

Smart Future Cities Conference, Newcastle NSW 1-2 October 2015

# Could Australia's energy system be transformed entirely to renewable energy?

Dr Mark Diesendorf

Associate Professor  
Interdisciplinary Environmental Studies  
UNSW Australia

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

<http://www.ies.unsw.edu.au/our-people/associate-professor-mark-diesendorf>



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




**Interdisciplinary Environmental Studies**  
Science

# We can choose Sustainable Energy instead of Fossil Fuels



Sustainable energy = Reduction of wasteful demand + Renewable energy

# How Renewable Energy can replace Fossil Fuels

Energy end-use at present	Energy end-use	Future renewable energy contribution
Electricity Currently mostly coal in Australia		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; H <sub>2</sub> in long term?
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. All-electric energy system may be possible (Jacobson & Delucchi 2011)

# Countries and States with Strong Renewable Electricity Targets

Country/state	2014 Renewable Electricity	Target
Denmark	39% of electricity consumption from wind + bioenergy from ag. residues	100% renewable electricity and heat by 2035; 100% transport 2050
Germany	26% from renewables.	At least 80% renewable electricity by 2050
Scotland	44% from renewables, mostly wind followed by hydro	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
South Australia	33% of electricity consumption from wind + 6% from rooftop PV	50% renewable electricity by 2025, subject to national RET retained
Schleswig-Holstein, Germany	About 100% net in 2014 – mostly wind	N/A





CST with thermal storage, Spain

# Diversity of RE Sources and Siting



Wind, Albany, WA (variable)



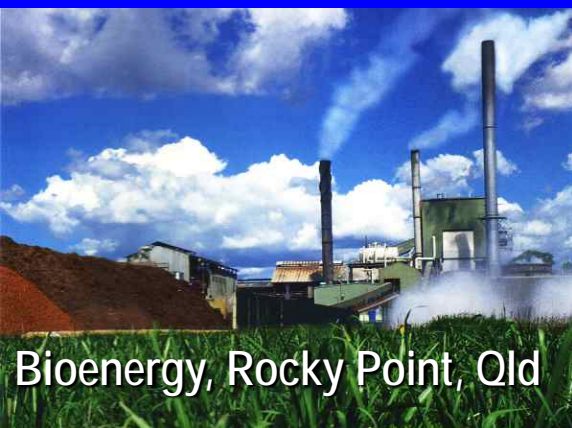
PV solar tiles (variable)

- Wind
- Biomass
- Solar PV
- Concentrated solar thermal (CST)
- Hydro (limited)
- Wave?
- Tidal current?
- Geothermal electricity?

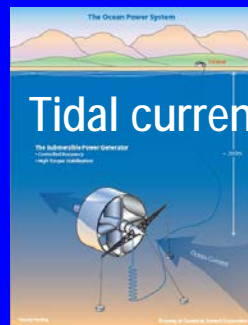


Geothermal

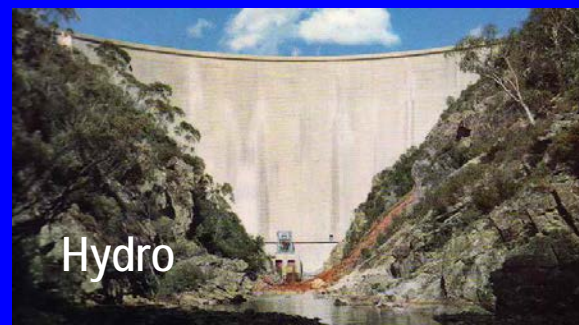
Australia has the lot!



