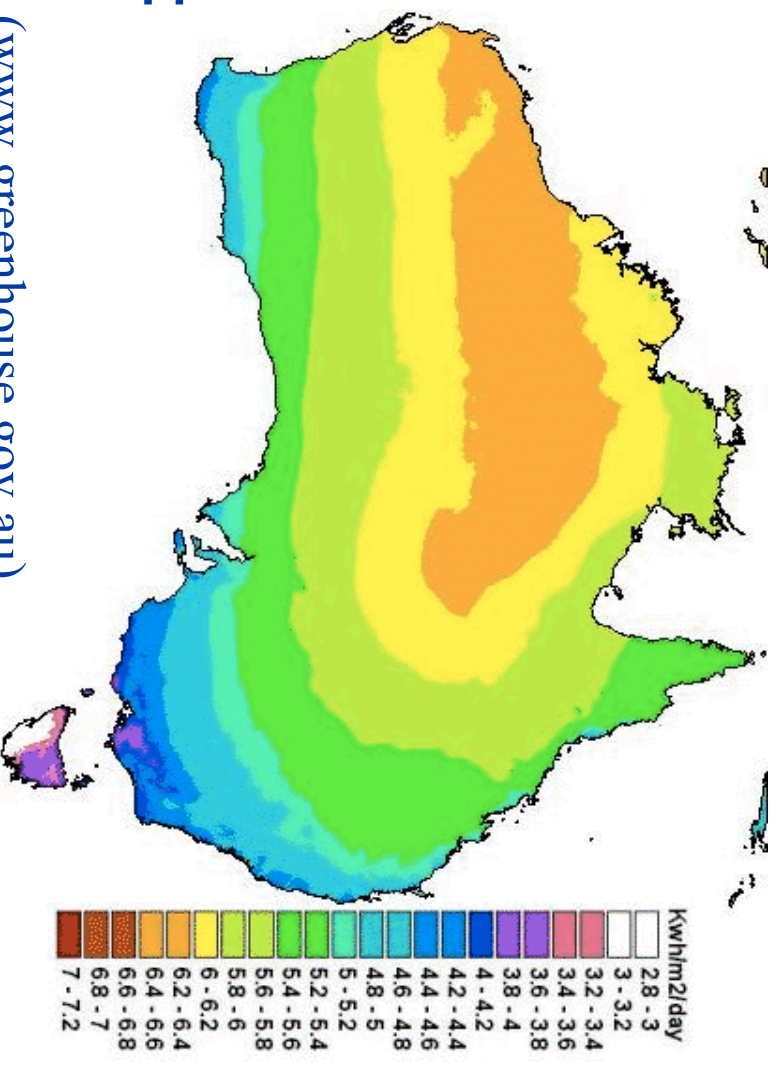


Solar Resource

Building Integrated PV & Solar Hot Water assessment:

- Key variables:
 - System efficiency
 - Solar radiation
 - Temperature
 - Rooftops
 - area, orientation, tilt, shading
- Further work needed:
 - Rooftop resource
 - Shading

(www.greenhouse.gov.au)



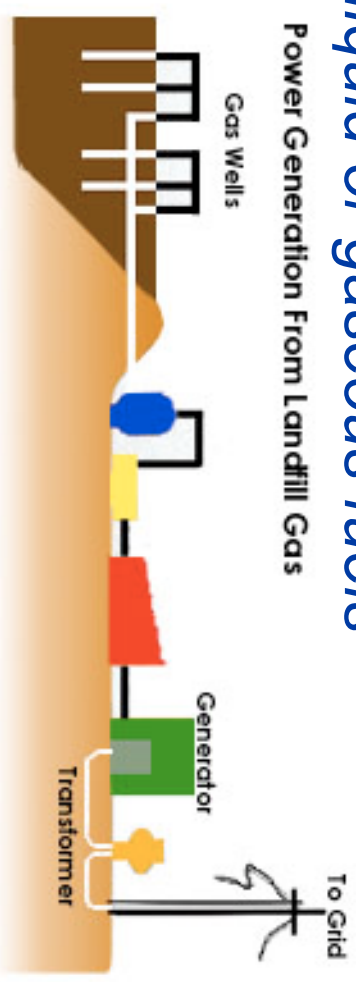
Australia has excellent solar resources but best in NW



