Sustainable Energy Solutions for Climate Change

Dr Mark Diesendorf

Institute of Environmental Studies
University of New South Wales
Sydney, Australia
www.ies.unsw.edu.au
m.diesendorf@unsw.edu.au

Rongbuk Glacier, Himalayas, 1968 and 2007

95% of all glaciers are shrinking; Earth has warmed by 0.8°C over past century.
Yes, we have always had heatwave, drought, firestorm and flood, but their frequencies are increasing.

The Fingerprint of Climate Change is Human

- Warming of surface and lower atmosphere coupled with cooling of stratosphere
- Night-time minimum temperatures are rising faster than day-time maxima (also rising)
- (Northern) winters are warming faster than (northern) summers
- Solar radiation has been constant over past 50 years, apart from well-known 11-year solar cycle
- High latitudes (eg Arctic, Antarctic) are warming faster than tropics

The fingerprint identifies the criminal. It's not the Sun, it's us… or, more precisely, mainly some of us. 90 companies caused 2/3 of warming since industrialisation. Mostly the result of CO₂ emissions from burning fossil fuel.
Sustainable Energy Solutions: Efficient Energy Use + Renewable Energy

- To mitigate the major cause of climate change, burning fossil fuels
- To ensure energy security and to increase energy independence
- To cap fuel and electricity prices
- To cut local pollution of air, water and soil – Morwell fire
- To create local employment and community engagement

Sustainable Energy is Diverse
- Energy efficiency
- Energy conservation
  - Smart grid
  - Passive solar design
    - Wind
    - Biomass
    - Solar heat
    - Solar PV
  - Concentrated solar thermal
    - Hydro
    - Wave?
    - Geothermal electricity?
- PV solar tiles, Sydney
- CST with thermal storage
- Wind, Albany, WA
- Bioenergy, Rocky Point, Qld
- Solar efficient homes, Christie Walk, Adelaide
How can Renewable Energy replace Fossil Fuels?

<table>
<thead>
<tr>
<th>Energy end-use at present</th>
<th>Future renewable energy contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>Electricity emits 35% of Australia’s GHG emissions. Could be supplied entirely by renewables within a few decades.</td>
</tr>
<tr>
<td>Transport</td>
<td>14% of Australia’s GHG emissions. Electric vehicles for urban transport; inter-city high-speed rail; biofuels for rural vehicles &amp; some air travel.</td>
</tr>
<tr>
<td>Heat (non-electrical)</td>
<td>About 17% of Australia’s GHG emissions. Low temperature heating &amp; cooling from solar &amp; heat pumps; high temperature heat from renewable electricity</td>
</tr>
</tbody>
</table>

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

Regions with Strong Renewable Energy Targets

<table>
<thead>
<tr>
<th>Country/state</th>
<th>2012 Renewable Electricity</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>30% from wind; some electricity &amp; district heating from agri. residues</td>
<td>100% renewable electricity and heat by 2035</td>
</tr>
<tr>
<td>Germany</td>
<td>About 21% from renewables.</td>
<td>80% renewable electricity by 2050</td>
</tr>
<tr>
<td>Scotland</td>
<td>35% from renewables including hydro</td>
<td>100% renewable electricity by 2020</td>
</tr>
<tr>
<td>South Australia</td>
<td>27% from wind + 4% from solar = 31%</td>
<td>33% renewable electricity by 2020 – almost achieved in 2013</td>
</tr>
<tr>
<td>China</td>
<td>Biggest wind capacity and solar hot water; biggest PV manufacture</td>
<td>15% of all primary energy from ‘low-carbon’ by 2020</td>
</tr>
<tr>
<td>California</td>
<td>About 24% in total from hydro, geothermal, wind, biomass, etc</td>
<td>33% renewable electricity by 2020</td>
</tr>
</tbody>
</table>
Sustainable Energy is under Attack by Vested Interests and Governments in Australia

- Review of Renewable Energy Target by biased committee – **Commenced**
- Review of alleged health impacts of wind farms – **Announced**
- Funding for Australian Renewable Energy Agency (ARENA) cut by $800 million – **Done**
- Profitable Clean Energy Finance Corporation to be closed – **Announced**
- State governments have cut feed-in tariffs for residential RE and even energy efficiency programs – **Done**
- Anti-renewable energy myths spread by politicians & others – **Continuous**

