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A Sustainable Energy Future for Australia

with Case Studies of Community/Local Projects

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Global Climate Change is Here!

Why change our Energy System?

- Global climate change results primarily from burning fossil fuels
- Impacts on Australia will be very large: drought; firestorms; floods; damage to coastal infrastructure, agriculture and tourism
- Energy security: peak in global oil production is here
- Avoid land degradation and air & water pollution from fossil fuels

How can Renewable Energy replace Fossil Fuels?

Energy end-use; current fossil source	Comment; Renewable energy substitute
Electricity mostly coal	Electricity generation --> 35% of Australia's GHG emissions. Could be entirely supplied by renewables within a few decades.
Transport mostly oil	14% of GHG emissions. Electric vehicles for urban transport and inter-city rail run on renewable electricity. Biofuels for rural travel.
Heat (non-electrical) mostly gas	About 17%. Low temperature heat from solar; high temperature heat possibly from biofuels & concentrated solar thermal.
Agriculture mostly diesel + coal-fired elec.	16%. Biodiesel + renewable electricity.

Global Status of Low-Carbon Energy Supply Techs

Market penetration

			Gas: combined cycle and single cycle
			Energy efficiency
			On-shore wind; Gen II nuclear?
		Off-shore wind; geothermal heat	Solid biomass combustion
Novel PV; CCS; novel biofuels	Marine; hot rock elec; Gen II biofuels (ligno-cellulose); fast breeder reactor (Gen IV)	Concentrated solar thermal + thermal storage; Gen III nuclear	solar hot water; solar PV; Gen I biofuels
R&D	**Demonstration**	**Pre-commercial**	**Commercial**

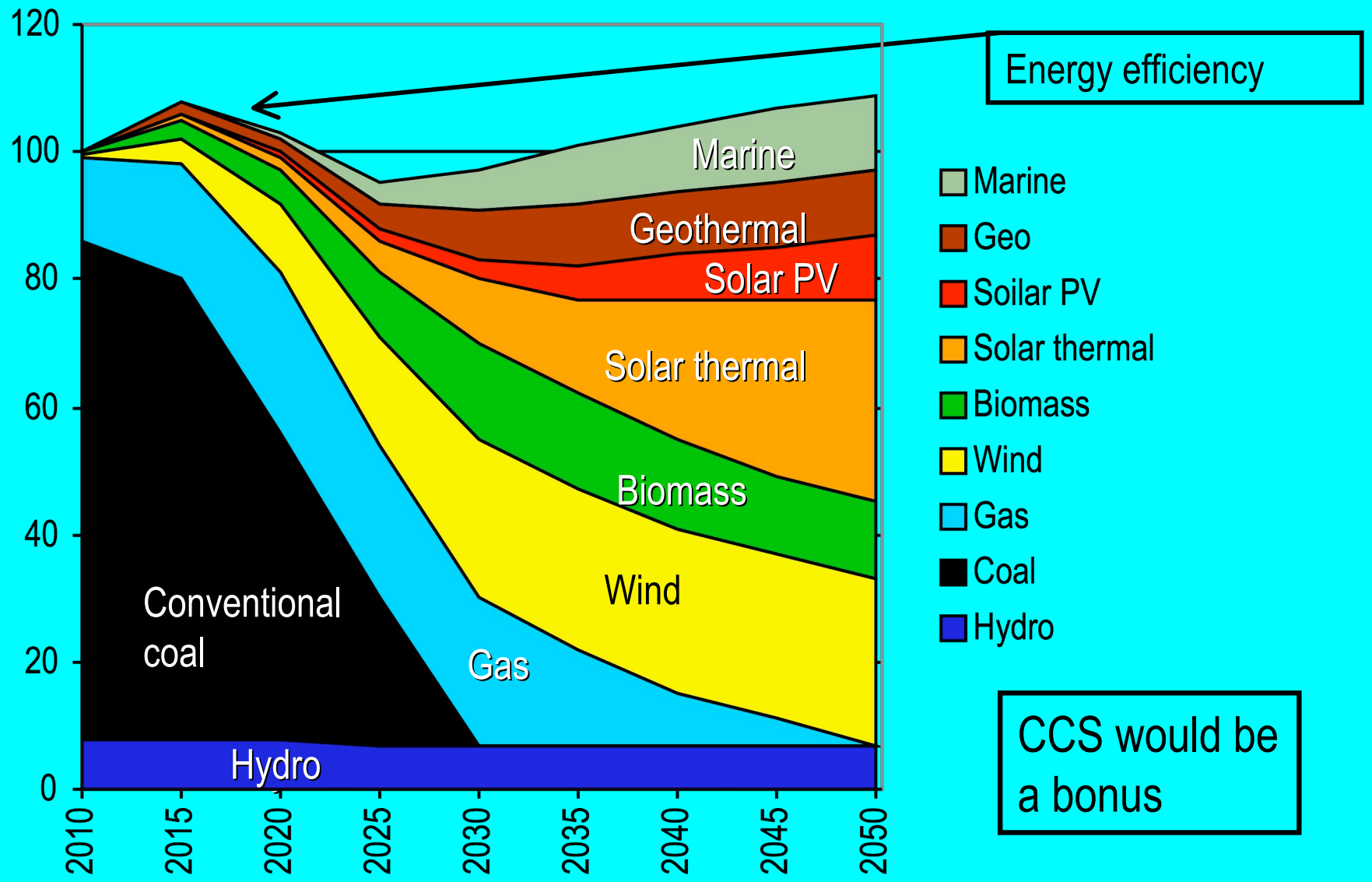
Adapted by the author from Foxon et al. (2005)