Bioenergy, Rocky Point, Qld



Tidal current



Hydro



Wave power



# Small, Medium & Large Scale RE

## Both on-grid and off-grid



PV module for solar lantern – 3<sup>rd</sup> world



Wharf Theatre, Sydney, 384 kW



Wind-diesel system WA



102 MW, Nyngan NSW

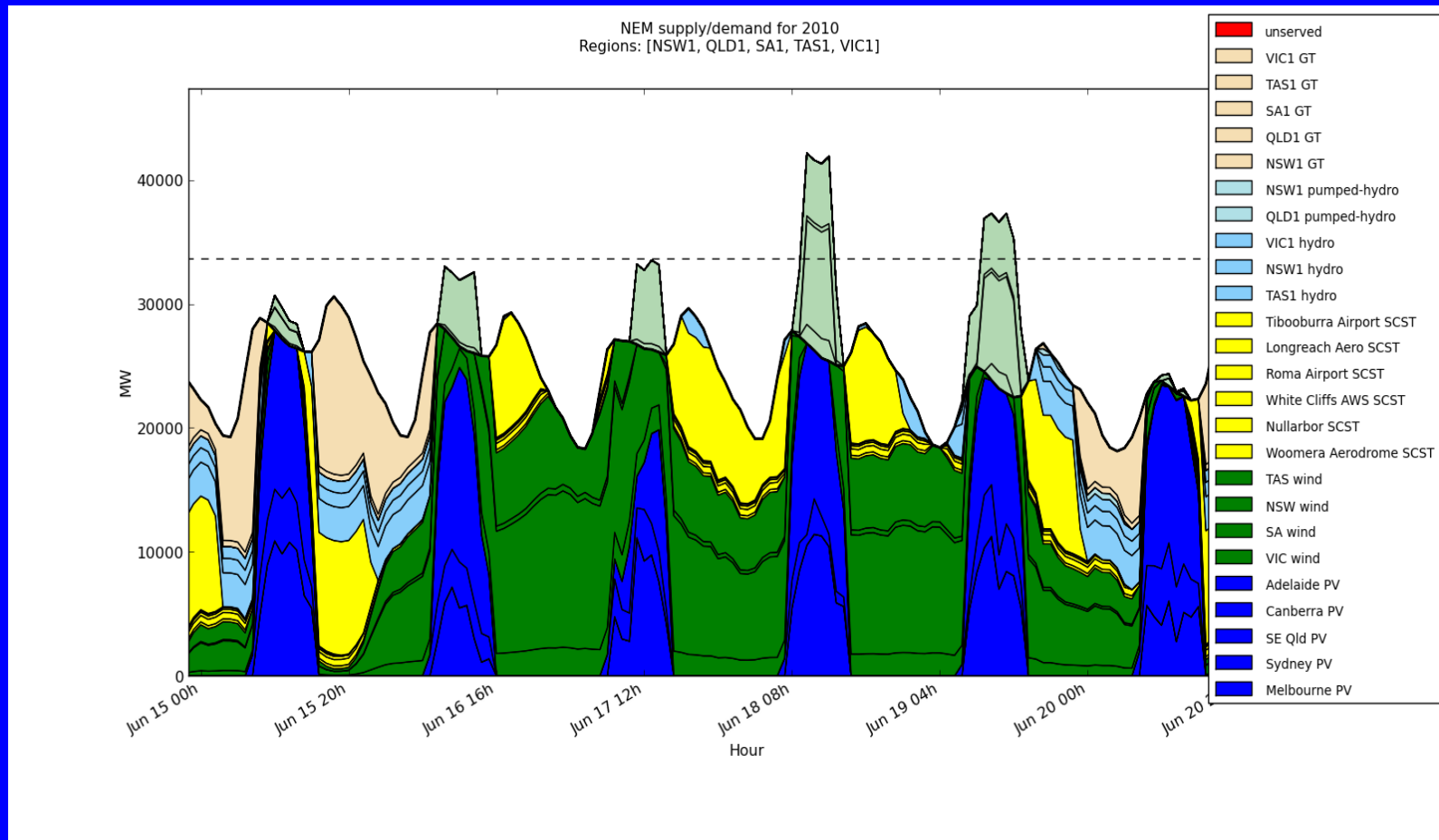
# Simulation Models of 100% Renewable Electricity (RE) in Australia

- ★ Hourly or ½ hourly data on electricity demand, solar & wind spanning 1-8 years
- ★ Each timestep, 100% RE supply balanced against demand to give reliable system
- ★ Mostly commercially available RE technologies scaled up
- ★ Beyond Zero Emissions (2010): ground-breaking single simulation with principal contribution from CST
- ★ Elliston et al. UNSW (2012, 2013, 2014, 2015): many simulations → economic optimal mix; compared fossil scenarios
- ★ AEMO (2013): RE mixes include hot rocks & wave; economics, but no comparison with fossil scenarios