Biomass energy

- Energy crops, possibly also for salinity control
- Agricultural by-products - eg bagasse (sugarcane)
- Municipal wastes
- *Burnt directly or converted to liquid or gaseous fuels*

(www.greenhouse.gov.au)





Wind energy

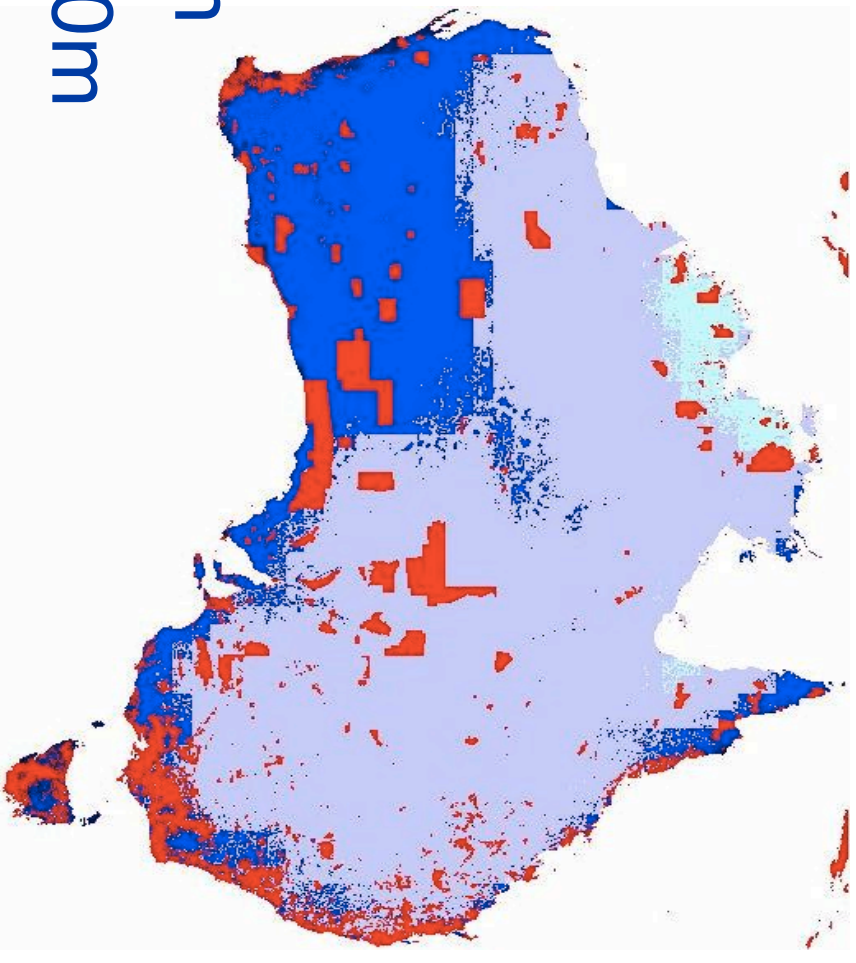
- 600 kW wind generator at Newcastle (>5 years old):
 - Latest machines up to 3 MW
- Normally installed in “wind farms” in rural areas
- Dependent on good wind resources, grid access and appropriate land-use
- *Fastest growing renewable technology world-wide:*
 - *Australia lags behind Europe*





Usable Wind Resources in Australia

- Model for
 - Wind Speeds
 - Land Availability
 - Grid access
- Red = Land exclusion
- Blue = > 6.2 m/s at 50m
- *Australia has excellent wind resources*

