100% Renewable Energy – Realistic or Ridiculous?

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Q. 100% Renewable Energy – Realistic or Ridiculous?

(my) A.

Not ridiculous!
Need to clarify scope
Very challenging to realise.
Perhaps easier in Australia than in most countries.
Are we asking the right question?

Not ridiculous!

- Very important but controversial, even for Australia
  - Trainer, Energy Policy 50, 306 (2012)
  - Trainer, Energy Policy (corrected proof online)
- and globally
  - Moriarty and Honnary, Renewable and Sustainable Energy Reviews 16, 244 (2012)
  - Jacobson & Delucchi, Energy Policy 39, 1154 (2011)
  - Delucchi & Jacobson, Energy Policy 39, 1170 (2011)

Define the scope

- What geographical region? Australia? The world? What about Japan, Korea, etc.?
  - Trainer, Energy Policy 50, 306 (2012)
  - Trainer, Energy Policy (corrected proof online)
- and globally
  - Moriarty and Honnary, Renewable and Sustainable Energy Reviews 16, 244 (2012)
- Several studies consider electricity only
- Include air travel? International travel?

Challenging!

- Resource availability varies geographically

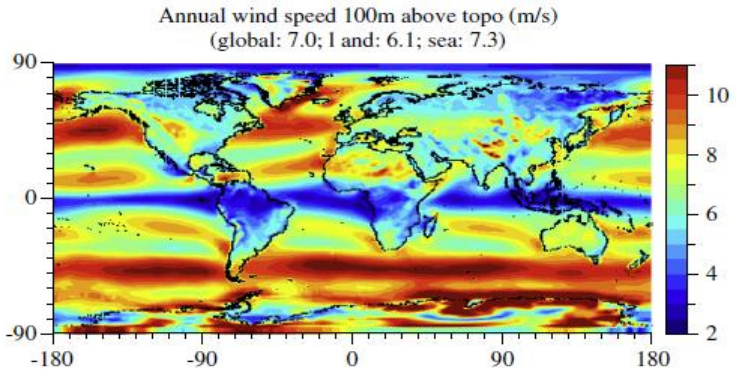


Fig. 1. Map of the yearly averaged world wind speed (m/s) at 100 m above sea level at 1.5 × 1.5° resolution, generated with the GATOR-GCMOM 3-D global model (Jacobson, 2010).

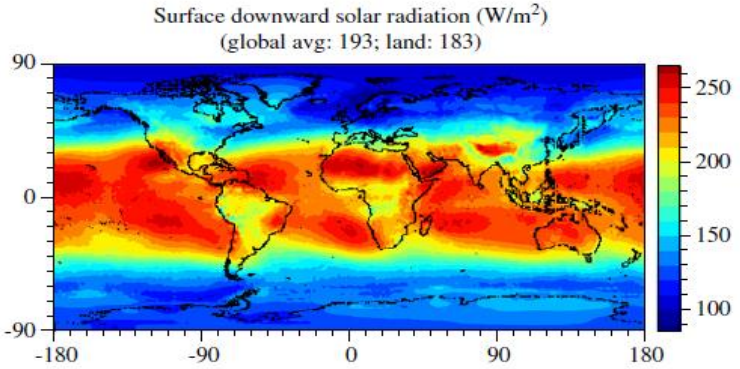


Fig. 2. Map of the yearly averaged downward surface solar radiation reaching the surface (W/m^2) at 1.5 × 1.5° resolution, generated with the GATOR-GCMOM 3-D global model (Jacobson, 2010).

- Intermittency
  - Uncertainty of supply reduces value
  - Redundant reserves required - expensive?
  - Grid instability from rapid changes
  - Geothermal is constant and biomass is storable
  - Tidal, wave are predictable
  - Recorded periods of low sun and low wind (Europe)

Challenging!

- Resource temporal and geographical match to load
  - Some might be easier than we think since many loads previously shifted to off-peak to suit coal-burning electricity generators
  - Resource diversity helps
    - Wind and solar can be complementary
  - Interconnection helps
    - Global grid?
  - Demand management helps (low or negative cost)
    - Price signals
    - “smart grid”
    - Energy efficiency, including building design and behaviour

Challenging!

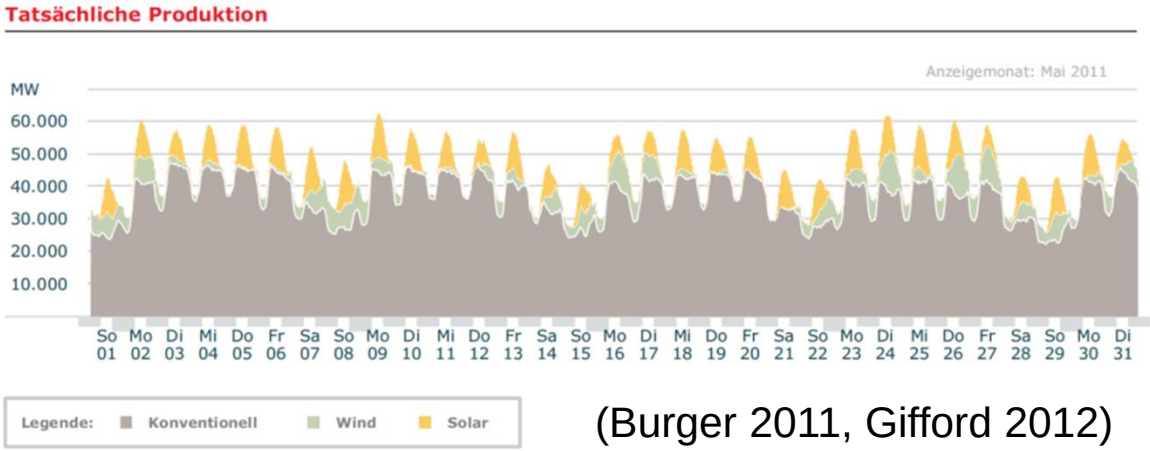
- Storage remains expensive (but feasible)
  - Pumped hydro
  - Biomass / Biofuel
  - Compressed air
  - Batteries (various)
    - Future resource of vehicle batteries
  - Hydrogen (?)
  - Chemical fuels
  - Fresh water production

Challenging!

- Embodied energy
  - PV, wind energy payback times (EPBT) << lifetime (but some controversy over definitions)
    - Have improved with manufacturing scale and research
    - Will tend to improve as renewable penetrate supply
    - Will tend to worsen as best opportunities taken
- Some loads very difficult
  - Air transport
  - Other transport

Challenging!

- Grid Issues
  - System stability (clouds)
  - Voltage rise in local regions
  - Frequency control
  - Phase balancing
  - Power factor
  - Harmonics
  - Fault behaviour
  - Islanding
  - Reverse power flow, reactive power
  - Peak shaving
  - IEA PVPS Task 14



(Burger 2011, Gifford 2012)

Australia

- Abundant renewable energy resources relative to demand
- Tyranny of distance
- Mismatch of location of supply/demand
- Electricity grid built around coal

Are we asking the right question?

- Is 100% very important, even if desirable?
- Is it failure to reach 90% or 95%?
- Currently, we don't even pick the low hanging fruit (eg. PV on big metropolitan roofs of factories, warehouses, cold stores, data centres)
- Main problem is $$ so we need to compare with our alternative paths to slow climate change!

Acknowledgements

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Some further reading on high penetration into electricity grids:

- **http://www.climatechange.gov.au/en/government/initiatives/aemo-100-per-cent-renewables/**
- **http://www.nrel.gov/analysis/re_futures/**