



**UNSW**  
A U S T R A L I A

**Institute of Environmental Studies**  
Science

Engineers Australia Eminent Speaker Presentation, February–April 2015

# A Sustainable Energy Future for Australia

Dr Mark Diesendorf

Institute of Environmental Studies  
University of New South Wales (UNSW)

Sydney, Australia

[www.ies.unsw.edu.au](http://www.ies.unsw.edu.au)

[m.diesendorf@unsw.edu.au](mailto:m.diesendorf@unsw.edu.au)



# Why do we need Sustainable Energy?

## Our Climate is Changing!



# Additional Impacts of Fossil Fuels

- ✦ Peak in global oil production
- ✦ Peak in global coal in a few decades
- ✦ Gas prices escalating in eastern Australia
- ✦ Air pollution and respiratory diseases
- ✦ Water pollution
- ✦ Land degradation
- ✦ Few jobs in fossil fuels



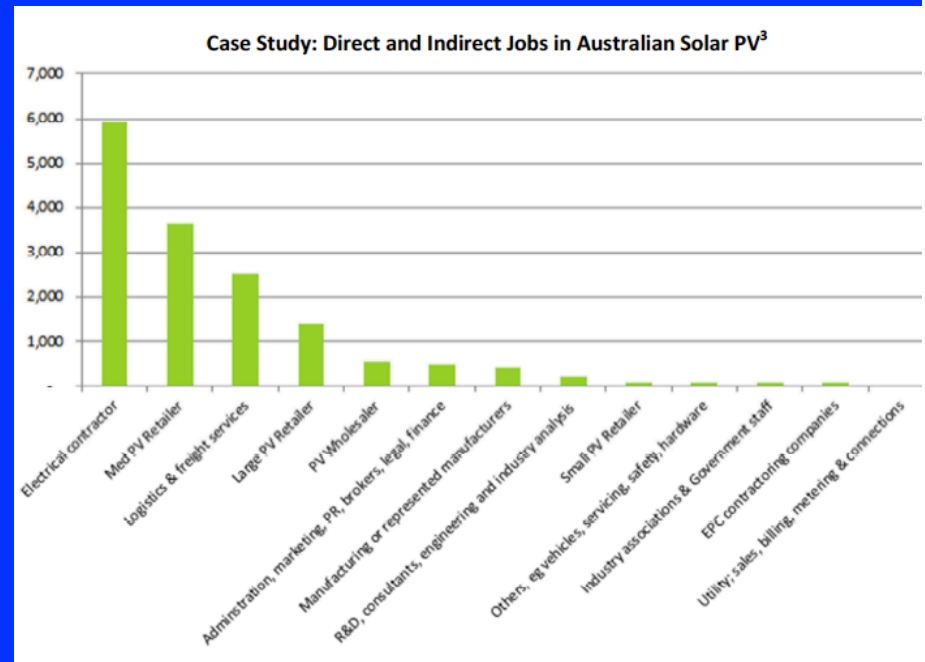
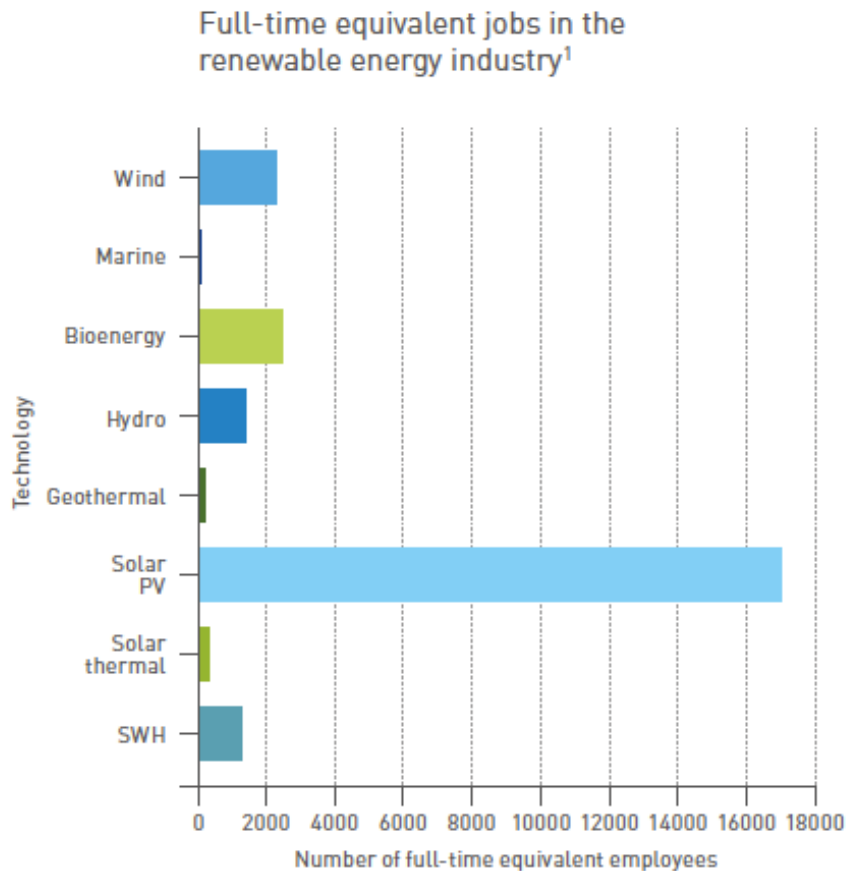
# Why do we need a transition?