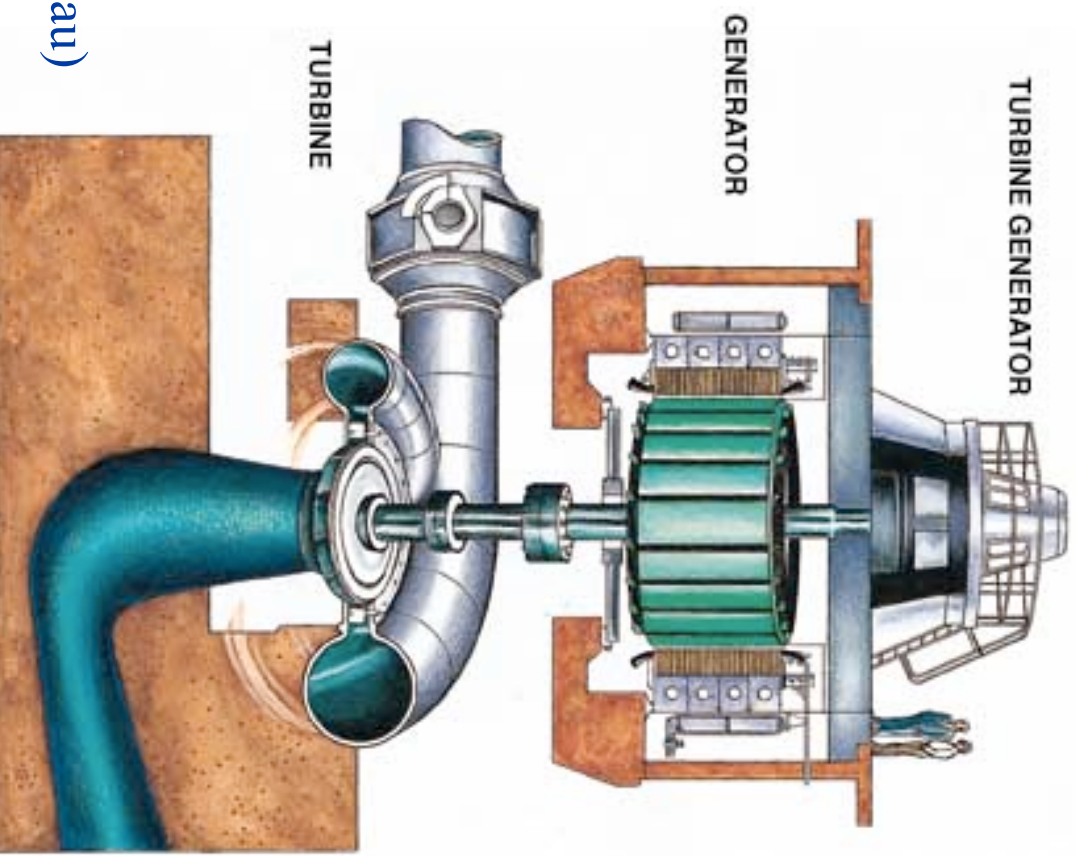




Hydro energy

- From:
 - Potential energy of water in storage dam
- To:
 - Rotational kinetic energy in turbine and then electrical energy
- *At good sites, large hydro can be cheaper than coal-fired power stations*

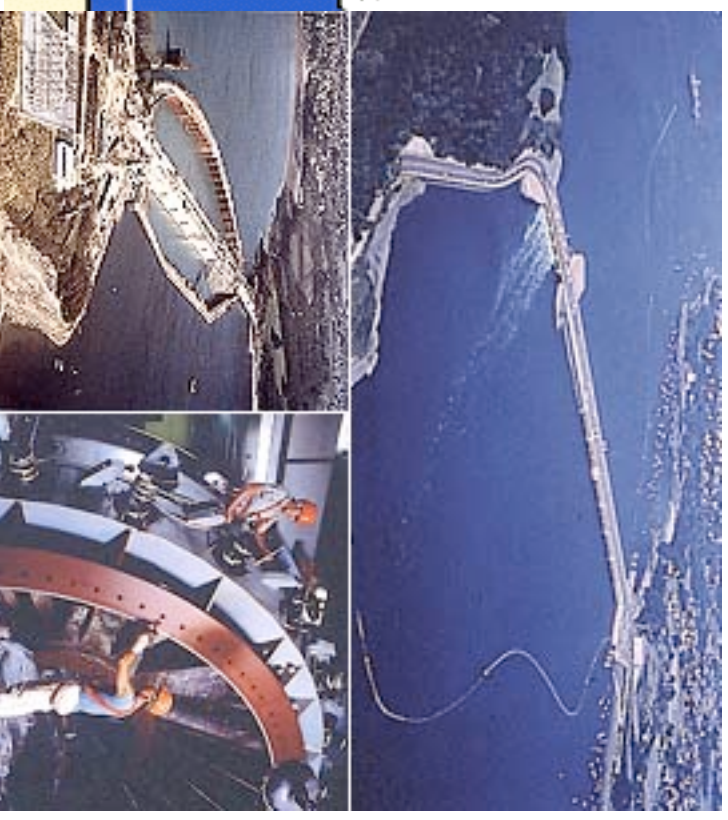
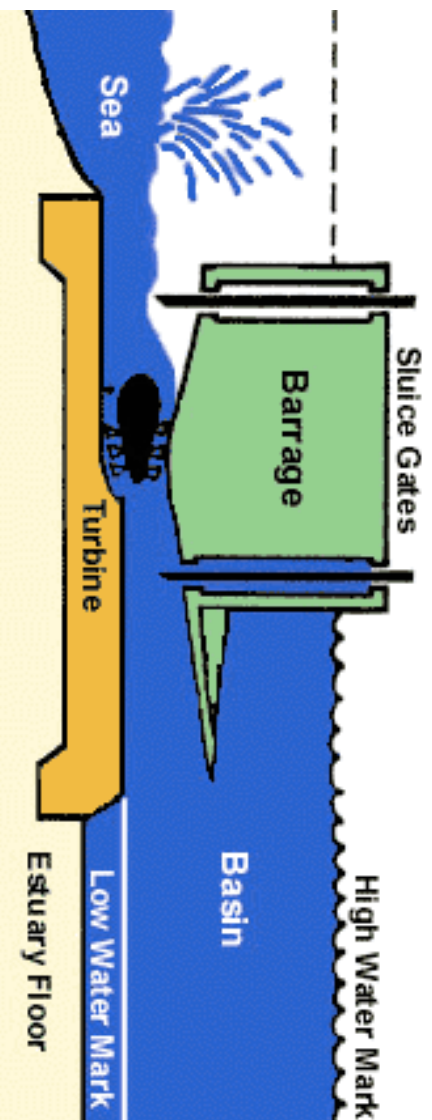
(www.greenhouse.gov.au)