# Supply and Demand for Challenging 6-day Period in Winter 2010 – Optimal Mix of RE in NEM

Source:  
Elliston et al.  
(2013)

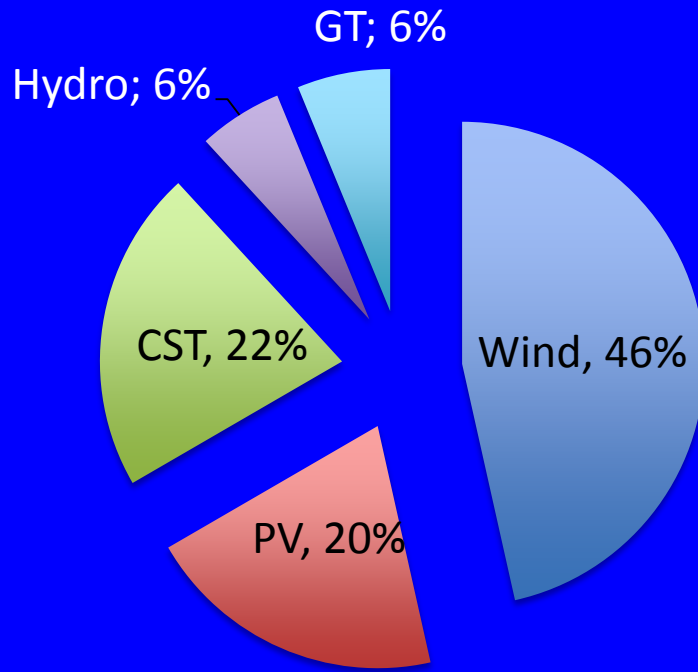


In calm winter evenings following cloudy days, gas turbines & demand management fill the infrequent lulls.



# Myth: “Renewable Energy is too unreliable”

**Busted** by UNSW evaluation of Optimal Mix of RE

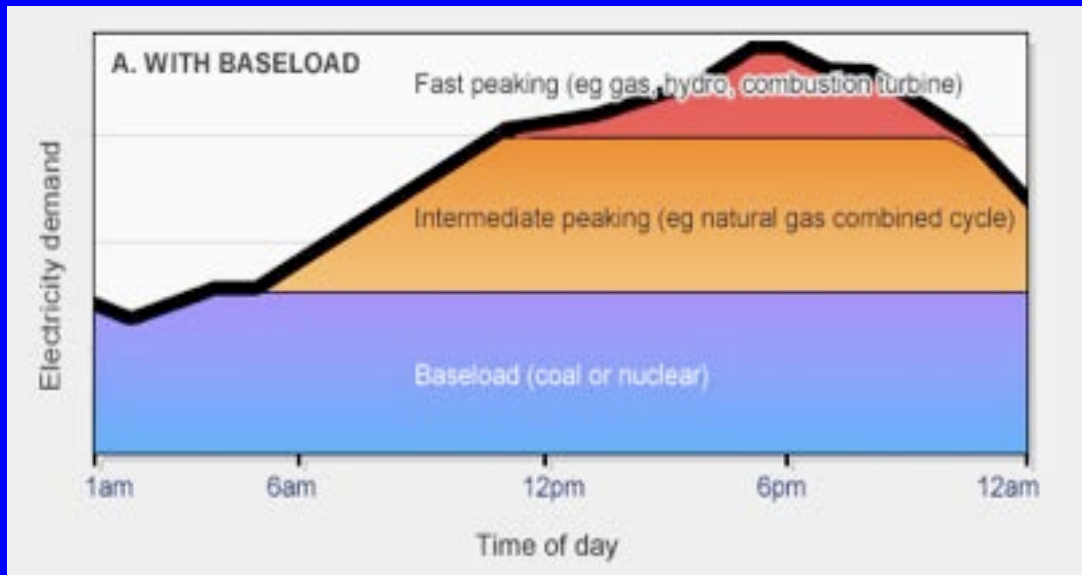


Although variable RE (wind + PV) contributes two-thirds of annual energy, reliability is maintained!