# Jobs in Renewable Energy

24,000 direct jobs in renewable energy in Australia at end 2012

Case study:: Solar PV jobs, incl. indirect



If RET is axed → huge job losses

## Direct Local Jobs per Unit of Electricity Generated by Power Stations

Source of electricity	Relative number of job-years per kWh in Australia
Coal electricity + coal mining	1
Wind power with 50% Australian content	2–3
Bio-electricity with 50% Australian content	Approx. 3.5 (mostly rural)
Wind power with 80% Australian content	3.5–5

Principal source: MacGill, Watt & Passey (2002)

# Energy Efficiency saves Energy and Money



Christie Walk, Adelaide



Water efficient shower



Heat pump hot water

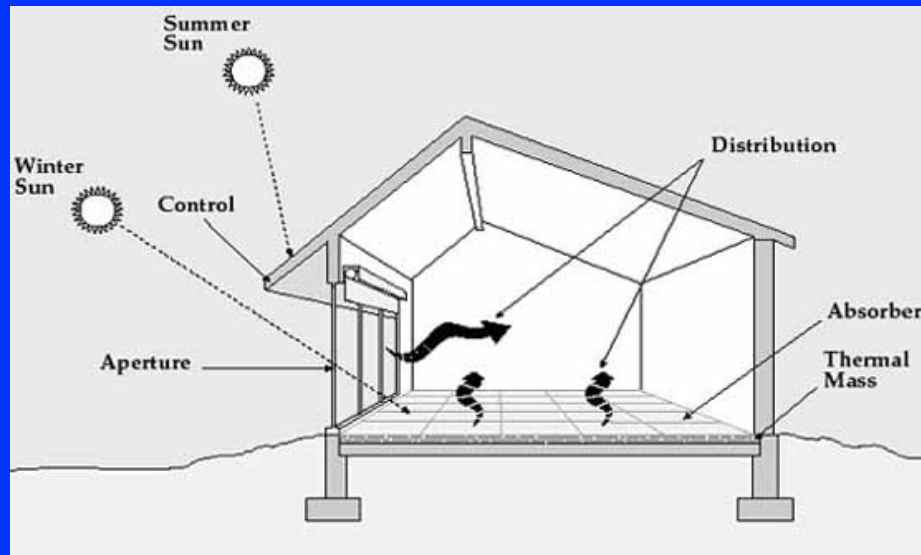


Ceiling fan



LED lights

# Sustainable Space Heating and Cooling



## New building

Passive solar design, accepting winter sun & excluding summer sun

## All residential buildings




- Insulation of ceiling and, if possible, walls and under floor
- Exclude drafts in winter
- Encourage drafts in summer
- Ceiling fans
- Efficient reverse cycle air conditioners
- Add thermal mass, especially if it can be exposed to winter sun

## Jobs

- For energy audits, sales, Installation
- Auditors, salespersons, electricians, plumbers, IT experts, architects



# How can Renewable Energy replace Fossil?

Energy end-use at present	Energy end-use	Future renewable energy contribution
Electricity Currently mostly coal		Could be supplied entirely by renewables in Australia & many countries within a few decades.
Transport Currently mostly oil		Electric vehicles for urban transport; inter-city high-speed rail; biofuels (initially) for rural vehicles & some air travel.
Heat (non-electrical) Currently mostly gas		Low temperature heating & cooling from direct solar & electric heat pumps; high temperature from renewable electricity

Electricity will play a greater role in heating/cooling and transport.  
Hence this presentation focuses on electricity.