Tidal energy

- Low-head hydro with two-directional flow
- Tidal range varies with solar-lunar alignment
- Sea water more corrosive than fresh water
- *Low head implies less cost-effective than most hydro*

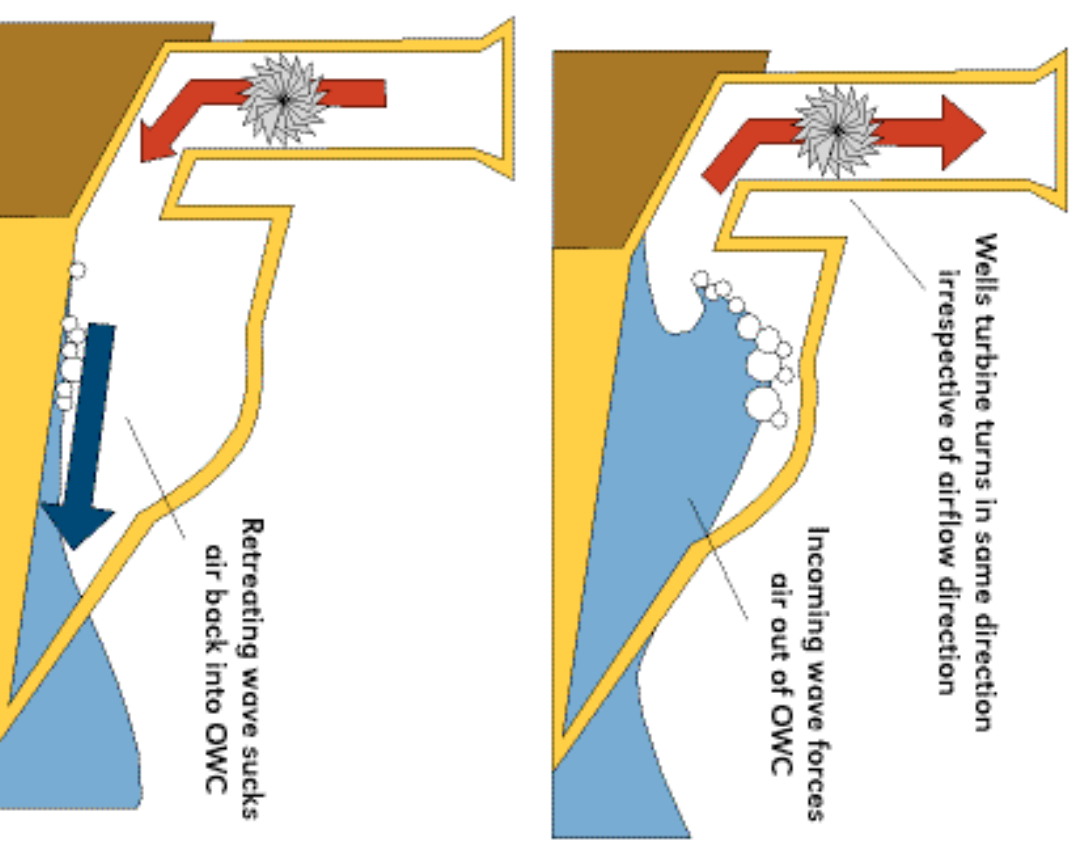




Wave energy

- Wave energy derives from wind energy:
 - Energy density varies dramatically
- Need strength to survive storms yet cheap & sensitive enough to produce energy from small waves
