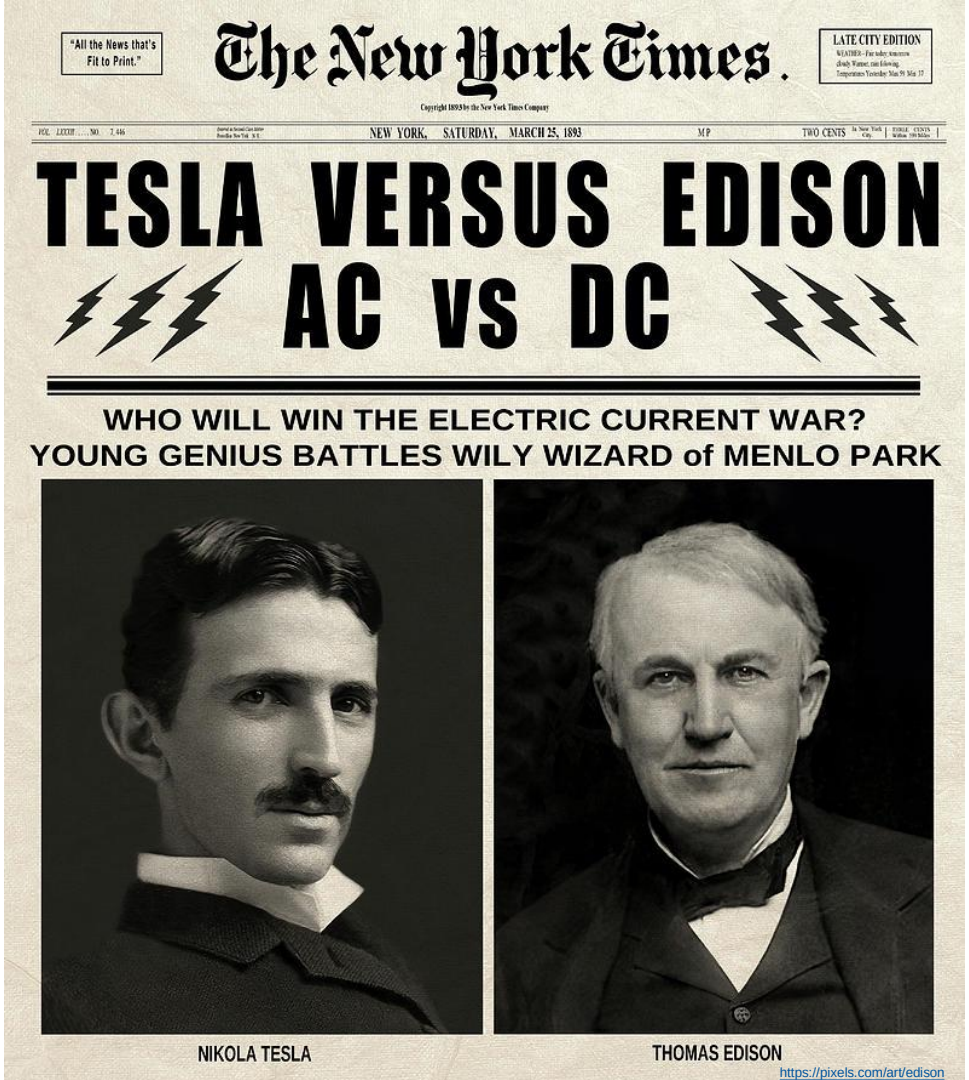
Australian National University

Electricity super-grids

Dr Bin Lu

bin.lu@anu.edu.au

ANU Grand Challenge *Zero-carbon energy for the Asia-Pacific*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The New York Times.

LATE CITY EDITION

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NEW YORK, SATURDAY, MARCH 25, 1893

TWO CENTS

TESLA VERSUS EDISON

AC vs DC

WHO WILL WIN THE ELECTRIC CURRENT WAR?

YOUNG GENIUS BATTLES WILY WIZARD of MENLO PARK

NIKOLA TESLA

THOMAS EDISON

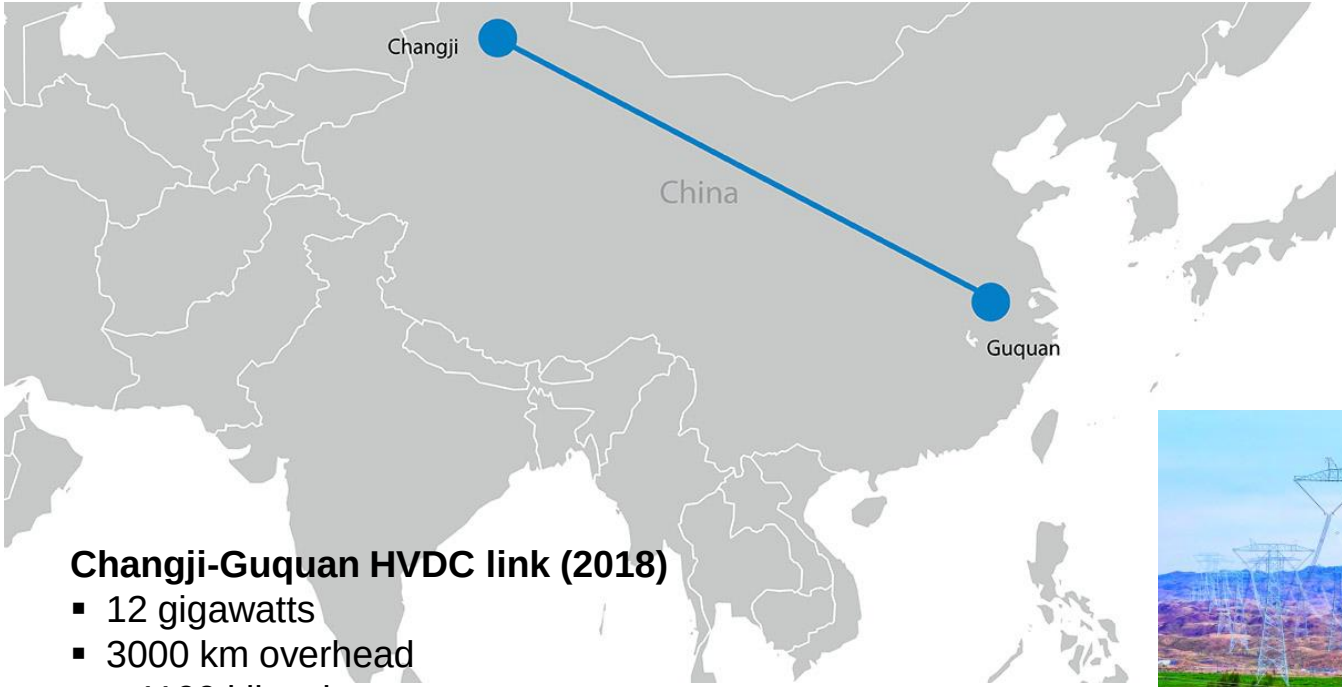
https://pixels.com/art/edison

The War of the Currents

High-voltage direct current (HVDC)

- Long-distance, bulk power transmission
- Submarine and underground power cables
- Electricity grids interconnection

High-voltage direct-current (HVDC)



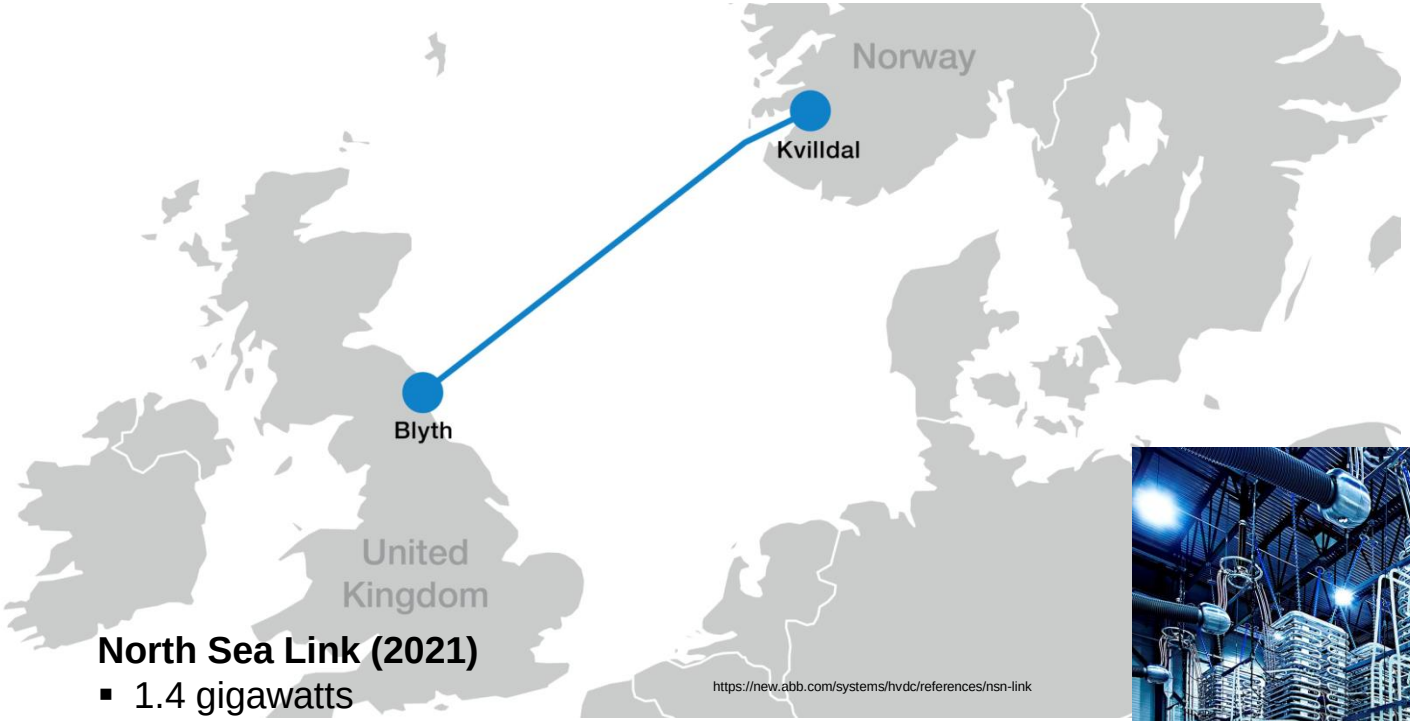
Changji-Guquan HVDC link (2018)

- 12 gigawatts
- 3000 km overhead
- ± 1100 kilovolts
- Line-commutated converters

https://new.abb.com/systems/hvdc/references/changji-guquan-uhvdc-link

Data source: ABB Group (2019)

High-voltage direct-current (HVDC)



https://new.abb.com/systems/hvdc/references/nsn-link

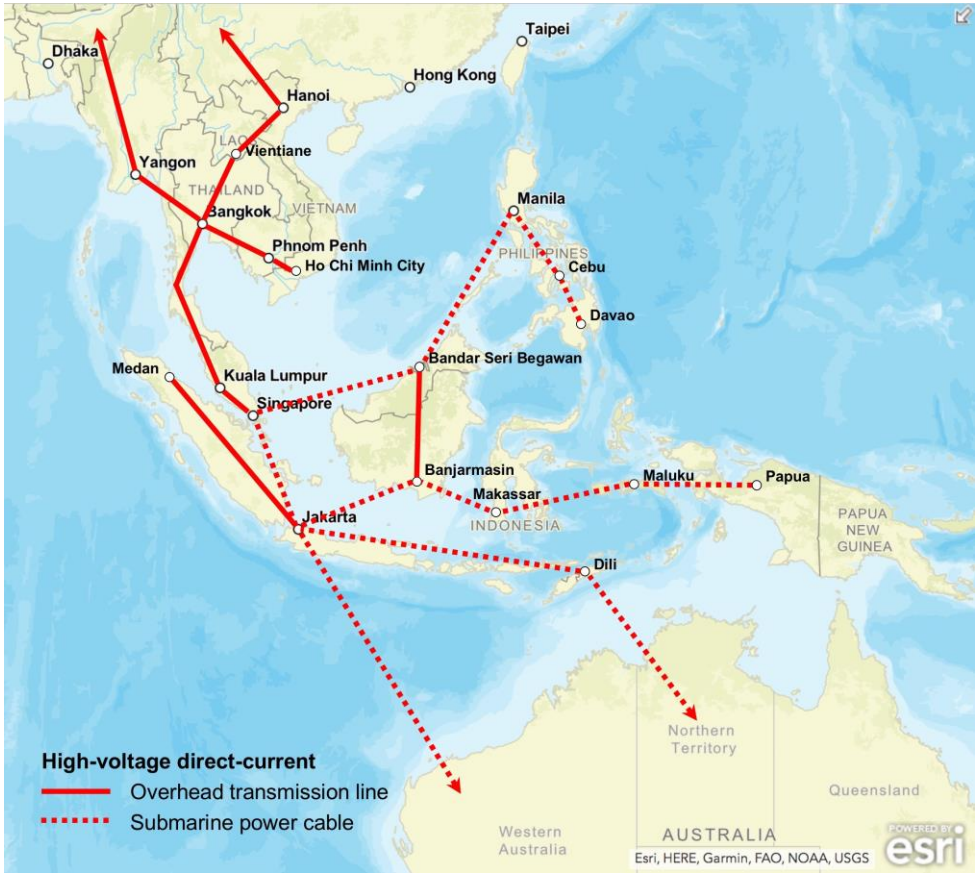
North Sea Link (2021)