# Renewable Electricity



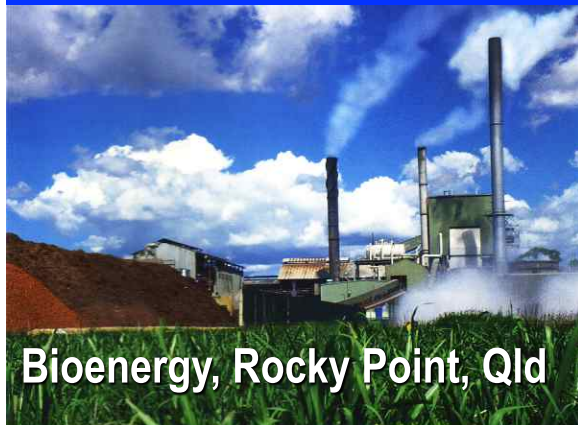
CST with thermal storage, Spain



Wind, Albany, WA

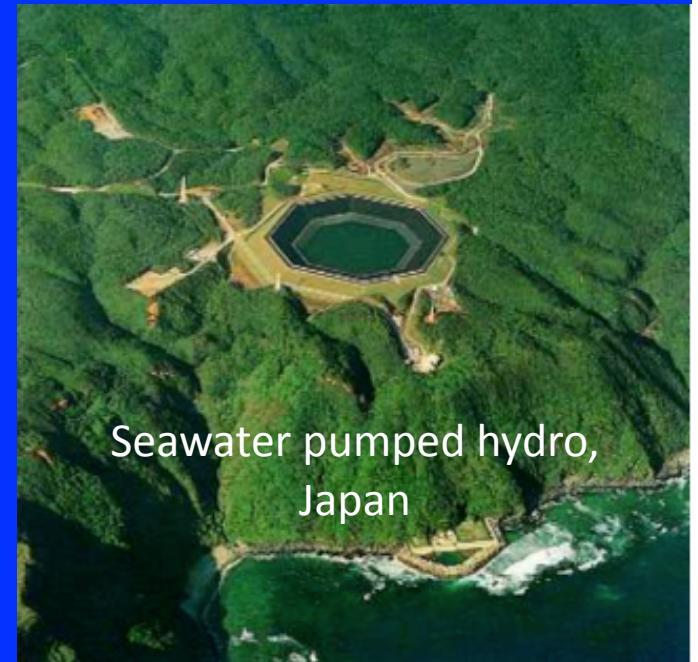


PV solar tiles, Sydney



Bioenergy, Rocky Point, Qld

Wind  
Biomass  
Solar PV  
Concentrated solar thermal  
Hydro  
Wave?  
Ocean current?  
Geothermal electricity?  
**Australia has the lot!**



Seawater pumped hydro, Japan



Wave

Pelamis sea trials

**Jobs** in manufacturing, installation, grid connection; a few in operation & maintenance <sup>10</sup>

# Countries and States with Strong Renewable Electricity Targets

Country/state	2014 Renewable Electricity	Target
Denmark	39% from wind + bioenergy from agricultural residues	100% renewable electricity and heat by 2035; 100% transport 2050
Germany	26% from renewables.	80% renewable electricity by 2050
Scotland	35% from renewables	100% renewable electricity by 2020
China	Biggest wind capacity and solar hot water; biggest PV manufacture	15% of all primary energy from 'low-carbon' by 2020
California, USA	About 24% in total from hydro, geothermal, wind, biomass, etc	33% renewable electricity by 2020
Schleswig-Holstein, Germany	About 100% net in 2014 – mostly wind	300% under discussion

# In Australia Renewable Energy is under Attack by Federal and most State Governments

- ★ Review of Renewable Energy Target by biased committee – **Reported**
- ★ Australian Renewable Energy Agency (ARENA) to be closed – **Announced, subject to Senate vote**
- ★ Clean Energy Finance Corporation to be closed – **Announced, subject to Senate vote**
- ★ 20<sup>th</sup> inquiry into sham wind turbine 'syndrome' – **Announced**
- ★ Election promise, to subsidise one million solar roofs – **Broken**
- ★ Most state governments removed mandatory feed-in tariffs for residential RE and some removed energy efficiency programs – **Done**
- ★ Anti-RE myths spread by politicians & others – **Continuous**

# Vested Interests are spreading False Myths about Renewable Energy (RE)

- ★ **Myth:** 'Base-load power stations, either coal or nuclear, are necessary, and RE cannot provide them'
- ★ **Myth:** 'Base-load power stations must run continuously as backup for RE'
- ★ **Myth:** 'RE is too variable or intermittent to make the predominant contribution to grid electricity supply'
- ★ **Myth:** 'RE is too expensive'
- ★ **Myth:** 'RE is too diffuse to run an industrial society'
- ★ **Myth:** 'RE is not ready to replace fossil fuels'
- ★ **Myth:** 'RE is responsible for the big increases in electricity prices'
- ★ **Myth:** 'Wind & solar have severe environmental and health impacts'

# Why the Attacks?

Renewable Electricity threatens big greenhouse gas emitting industries, state gov't revenue, & utility business models

## ★ 'Merit Order Effect' at wholesale (generation) level

- Wind farms, with very low operating cost, are displacing coal-fired power stations and reducing wholesale price of electricity

## ★ 'Death Spiral' at distribution/retail level

- Growth in rooftop solar PV and increased energy efficiency are reducing demand for grid electricity

## ★ Result

- Utilities & big business lobbying federal & state governments to stop growth in RE
- Government policies try to stop growth of RE
- False myths disseminated by malicious and lazy media

# Mythbusting by Two Methods

## ★ Practical experience

- Denmark: wind supplied 39% of electricity consumption in 2014
- South Australia 30% wind + 5% solar PV;

## ★ Hourly computer simulations of demand and supply by 80–100% renewable electricity in many countries

- Over 30 studies of states/provinces, countries, regions and whole world
- These find that renewable electricity systems can be just as reliable as conventional systems
- Predominantly renewable electricity systems are affordable
- Myths hostile to RE are busted