- *Still under development*

(www.greenhouse.gov.au)

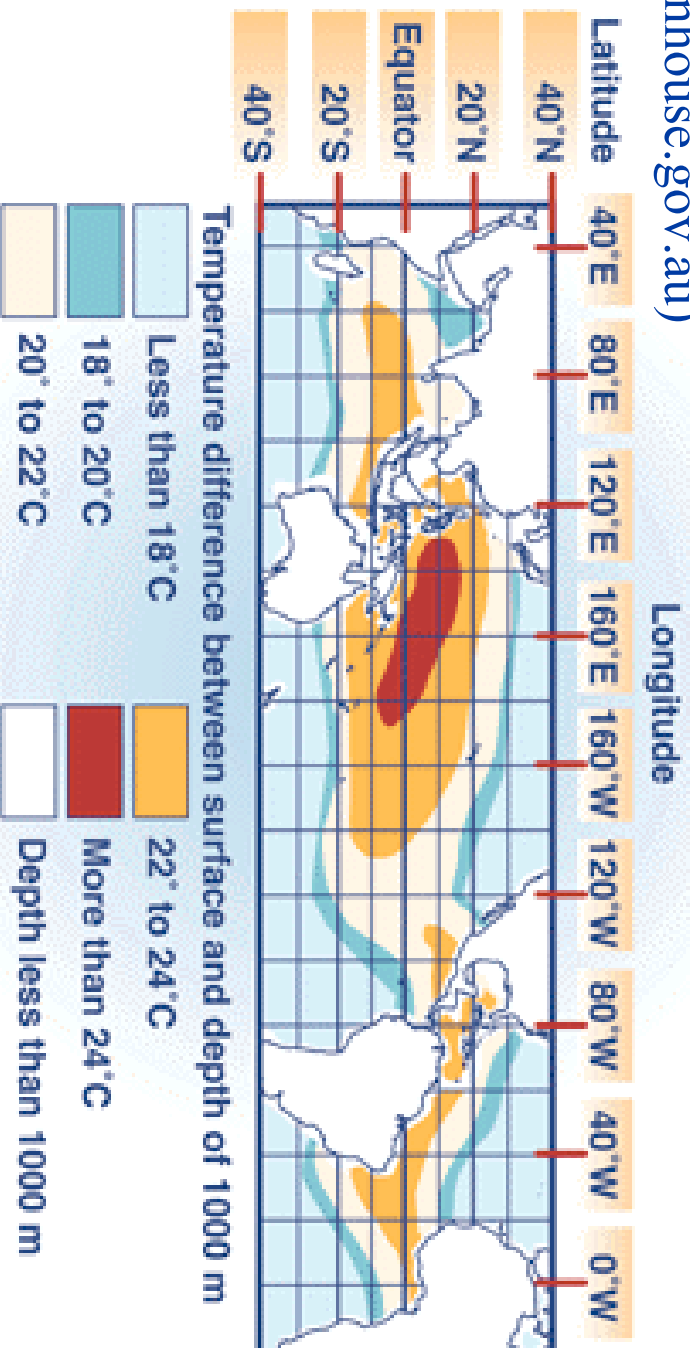




Ocean thermal energy

- Heat engine that uses temperature difference between surface & ~1000 m depth (in tropics)
- *Still under development, low Carnot efficiency*

(www.greenhouse.gov.au)





Geothermal energy - groundwater (Wairakei, New Zealand)

- Geothermal power plant using natural ground water
- *No suitable sites in Australia*