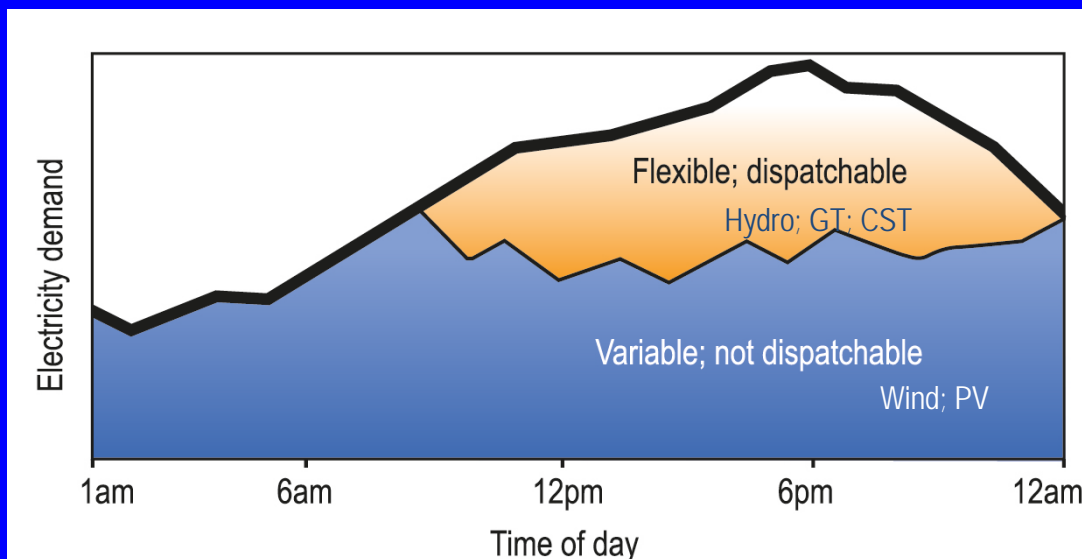
Technology costs projected to 2030 by BREE (2012).  
GT is gas turbines burning renewable fuels;  
CST is concentrated solar thermal with thermal storage.  
5% discount rate; no extra transmission



# Myth: “Base-load power stations are needed”



Traditional concept  
with base-load power stations  
supplying base-load demand  
**BUSTED!**



**New concept**  
100% RE without base-  
load power stations;  
variable + flexible-  
dispatchable stations  
meet demand reliably

# Achieving Reliability in Large-Scale RE

- ★ Variable RE balanced with flexible, dispatchable RE technologies
- ★ Diversity of RE technologies
- ★ Geographic diversity of wind and solar
- ★ Key transmission links
- ★ Smart demand management