Attacks on Climate Action in General also Damage Sustainable Energy

- Carbon price to be terminated – **Announced**
- Climate Commission (advised public) shut down – **Done, by community has replaced it with Climate Council**
- Climate Change Authority (advises government) to be shut down – **Announced**

Just one of these many policies against climate action and sustainable energy could possibly be explained by ignorance or incompetence.
The whole set can only be explained by a deliberate campaign strategy.
Vested Interests are spreading False Myths about Renewable Energy (RE)

- **Myth:** ‘Base-load power stations, either coal or nuclear, are necessary, and renewable energy (RE) cannot provide them’
- **Myth:** ‘RE is too variable or intermittent to make the predominant contribution to grid electricity supply’
- **Myth:** ‘Coal-fired power stations must run continuously as backup’
- **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 in recent years’

Why the attacks?

Renewable Electricity threatens Utility Business Models, State Gov’t revenue & big Greenhouse Gas emitting Industries

- **‘Merit Order Effect’ at wholesale (generation) level**
  - Wind farms, with very low operating cost, are displacing coal-fired power stations, eg, in South Australia, and reducing wholesale price of electricity

- **‘Death Spiral’ at distribution/retail level**
  - Growth in rooftop solar PV and increased energy efficiency is 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
- eg. South Australia 27% wind + 4% solar;
- Denmark 30% wind + about 8% bioenergy from agricultural residues

Hourly computer simulations of demand and supply by 80–100% renewable electricity in many countries, including Australia
- Beyond Zero Emissions (2010): single half-hourly simulation spanning 2 years; RE mix dominated by CST; no PV; east-west transmission link
- AEMO (2013): 4 RE scenarios; modest, unnecessary contributions from wave and hot rocks; no fossil fuelled comparison scenarios
- Melbourne Energy Institute (in progress)

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

- Hourly data on electricity demand, solar & wind for NEM in 2010
- Simulation model built by Ben Elliston: hourly time-steps through 2010, balancing supply and demand while maintaining reliability
- All commercially available RE technologies; cost projections to 2030 by BREE (2012)
- Simplified transmission model
- Optimal mix of RE technologies determined
- Comparison fossil scenarios (see below)
Supply and Demand for a Typical Week in Summer 2010 – Optimal Mix of RE

In summer, negligible gas turbine (GT) energy used.

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

In calm winter evenings following cloudy days, GTs & demand management are important.
Do we need Base-load Power Stations?

Old concept: Base-load demand supplied by base-load power stations

New concept: No base-load power stations; reliable supply maintained by mix of variable & flexible power stations

Meeting Demand reliably without Base-load Power 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
Additional Ways of Increasing Grid Reliability for Insurance against Rare Extended Overcast Calm Periods

* Increase geographic dispersion of solar and wind farms and build new transmission links to facilitate dispersion
* Introduce smart grids and smart devices to allow consumers and utilities (under contract) to cut peak demands when supply is limited
* Pay for reserve capacity in terms of vehicle-to-grid capacity, mini-hydro and biofuelled gas turbines and biodiesel generators

100% RE Least-Cost Energy Generation Mix 2030
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 Bureau of Resources & Energy Economics (BREE 2012). Low costs of the range
UNSW’s Four Comparison Scenarios
None in BZE (2010) or 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 CCGT and peak-load GT; GHG emissions 40% of existing – unacceptable!