# UNSW Simulation Models of 100% Renewable Electricity (RE) in National Electricity Market

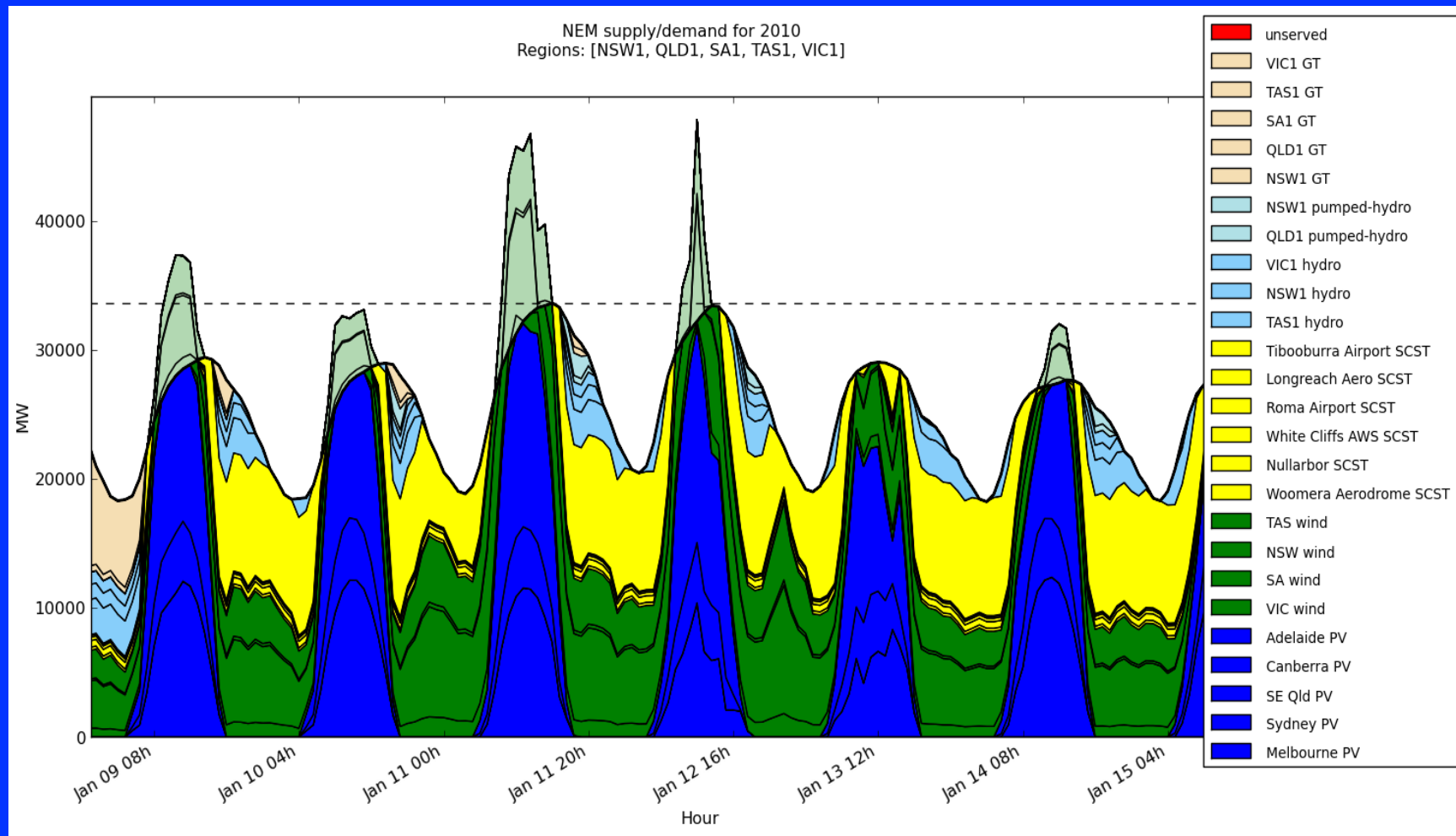
(Journal papers by Elliston, MacGill and Diesendorf 2012, 2013, 2014)

- ★ Hourly data on electricity demand, solar & wind for NEM, initially spanning 2010
- ★ All commercially available RE technologies scaled up
- ★ Simulation model built by Ben Elliston: hourly time-steps through 2010, balancing supply and demand; maintaining reliability
- ★ Cost projections to 2030 by BREE (2012)
- ★ Economic optimal mix evaluated
- ★ Simplified transmission model
- ★ Comparison fossil fuelled scenarios



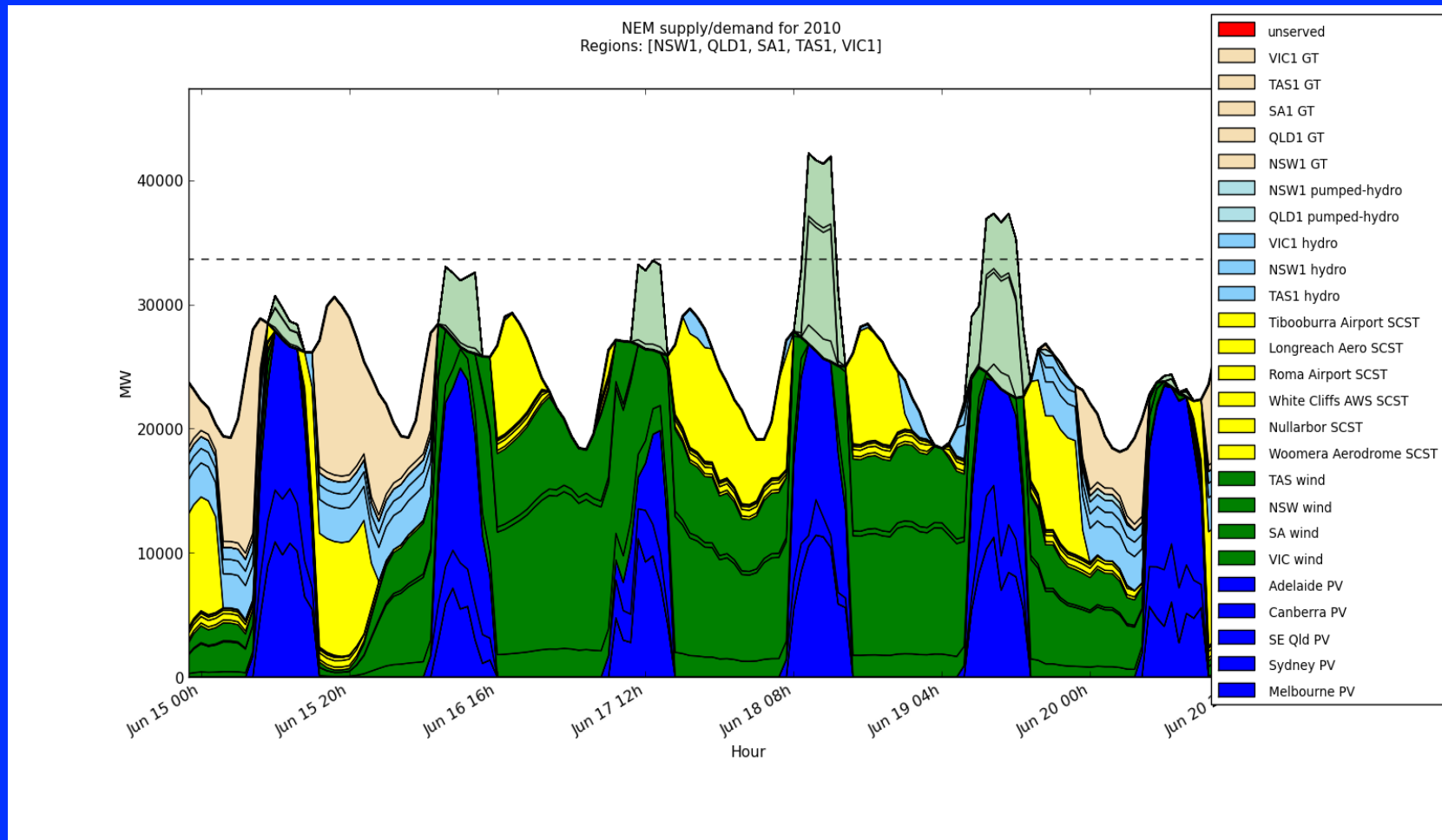


# Supply and Demand for a Typical Week in Summer 2010 – Optimal Mix of RE



In summer, negligible gas turbine energy used.

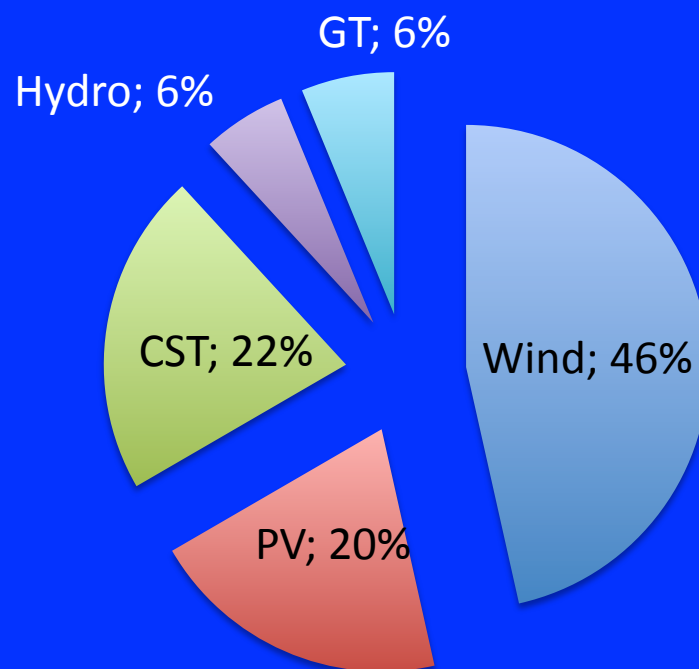
# Supply and Demand for a more Challenging Period in Winter 2010 – Optimal Mix of RE



In calm winter evenings following cloudy days, gas turbines & demand management are important.

# 100% RE Least-Cost Energy Generation Mix 2030 projected costs by BREE

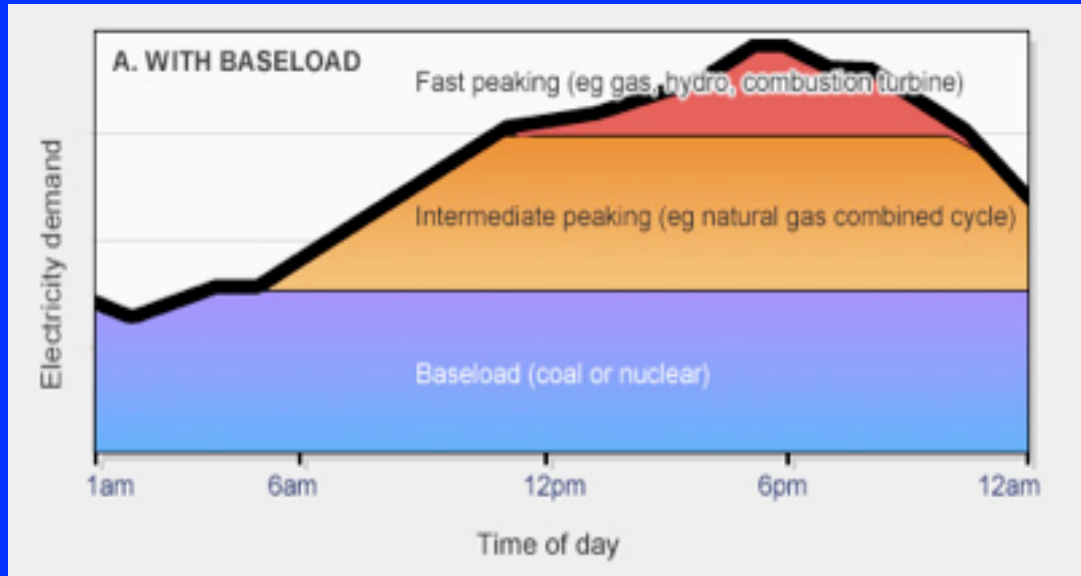
5% Discount Rate; no extra transmission



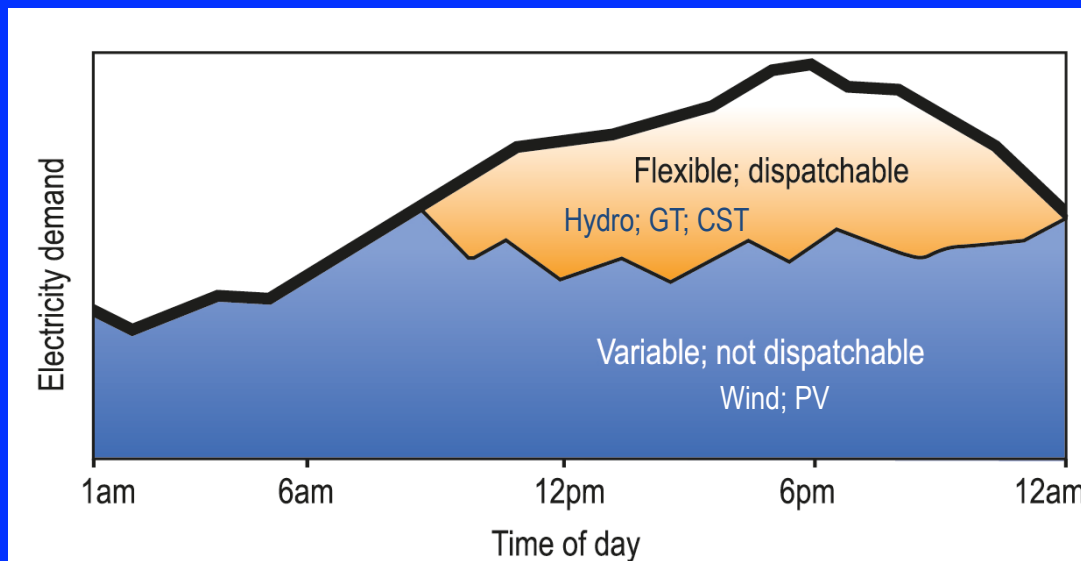
Note: Variable RE contributes two-thirds of annual energy and reliability is maintained!

Technology costs projected to 2030 by BREE (2012).  
GT is gas turbines burning renewable fuels;  
CST is concentrated solar thermal with thermal storage.

# Meeting Demand without Base-load Stations



Traditional  
concept:  
With base-load  
power stations



New  
concept:  
No base-load  
power stations

# Meeting Demand without Base-load Stations

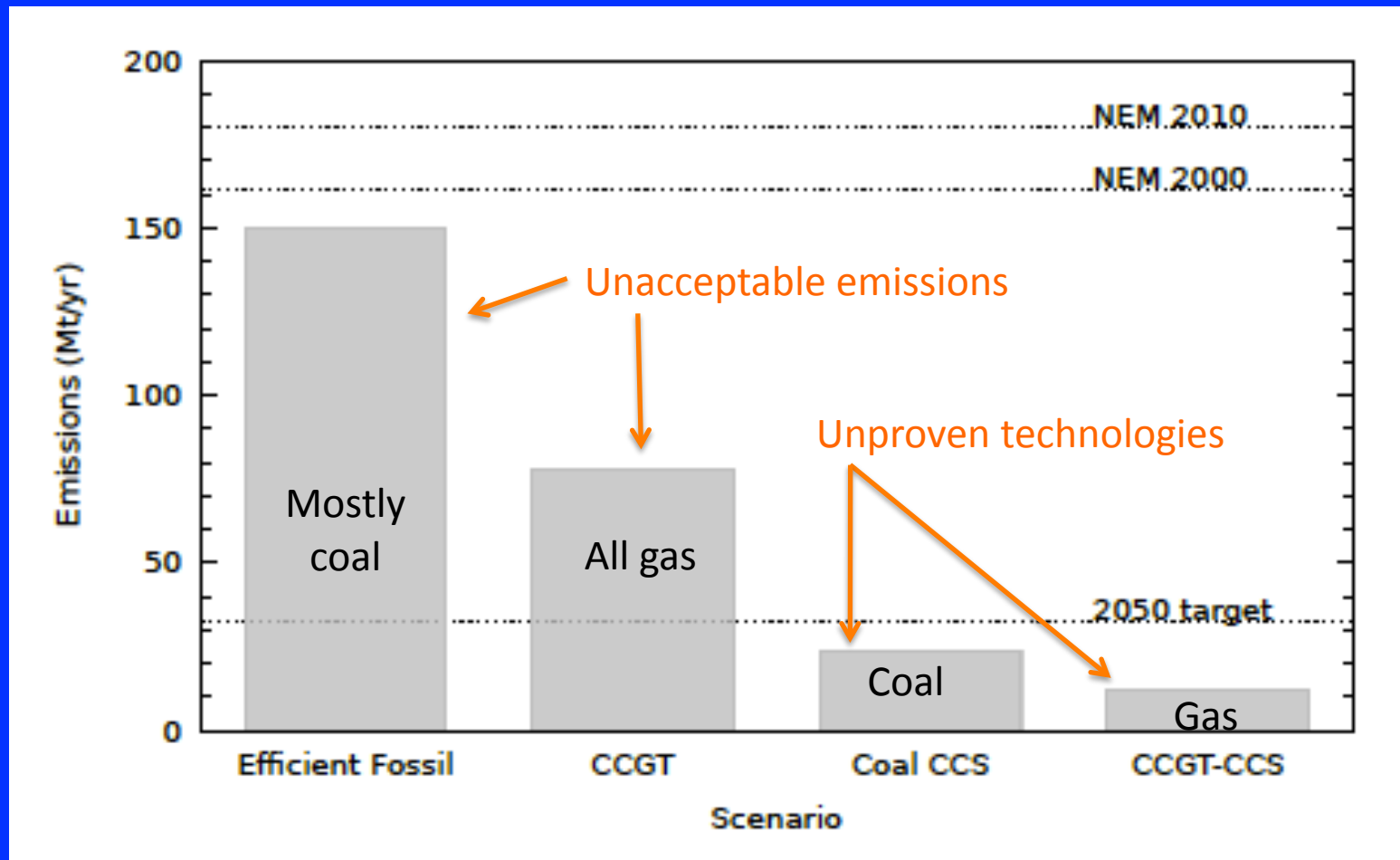
- ★ Renewable electricity supplied by mix of variable plants (wind and PV without storage) and flexible/dispatchable plants (CST with thermal storage, hydro with storage, biofuelled gas turbines)
- ★ Flexible plants (together with improved weather forecasting) balance the fluctuations in power output from inflexible plants
- ★ Demand management in a 'smart grid' can also play an important low-cost role.
- ★ Key parameter is reliability of the whole supply-demand system, not reliability of individual technologies. Reliability criterion satisfied in all simulations: unmet annual energy < 0.002% of annual demand

# UNSW's Four Comparison Scenarios

None in AEMO (2013) study

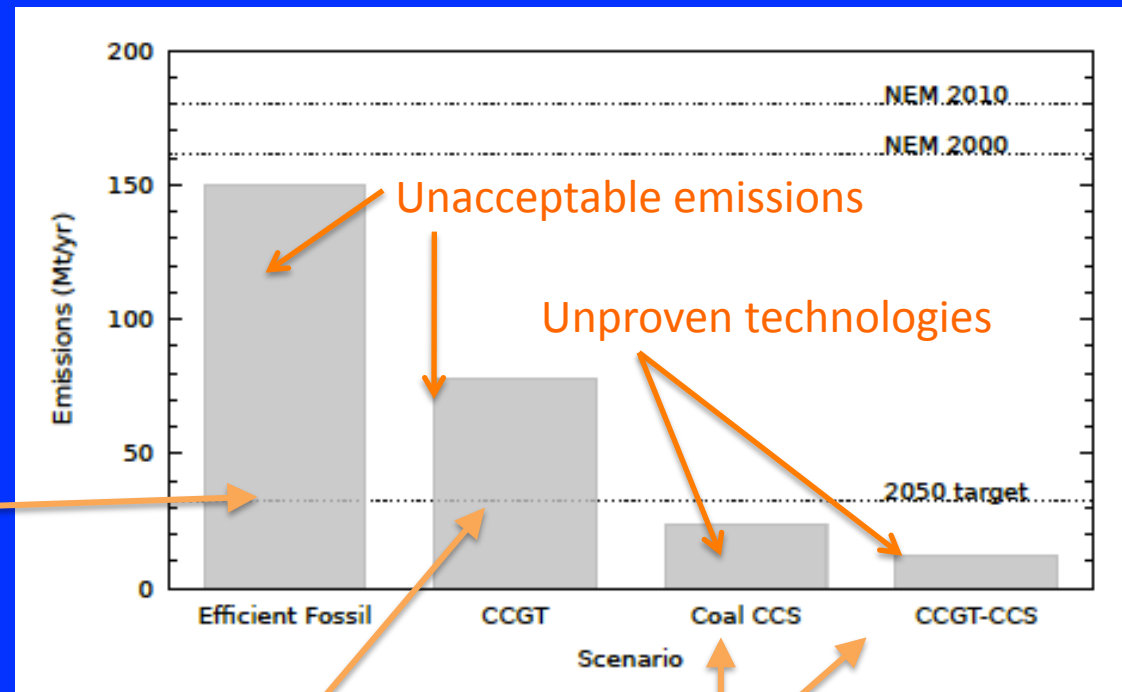
1. Most efficient commercially available fossil power stations (no CCS); GHG emissions still 81% of existing system – **unacceptable!**
2. All gas (no CCS), base-load combined cycle and peak-load open cycle; GHG emissions 40% of existing – **unacceptable!**
3. Base-load coal with CCS (**unproven technology**) + peak-load gas turbines
4. Base-load gas with CCS (**unproven technology**) + peak-load gas turbines

# Annual CO<sub>2</sub> Emissions from 4 comparison Fossil Fuel Scenarios



# Summary of Results: Economics of the Four Fossil-Fuelled Comparison Scenarios

CCS is hypothetical carbon capture and storage; CCGT is combined cycle gas turbine



## Efficient fossil:

100% RE competes either if CO<sub>2</sub> price is \$50-100 per tonne, or fossil subsidies of \$10 billion p.a. transferred to RE

All gas: 100% RE competes if domestic gas prices increase to near export prices; already happened in Qld.

Fossil + CCS:  
100% RE competes almost everywhere



# Busted Myths about Renewable Energy

- ★ **Myth:** 'Renewable energy cannot provide base-load power.'  
Myth is based on false notion that base-load demand must be supplied by base-load power stations – **BUSTED**
- ★ **Myth:** 'Renewable energy is too variable or intermittent to make the predominant contribution to grid electricity supply – **BUSTED**
- ★ **Myth:** 'Coal-fired power stations must run continuously as backup' – **BUSTED by both experience (eg, SA) & simulations**
- ★ **Myth:** 'Renewable energy is too expensive' – **BUSTED**
- ★ **Myth:** 'Renewable energy is too diffuse to run an industrial society' – **BUSTED**
- ★ **Myth:** 'Renewable energy is still immature' – **BUSTED**

# Policies needed in Australia

- ★ Set stronger greenhouse targets
- ★ Re-introduce a carbon price, preferably as a tax rather than ETS
- ★ Terminate subsidies to production & use of fossil fuels (\$10B+ p.a.).
- ★ Increase RET for 2020 and set much higher target for 2030
- ★ Keep ARENA & CEFC
- ★ Ensure that fair feed-in tariffs are set. In 'smart' grids, these could vary with supply and demand
- ★ Upgrade transmission system for large-scale RE: priority SA–NSW link
- ★ Expand seeding grants for community renewable energy projects
- ★ Expand energy ratings for buildings, appliances & equipment; mandatory energy labelling and energy performance standards

## Additional Energy/Climate Policies suggested for Victorian Gov't

- ★ Further extend and expand the Victorian Energy Efficiency Target with policies to cut primary energy demand by at least 20% by 2020
- ★ Remove extreme restrictions on wind farms
- ★ Ban new coal-fired power stations, coal mines and coal exports
- ★ Restore 20% emissions reduction target (in absence of national carbon price); develop and implement a strategy for zero emissions by 2050
- ★ Set target for renewable electricity equivalent to pro rata national RET of 41 TWh per year in 2020 and at least double that by 2030
- ★ Restore requirements for Government agencies to purchase green electricity

# Hepburn Community Wind Farm

near Daylesford, central Victoria

- ★ Community projects were foundation in Denmark & Germany
- ★ Hepburn is Australia's first medium-scale community RE project
- ★ 2 turbines, 4.1 MW total
- ★ Cooperative with about 2000 members
- ★ \$9.6M from members + \$1M Vic gov't grant + \$3M loan
- ★ Revenue returned to members and local community trust fund
- ★ Spin-off group Embark is facilitating other community projects in Australia



See <[hepburnwind.com.au](http://hepburnwind.com.au)>

## Further Information

Research papers &  
non-technical  
articles

[http://www.ies.unsw.edu.au/  
our-people/associate-  
professor-mark-diesendorf](http://www.ies.unsw.edu.au/our-people/associate-professor-mark-diesendorf)

## New book

*Sustainable Energy Solutions  
for Climate Change*, UNSW  
Press and Earthscan, 2014

Mark Diesendorf

# SUSTAINABLE ENERGY SOLUTIONS for climate change