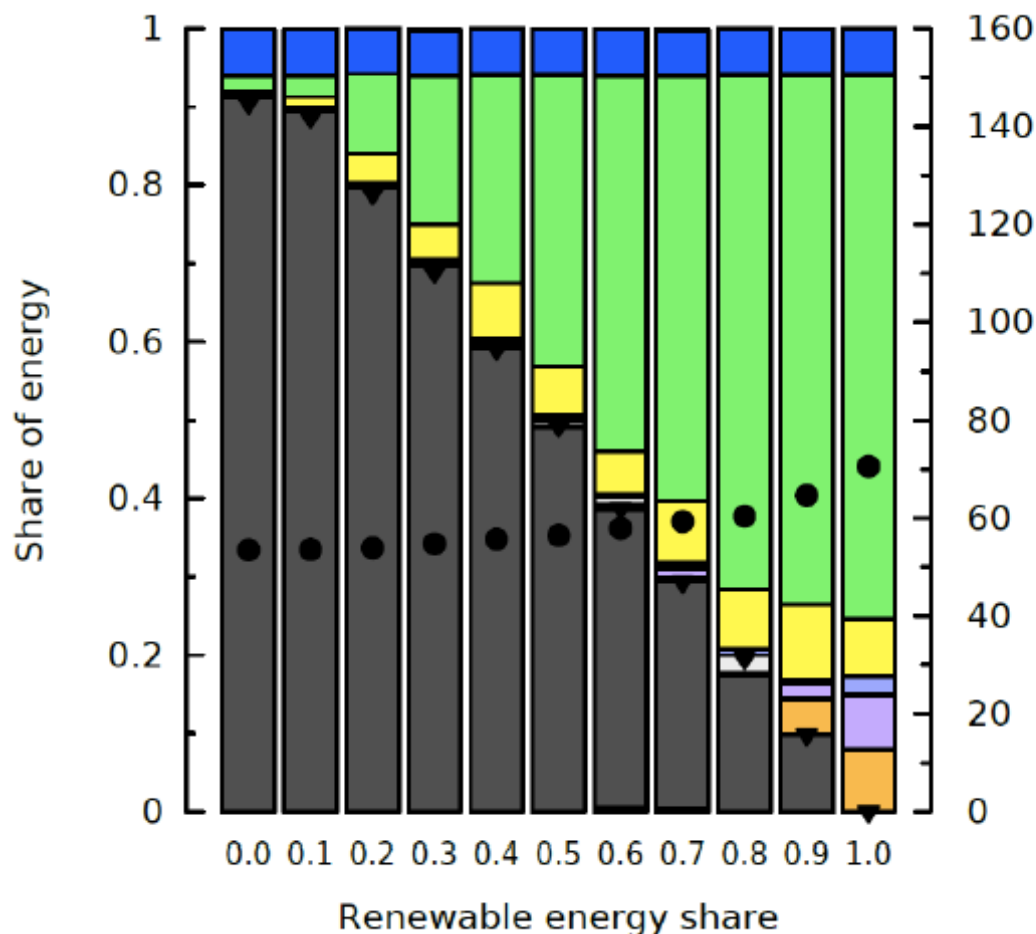


# Recent UNSW Modelling: Costs of Increasing RE Share

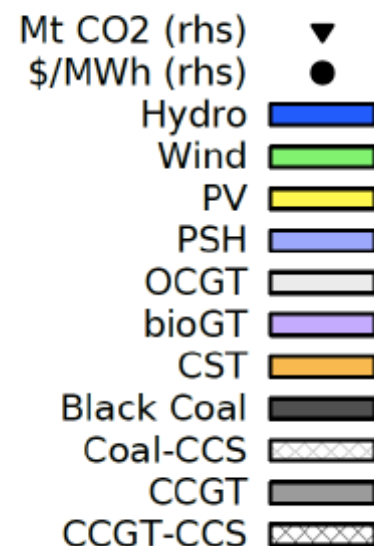
Elliston, Riesz, MacGill (2015, under review)

## UNSW modelling

2030, \$9/GJ gas, no carbon price



- 10-20% RE: \$54 /MWh
- 100% RE for \$71 /MWh
  - (only \$17 /MWh more)
- High wind, low PV
- Costs increase ~ linearly to 80% RE
- Wind displaces coal
- 50% RE < \$60/MWh, only \$3/MWh more than 10% RE





# Rooftop Solar PV

- ★ Electricity retailers are cutting feed-in tariffs to 0–8 c/kWh, while retail prices are 25–50 c/kWh
- ★ PV is still cost effective for avoiding large daytime electricity use @ 28 c/kWh
- ★ PV not cost effective for those who use most electricity after sunset
- ★ Batteries still very expensive; will be much cheaper in 5–10 years as market grows
- ★ Initially batteries will be used to meet evening peak demand, not to disconnect from grid in suburbs



# Key Policies needed for RE in Australia

- ★ Increase Large-scale RE Target (LRET) for 2020 and set much higher targets for 2025 & 2030; separate tranches for PV & CST -- **Federal**
- ★ Increase funding for Australian Renewable Energy Agency ( ARENA) & Clean Energy Finance Corporation (CEFC) – **Federal**
- ★ Terminate subsidies to production & use of fossil fuels (> \$10B p.a.) – **Federal & State**
- ★ Hold Reverse Auctions, backed up with feed-in tariffs or contracts for difference, for large-scale RE – **State**
- ★ Make it illegal for electricity utilities to refuse feed-in of RE and set fair mandatory feed-in tariffs – **State**
- ★ Price smart grid electricity to follow time-varying supply & demand
- ★ New transmission spine SA–NSW; further strengthen SA-Vic link – **Federal & State**

## Further Information

Book + research papers on IES  
& CEEM websites at UNSW

Mark Diesendorf

# SUSTAINABLE ENERGY SOLUTIONS for climate change