3. Base-load coal with CCS (unproven technology) + peak-load gas turbines

4. Base-load CCGT gas with CCS (unproven technology) + peak-load gas turbines

Annual CO\textsubscript{2} Emissions from the Four Fossil-Fuelled Comparison Scenarios

CCS is carbon capture & storage; CCGT is combined cycle gas turbine
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$_2$ price is $50-100 per tonne, or fossil subsidies transferred to RE

All gas: 100% RE competes if domestic gas prices increase to near export prices

Fossil + CCS: 100% RE competes almost everywhere

Unacceptable emissions
Unproven technologies

Busted Myths about Renewable Energy (RE)

- **Myth**: ‘RE cannot provide base-load power.’ Based on false notion that base-load demand must be supplied by base-load power stations – **BUSTED by simulations and elementary logic**

- **Myth**: ‘RE is too variable or intermittent to make the predominant contribution to grid electricity supply – **BUSTED by simulations: variable RE’s contribute 66% of annual electricity; flexible RE 34%**

- **Myth**: ‘Coal-fired power stations must run continuously as backup’ – **BUSTED by both experience & simulations**

- **Myth**: ‘Renewable energy is too expensive’ – **BUSTED by simulations & economic analysis based on conservative projections**

- **Myth**: ‘Renewable energy is not ready’ – **BUSTED: UNSW simulations use only commercially available technologies**
Conclusion re Reliability and Economics

- 100% renewable electricity systems meet reliability criteria without base-load power stations, even when 2/3 of RE is variable
- Coal + CCS could only compete with 100% RE under uncommon combinations of costs: eg, power station close to storage reservoir AND low CO₂ price
- But, low CO₂ price means no economic driver for developing and using CCS in Australia
- Hence, in a climate-constrained world, there may be no future for coal-fired electricity, even if CCS becomes commercially available
- All-gas and gas+CCS can only compete with 100% RE if domestic gas price doesn’t rise to near export parity (it is almost there in Qld)
- RE is a good long-term investment

Principal Government Policies Needed to Drive Renewable Energy

- Set stronger greenhouse targets + targets for renewable energy
- Supplement Renewable Energy Target with Feed-in Tariffs (FiTs) for large-scale renewable energy power stations, especially solar, and restore fairer FiTs for small systems
- No compensation for closing coal-fired power stations
- Keep carbon price and Clean Energy Finance Corporation
- Upgrade transmission system for renewable energy: priority SA–NSW link
- Extend time of use electricity pricing to more residential & commercial consumers; then solar PV households will install some batteries
- Assist community renewable energy projects to get started
- Terminate subsidies to production and use of fossil fuels (>10 billion p.a.)
Principal Government Policies Needed to Drive Energy Efficiency

- Set targets for energy efficiency
- Implement Mandatory Energy Performance Standards, ratings and labelling for ALL buildings, appliances and energy-using equipment
- Implement ‘smart’ electricity grid and ‘smart’ devices to encourage demand reduction at key times by users and utilities
- Fund assistance schemes for residential, commercial and industrial sectors

Principal Government Policies Needed to drive Sustainable Transport

- National & state governments to fund infrastructure for rail: light, heavy and high-speed inter-city
- State & federal governments to fund local governments to build bicycle paths and bicycle parking stations
- National governments to assist purchase of electric vehicles (subject to mandatory renewable electricity charging)
- State governments to integrate urban & transport planning
Other Greenhouse Mitigation Policies Needed

- End population growth in countries with high per capita emissions
- To help stabilise populations in less-developed countries, by funding primary education, family planning and general poverty alleviation
- Encourage low-meat diets, especially low beef and lamb
- Fund R&D for eco-cement and steel-making without coal
- Fund research on steady-state economic systems and start implementing policies to make the economy our servant
- Local and state government support for community RE projects
- Build manufacturing capacity for sustainable energy systems and other clean technologies
- Increase funding for education & training in sustainable energy and sustainable development in general

What We Can Do

- Individual and household action
  - Make our homes and other activities sustainable
  - Talk to friends and acquaintances, write to newspapers, on-line comments, local radio
  - Divest
  - Join Solar Citizens, climate action groups, etc and participate in community action

- Community action
  - Community renewable energy & energy efficiency projects
  - Community social & ‘political’ actions (eg Clean Energy for Eternity)
  - Divest collectively

- Large-scale social and political action
  - Participate either as individuals or community groups
  - Either support political parties with positive, effective climate action & sustainable energy policies, or demand that your party implements such policies
Our Main Hope: Community Climate Action

- 150 climate action groups
- Environmental, social justice, professional, business, trade union and faith groups
- Community renewable energy projects

Further Information

Research papers: