Economic viability of an international transmission network in Australasia

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Australia’s desert region

Australia’s desert region has some of the world’s best solar resource and wind resource.

Low seasonal variability as well
Can a carbon-neutral NEM benefit from it?

NOT Really
How did we arrive at that conclusion?
Modeling of the NEM

- Minimising total system cost
- 5-year step from today to 2050 to show transition; taking into account the existing generators
- Appropriate level of abstraction, i.e. hourly resolution, 55 locations across the NEM, 21 nodes (vs. interconnectors only)
- Unit commitment, i.e. we only consider ramp rates, minimum on time, round trip efficiency, etc. i.e. no hot/cold start of generators, etc.
- A wide range of generation and storage technologies
- Hourly economic dispatch with power flow constraints
- Historical demand and weather data with sampled days with hourly energy balance with economic dispatch
- 30% state level synchronous generation limit
- 50, 60, 70, 80, 80, 100 % emission reduction up to 2050 subject to 2013 level
- Technology cost projections, fuel costs and maintenance costs, etc. taken from the Australian Energy Technology Assessment (AETA) report, the CSIRO technology cost projections, AEMO’s ISP
Bridging the research gap -- how we attempted to

Model the transmission grid and grid services, e.g. system Inertia

Abstraction of the Network
Bridging the research gap

--- how we attempted to

Model the optimal power flow

Direct Current PF with Economic Dispatch

The 21-node network model at the hour of peak NEM demand in the tested year (15:00 on 11 January 2010). Red transmission lines are constrained, orange lines are above 80% of their limit, green lines are at less than 80% of their limit. The next injection (generation minus demand) in MW is indicated in the label adjacent to the node (blue labels indicate positive net injection, orange labels negative).
Why to model transmission network

Bridging the research gap

- Copper Plate Transmission
- The 21-node Transmission Model
Bridging the research gap

Why to model unit commitment

when penetration of intermittent RE gets considerably high, coal and CCGT power plants tend to run as peaking plants, which is unrealistic.

In high RE, existing coal generation is likely to shift to a progressively more seasonal generation pattern before retirement due to limitations on their dynamic performance. The implemented UC enables such behaviour to be modelled.
Bridging the research gap

Why Mixed-Integer Pumped Hydro Dispatch

- Mixed-Integer pumped hydro model with 30% sync limitation:

It is assumed that pumped hydro storage can provide inertia to the system no matter in pumping or discharging state. However, this assumption leads to pumping and discharging happening at the same time (which is unrealistic) when the system is lacking in synchronous generation.
Should we leave the abundant RE resources there?

Australia’s lucrative fossil exports are doomed to decline as the world decarbonises;
If planned well, Australia not only can be a RE exporting superpower, it could lead a manufacturing boom.

Our recent project explores opportunities for Australia to export 100% renewable electricity to Indonesia via high-voltage DC (HVDC)

Projected energy demand from the IEA’s Global Energy Outlook.
It surely will be an Asian Century!
Our research shows it is challenging for Indonesia to power this energy growth with its own renewables.
Our recent study – renewable electricity export to Indonesia

Electricity generation in Australia and Indonesia is currently dominated by coal and gas.

For the Java-Bali power system, according to official estimates, the annual demand growth rate from 2016 to 2030 will be 7% – a tenfold growth by 2050 [1].

HVDC: Mature technology, Transmit Gigawatts at Megavolts over thousands of km

State-of-the-art: 1100 kV, 3000 km, 12 GW in China with only 10% loss.
Scenarios and inputs

Scenario 1: BAU for Indonesia, no HVDC
Scenario 2: BAU for Indonesia, with HVDC
Scenario 3: 100% abatement Indonesia, no HVDC
Scenario 4: 100% Abatement Indonesia, with HVDC

All scenarios have 100% abatement for the NEM.
Results

Scenarios 1 and 2:

For the NEM:

100% abatement

- the bulk is provided by wind since placement of wind farms throughout the NEM would minimize variability in aggregated output
- PV is widely deployed in synergy with PHES
- PHES stores a considerable portion of the solar power during the day and dispatches it during the evening while providing inertia in both operations

For Java-Bali (BAU) the cheapest option is fossil fuel, the model suggests coal, CCGT and OCGT given their ramping requirements
Scenario 3: for Java-Bali with 100% renewables:

it is challenging to meet its domestic demand with local renewable resources. A large amount of power would be curtailed (due to oversizing) during low-demand periods. The lack of both high-quality resources and a broad geographic area to compensate power variation makes the 100% abatement exercise very costly – $AUD270/MWh in 2050.
With the HVDC interconnector

Scenario 4 (right):

100% renewables with HVDC connection to Australia

The interconnector changes the results dramatically—
the magnitude of generation is greatly reduced due to imports; energy curtailed from local wind and solar PV becomes negligible.
NEM is a beneficiary as well

In Scenario 4 the model also reveals that the NEM could profit from additional renewables as well if connected to the Northern Territory through a ground HVDC line to use the power that would be curtailed if unused by Indonesia through the submarine link. Details can be seen from the generation dispatch graphs without (upper) and with (lower) the HVDC interconnectors.

The lower figure shows that with the submarine interconnector available, in 2050 a large amount of electricity (primarily wind and concentrated solar thermal) is imported into Java-Bali, especially in the evening after the sun has set.
Starting from 2035

The modelling work presents a strong case for building an HVDC interconnector between Australia and Indonesia to facilitate a 100% abatement target for both countries. Despite the expensive HVDC links, the wholesale electricity cost for this 100% renewable Australasia system could be reduced by more than 16%.

Our estimates may be on the conservative side, as we assumed a constant cost for the HVDC technology but it’s likely to become cheaper in the coming decades.

The model finds the international HVDC cable of capacity 43.8 GW, and the regional HVDC cable with a capacity of 5.5 GW. Construction starts from 2035, enabling the flow of renewable energy from the CNT to Java-Bali.
We should do it!

Climate Change – Real Challenge
Renewables Export – Real Opportunity

Comparison with hydrogen export will also be studied next
Thank you

Questions?