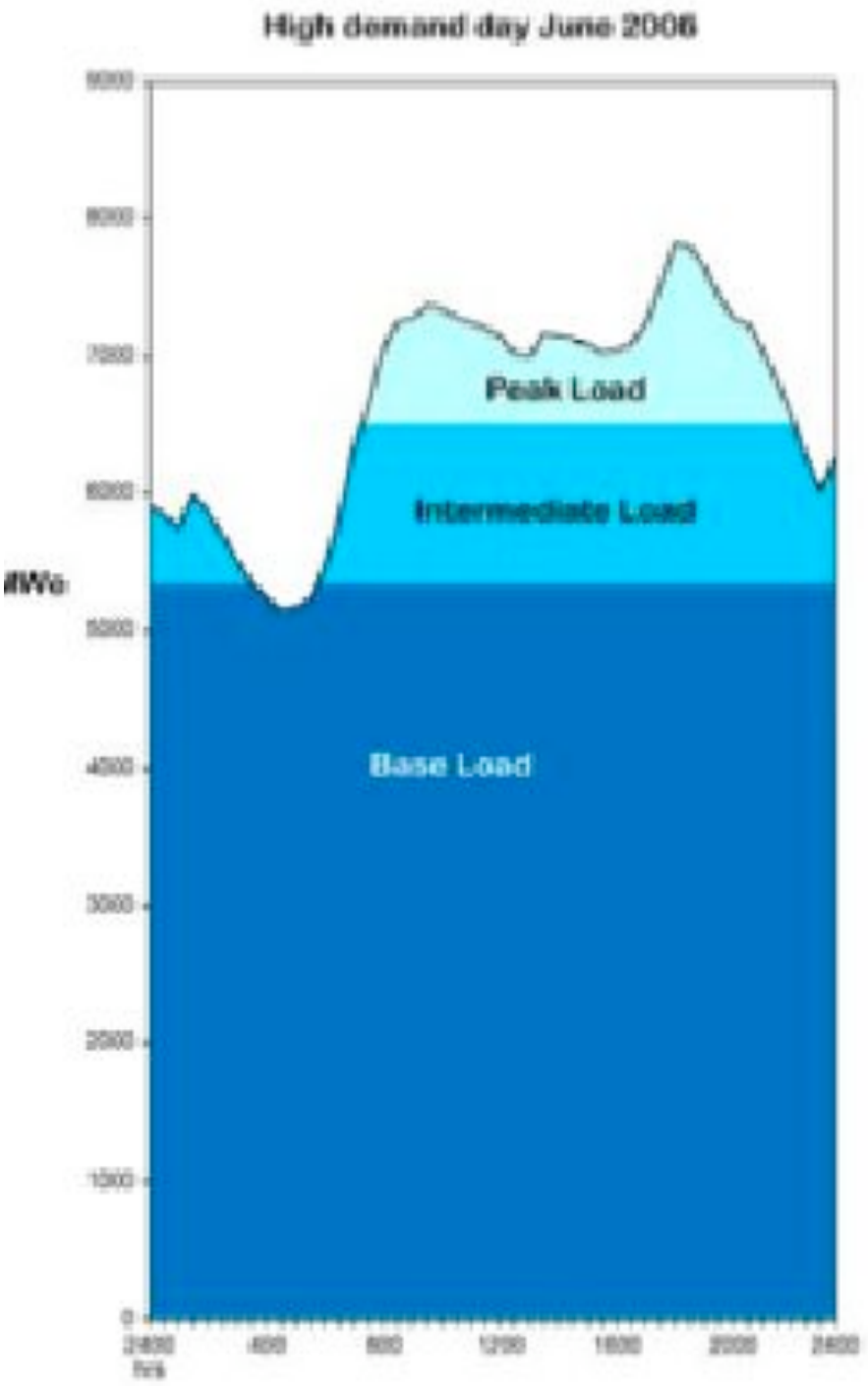
Technology status

Action for Renewable Energy Needed on all 3 Scales

- Residential: rooftops & gardens
- Local community: medium-scale wind, solar & biomass
- State/National: grid-connected

IES Scenario for Australian Electricity, 2010–2050





Daily Elec Demand met by 100% Renewable Energy by 2050

Peak-load: Hydro; CST + thermal storage; biofuelled gas turbines; PV

Int.-load: CST+ thermal storage, bioenergy; PV

Base-load:

- Demand reduction by solar hot water and energy efficiency;
- CST + long-term thermal storage;
- Bio-electricity
- Wind with supplementary peak-load
- Geothermal (when commercially available)

Wind Power

Wind could supply 20-25% of USA's, Europe's & Australia's electricity

- Commercial technology
- Global wind capacity at end 2010: 194.4 GW; growth rate 23% per yr
- Biggest contributor to new generating capacity in EU in 2008 & 2009
- In 2010, 21% of electricity achieved in Denmark; 15% in Spain and Portugal
- Changes to transmission network needed
- Large-scale dispersed wind farms, with a little extra peak-load back-up, can substitute for some coal power stations

Albany wind farm, Western Australia.

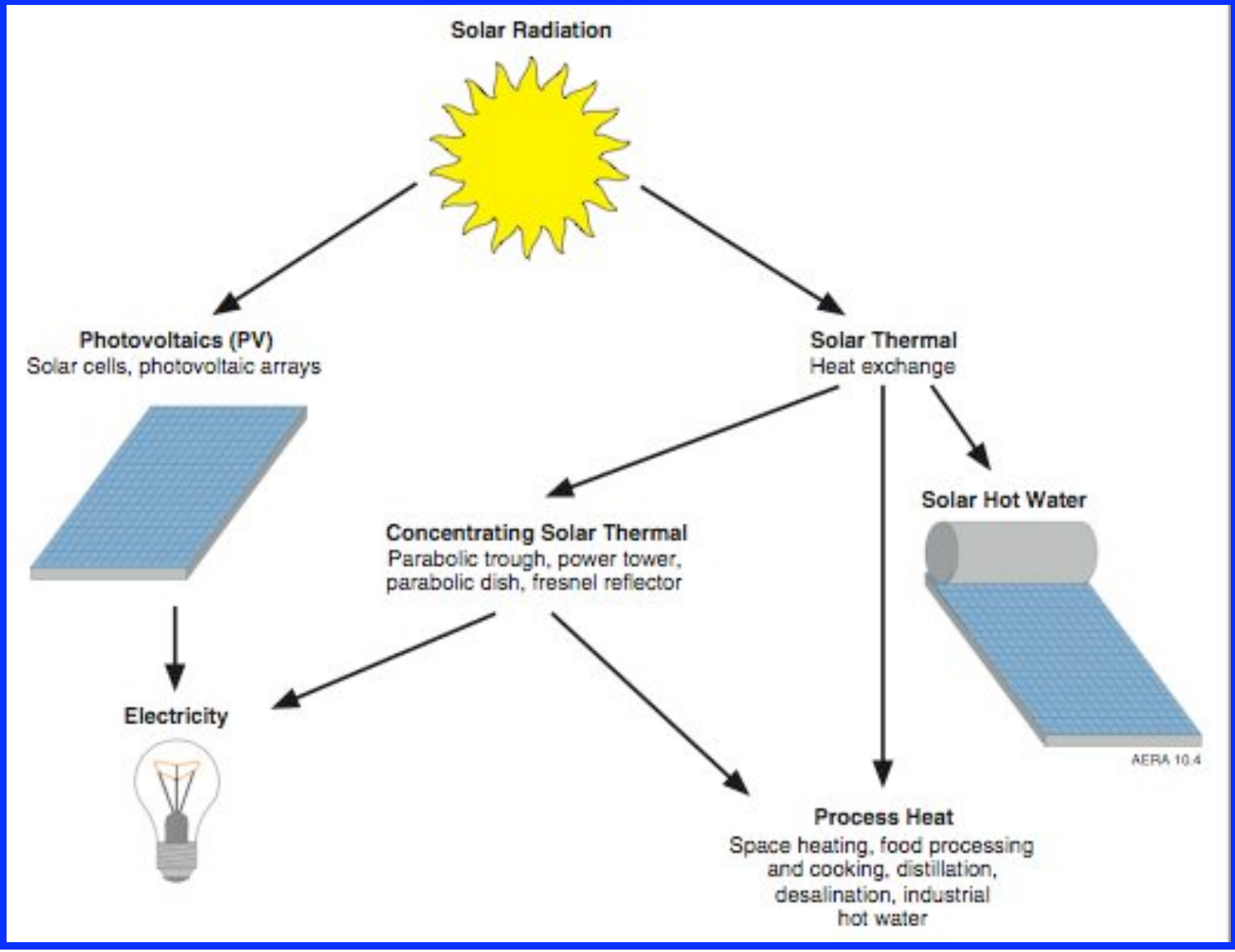
Bioenergy from Crop Residues

Does not use additional land

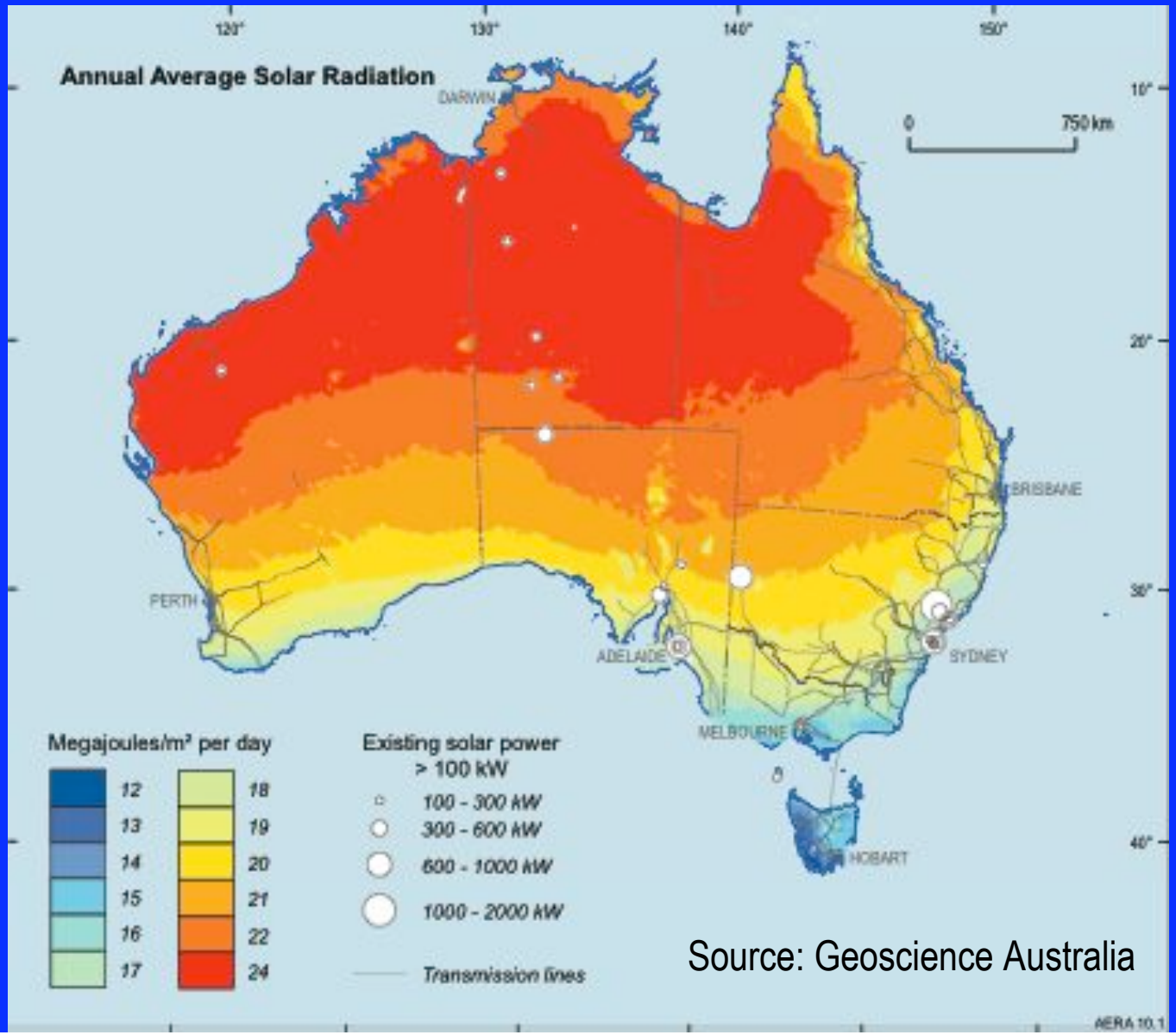
- Residues & organic wastes cheapest & fastest
- Residues from sugar, wheat, plantation forests
- Fuels base-load power and heat (cogeneration) & peak-load turbines
- Biomass residues don't compete with food production
- Ash can be back-loaded to fields
- Could supply 30% of Australia's electricity in good years; 15% during drought years

Burning sawmill & sugar cane residues in Queensland, Australia

Two Types of Solar Electricity: PV and Thermal



Australia's Solar Resource



Source: Geoscience Australia

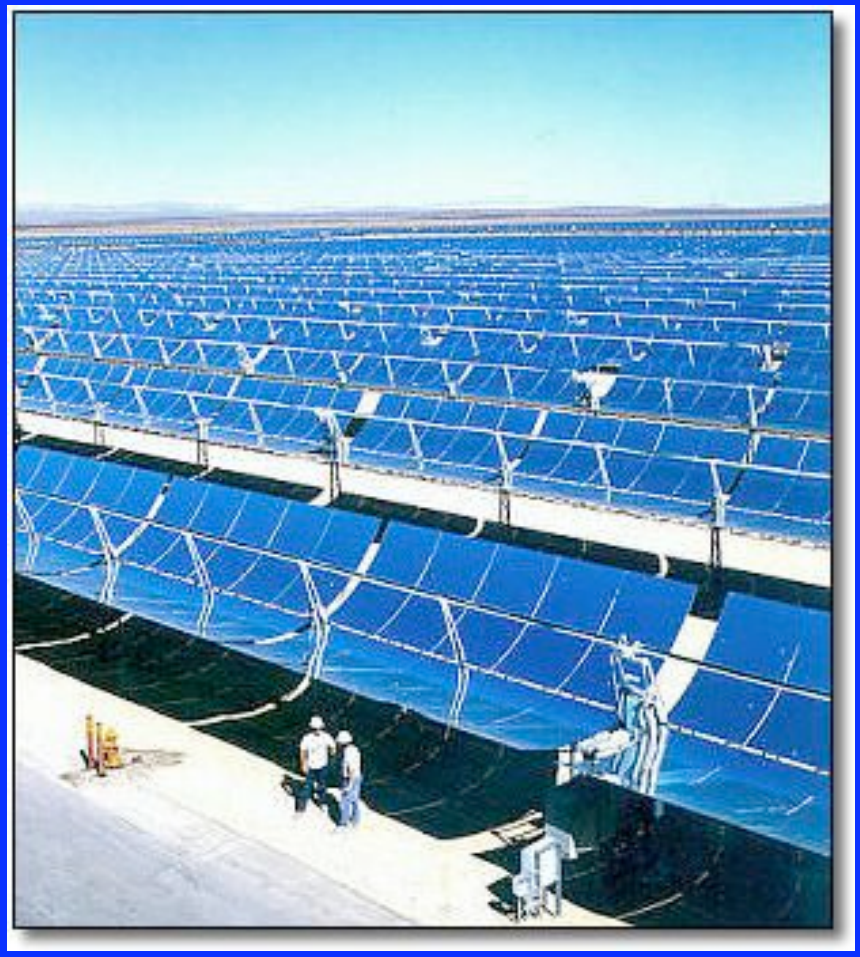
1. Big seasonal (and daily) variations.
2. Flat-plate systems (hot water; PV) work in diffuse sunlight.
3. Concentrated solar needs direct sunlight.
4. Trade-off between solar intensity & transmission cost.

Solar Photovoltaic (PV) Modules
could supply most *residential* electricity from roofs

- Global capacity at end 2010: ~40 GW
- Global production 2010: ~16 GW; recent global growth rate 30–40% per year
- Australian capacity at end 2010: 571 MW, of which 383 MW installed in 2010
- Electrical storage is still expensive, so PV is daytime power
- Just as important as base-load
- Tech advances and expanding market are reducing price; 40% reduction in 2010
- Needs continuing R&D funding and temporary market stimulus by feed-in tariffs

Concentrated Solar Thermal Electricity (CST)

- Revival post-2004 in Spain and USA
- A mix of pre-commercial & demonstration technologies. Some will soon be fully commercial soon.
- Globally 1000 MW operating; 1000 MW under construction; 8000 MW advanced planning; in Oz only pilot plants so far
- Low-cost thermal storage in molten salts, concrete, graphite, ammonia
- Can generate 24-hour power



354 MW system in California: Generation I is bankable

CST Power with Storage

Andasol 1, Spain, 50 MW, parabolic troughs, 7.5 hr storage; bankable with feed-in tariffs

Detail of molten salt storage tanks

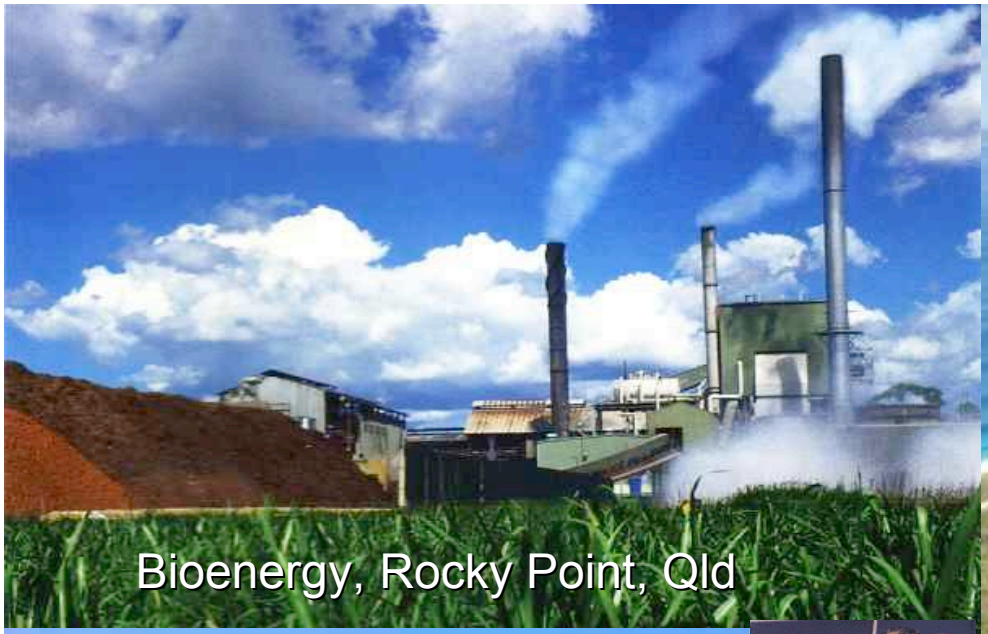
2nd Generation CST: Gemasolar Power Tower with 15-Hour Storage in Molten Salt

- Location: near Seville, Spain;
- tower height 140m;
- temperature > 500°C;
- Rated power 20 MW;
- on-line May 2011;
- 15 hr thermal storage
- capacity factor 63%;

Geothermal: Hot Rocks or 'Engineered'

- Pilot plants in France, Germany & USA
- In Australia, huge potential in remote SA and SW Qld
- Australian demonstration plant 'soon'?
- Base-load power from deep wells
- In theory, low water use and low pollution

- Pre-commercial space heating & cooling from shallow excavations -- not remote and not hot rock


Bioenergy, Rocky Point, Qld


Wind, Albany, WA


Solar-efficient homes, Christie Walk, Adelaide


Concentrated solar

Energy efficiency
Wind, biomass,
Solar PV & CST,
hydro, geothermal?

Sustainable Energy Mix


PV solar tiles, Sydney

Sustainable Energy Systems

- A mixture of different technologies, at different stages of commercial development, with different properties
- Together can provide an energy system just as reliable as fossil fuels
- Can be ecologically sustainable
- Can create more local employment

100% RElec Simulation: Zero Carbon Australia

(Report by Wright & Hearps 2010; simulations by Jack Actuarial Consulting P/L)

- Simulated 2008 and 2009 with real data on electricity demand, CST from 12 sites and wind from existing wind farms
- Stated energy generation mix 60% CST with 17 h storage and solar multiple 2.6; spilled solar energy 35% of total electricity demand/supply
- Actually there were contributions from existing hydro and biomass heaters (!) of the thermal storages
- Hypothetical transmission line from WA to eastern states and no limits on transmission capacity within Australia
- Claims 100% coverage of demand; no sensitivity analysis
- Claims 10 yr transition, but this a really an assumption; doesn't take into account shortage of power engineers and weak manufacturing capacity