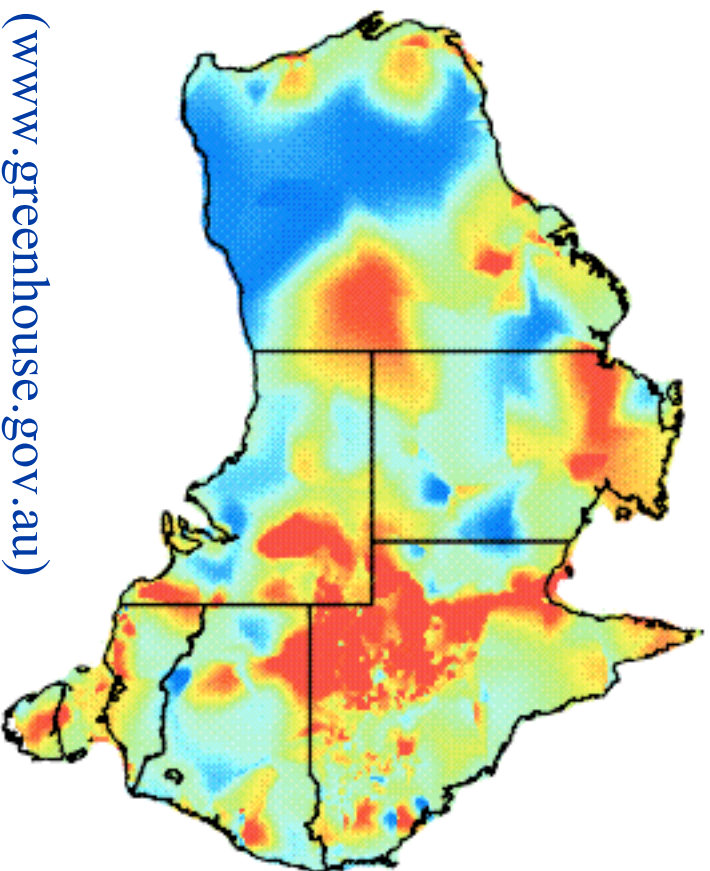
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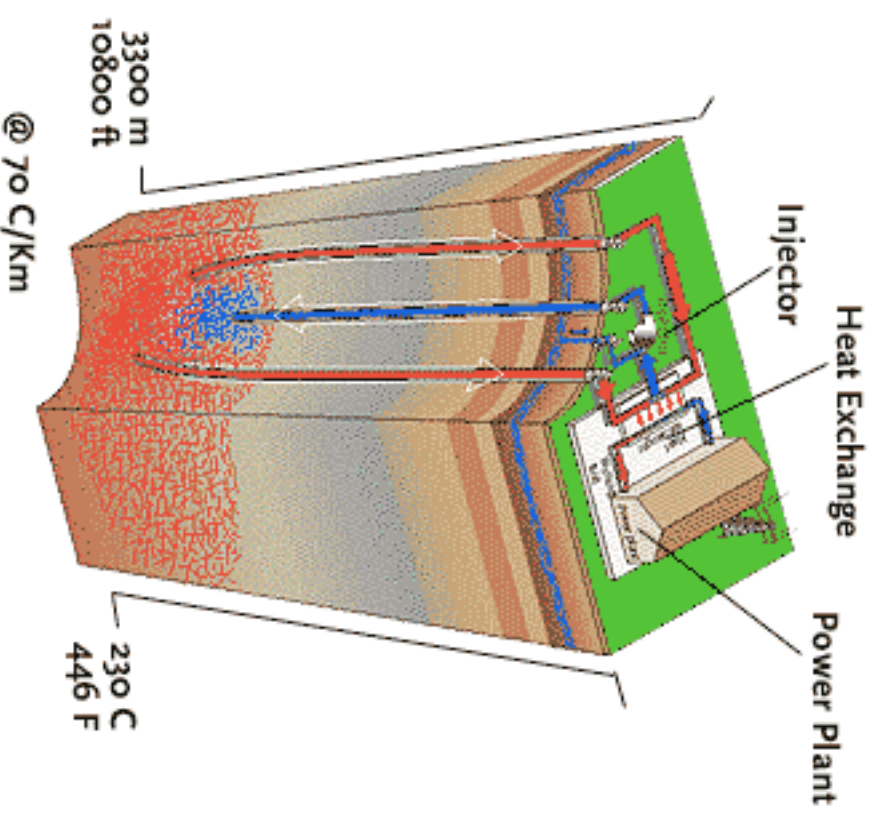
Geothermal energy - hot dry rock