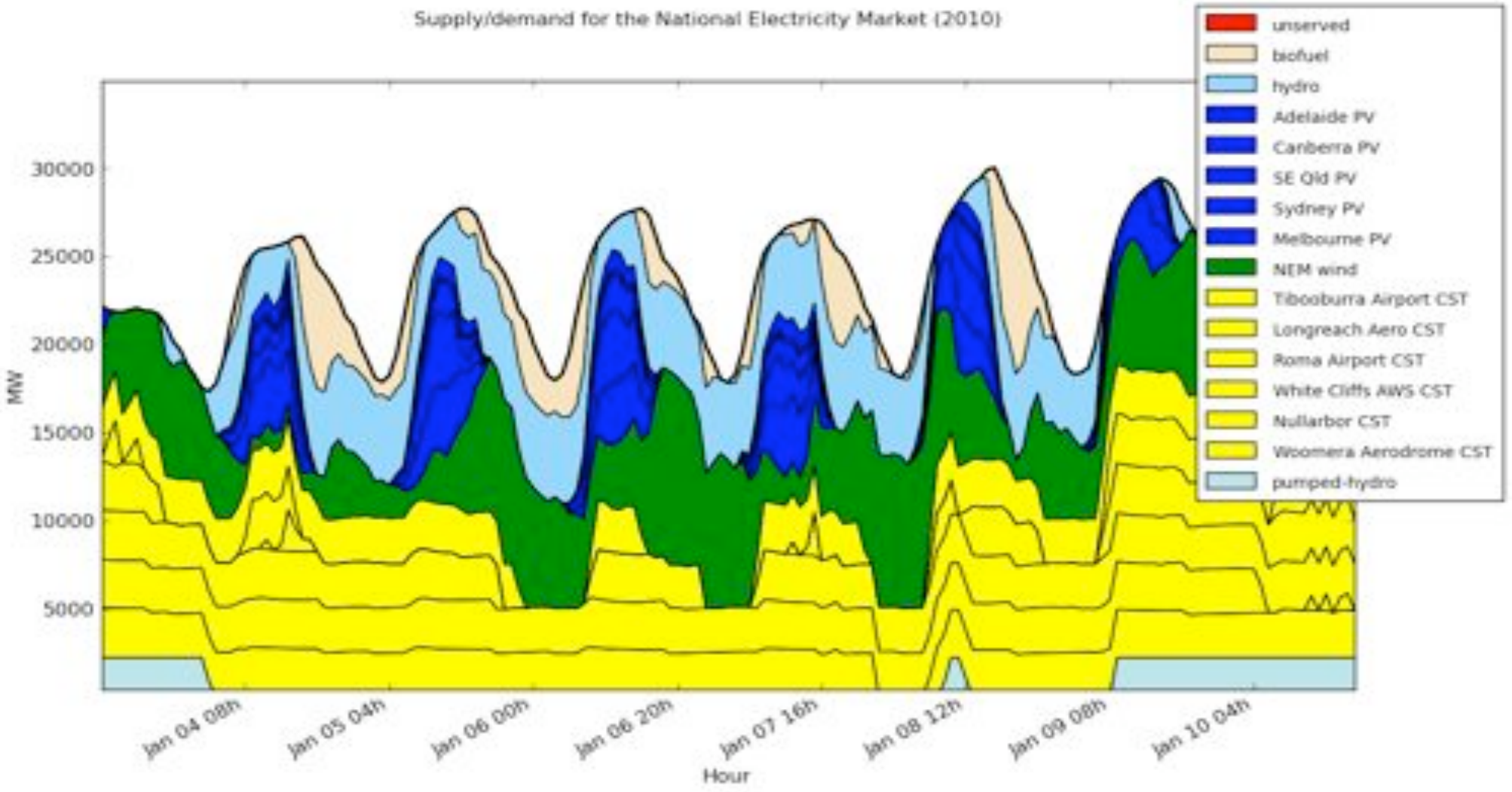
100% RElec Simulations

(Paper submitted by Elliston, Diesendorf & MacGill, UNSW, 2011)

- So far simulated 2010 hourly demand for NEM (5 states)
- Real data on electricity demand, CST from 6 sites with 15 h storage & solar multiple 2.5, wind from existing wind farms, PV from 5 regions, existing hydro and biofuelled gas turbines
- Baseline energy generation mix: CST 40%, wind 30%, biomass 14%, PV 10%, hydro 6%; spilled only 4.4%. Sensitivity analyses performed.
- Assumed no link to WA; no limits on transmission within NEM
- Same reliability obtained as existing supply system (not 100%)
- Principal challenge is several winter evenings when solar thermal storages are not full and wind power is low.
- Handled with high gas turbine capacity. Cheaper to reduce demand by improving home insulation and having ‘smart grid’.