Australia has plentiful hot dry rock at ~3000m
(needs water injection)

Trial in Cooper Basin, SA



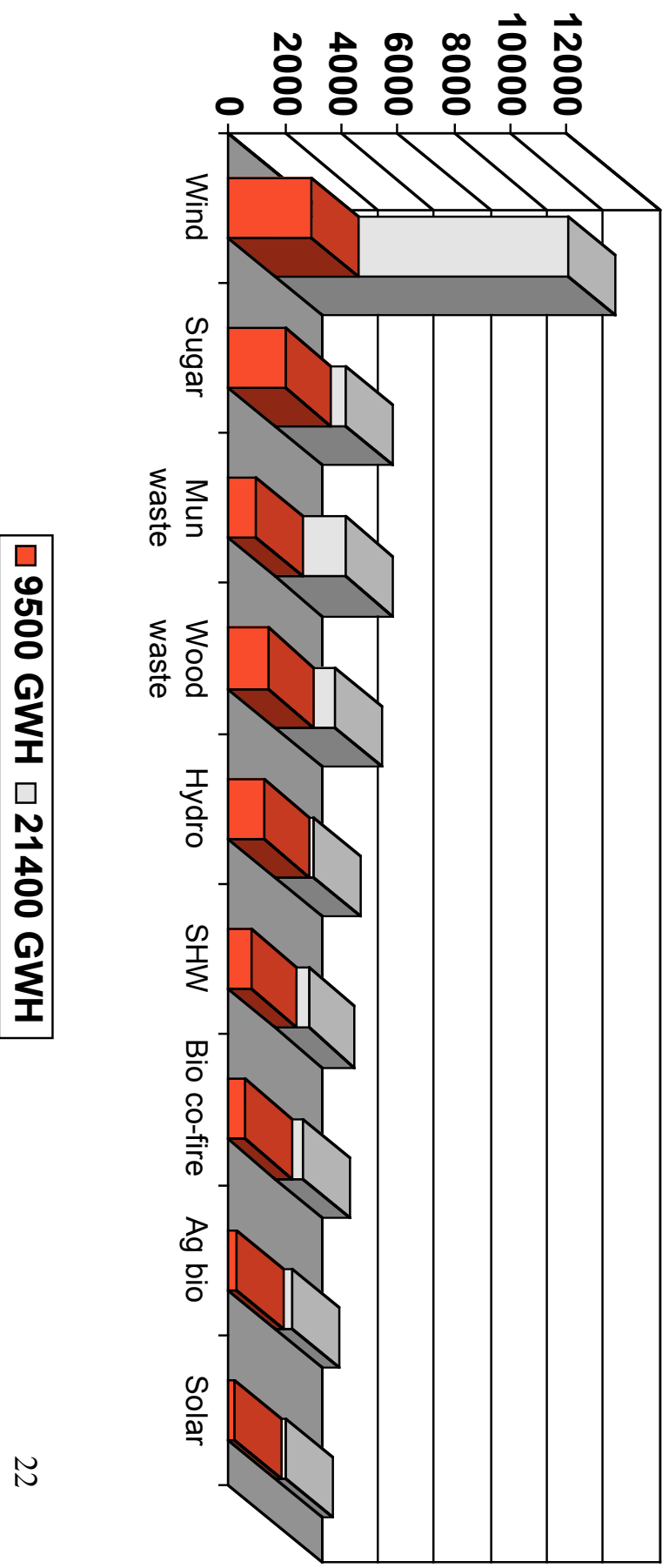
(www.greenhouse.gov.au)





AEA prediction of sources for MRET 9500 & 21400 GWh pa targets

(MRET: Mandatory Renewable Energy Target)
(AEA: Australian Ecogeneration Association)
(GWh per year)





Career opportunities for electrical engineers

- Technology development:
 - PV, solar thermal, biomass, wind, hydro, tidal, wave, OTEC, geothermal
- System design & installation
- System operation
- Power system integration (network, operation, protection, planning)



Conclusions

- Growing interest in electricity generation from renewable energy:
 - Climate change
 - Technological progress
 - Resource security (in some countries)
- Growing employment opportunities:
 - Technology, system design & installation
 - Operation & power system integration