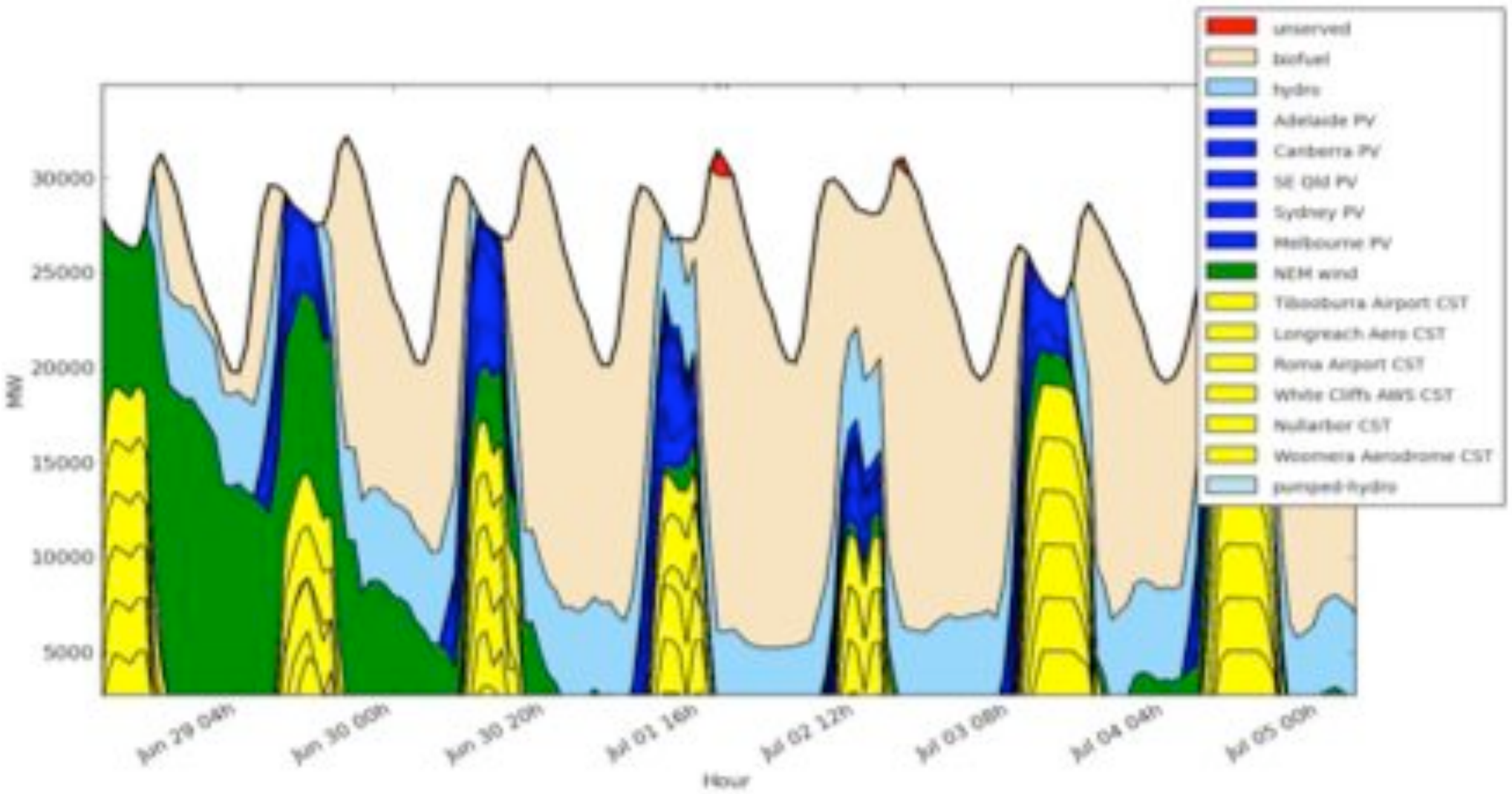
Summer 2010: a UNSW Simulation

(From a paper submitted by Elliston, Diesendorf & MacGill)



Winter 2010: a UNSW Simulation

(From a paper submitted by Elliston, Diesendorf & MacGill)



Community Case Study: Samsø, Denmark

‘Samso is CO2 negative’. 5:33 min. http://www.youtube.com/watch?v=1_ZY0ilFdYw

Community Case Study: Güssing, Austria

- Initiative of local gov't in 1990 in a poor district of Austria
- Biomass cogeneration district heating and power plant
- Innovative: based on thermal gasification of wood (forest residues) in steam
- Biodiesel plant
- --> Energy independence achieved 2001 & regional economic development followed
- European Centre for Renewable Energy Güssing: R&D, training, continuing education & eco-energy tourism: http://www.eee-info.net/cms/EN/

Güssing power plant

Community Case Study: Freiburg, Germany

Vauban solar suburb

Vauban suburb

- City contracted community association (Forum Vauban) to lead residents' participation
- Cooperatives of owner-occupiers
- Dense energy-efficient units with network of open spaces
- PV & solar hot water
- New tram line in 2006
- Car-free housing blocks with pay car parks at perimeter

Vauban tram

Energy from non-recyclable waste

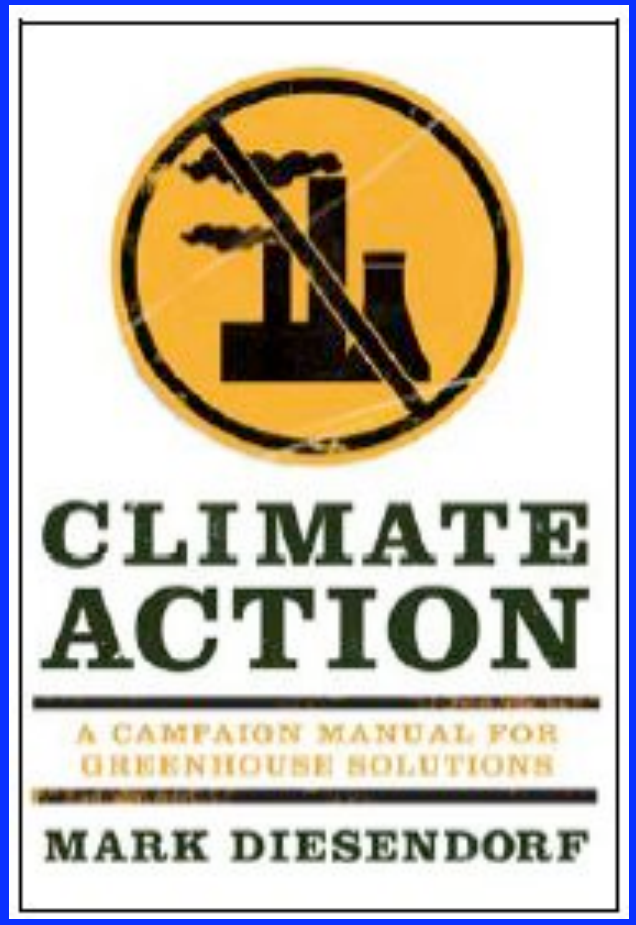
Solar building

Principal Policies to Deploy RE in Australia

Policy	Comment
Renewable Energy Target with tradable certificates (federal)	✓ Helps deploy lowest cost RE technologies, eg wind
Feed-in tariffs (states & territories)	Too successful, most terminated; limited to small systems (except in ACT)
Solar Flagships demonstration fund (federal)	Partial support for only 1 large PV and 1 large CST power station
Australian Solar Institute	✓ R&D on PV and CST
NEW: Clean Energy Finance Corporation (before parliament)	✓ Part of Clean Energy Future Package; may eventually help large-scale CST & PV

We still need feed-in tariffs to drive large-scale solar, which has big potential in all states of mainland Australia, and support for community projects and key transmission links.

Grass-Roots Pressure is needed on Gov’ts



UNSW Press 2009