- 1.4 gigawatts
- 730 km submarine
- ± 525 kilovolts
- Voltage source converters

https://new.abb.com/news/detail/12946/abb-wins-140-million-order-to-boost-integration-of-renewables-in-europe

Data source: ABB Group (2019)

Asia-Pacific Super Grid



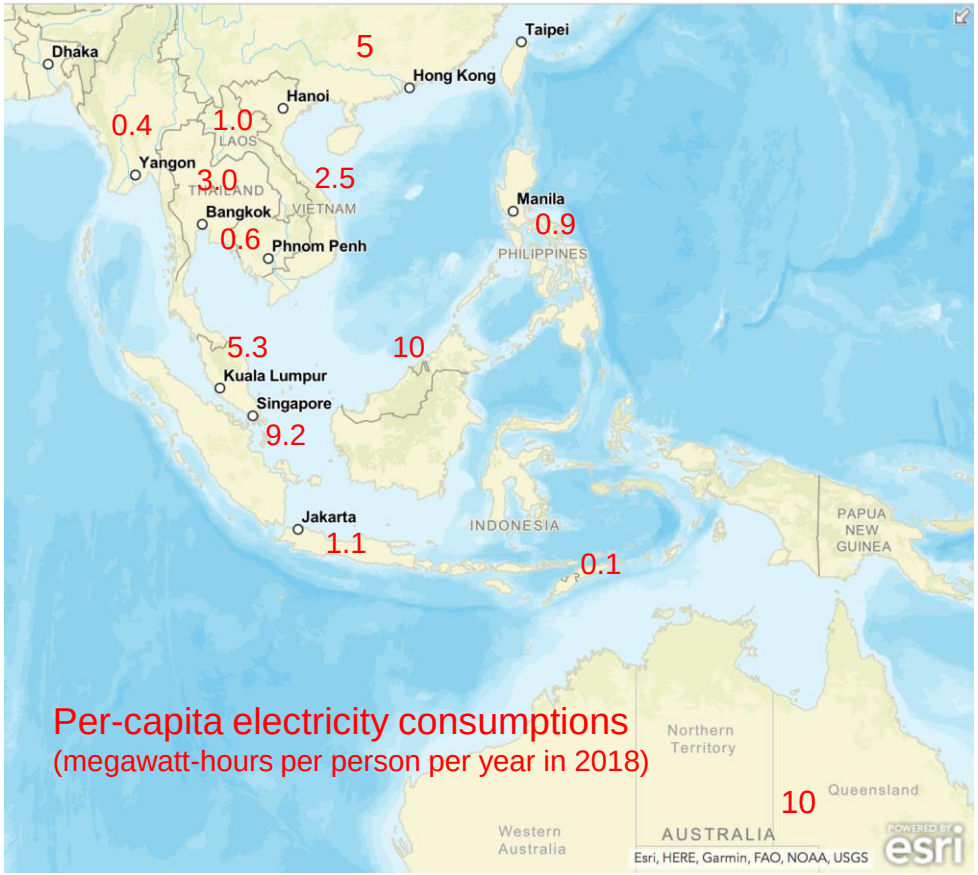
Question 1:

- Is an “Asia-Pacific Super Grid” technically feasible and economically competitive?

Question 2:

- How the Southeast Asian electricity industry will benefit from a fully integrated electricity market?

Rapid growth of electricity demand



Electricity demand in Southeast Asia

- 2020: ~1200 terawatt-hours
- 2050: ~7500 terawatt-hours
  (if assuming 9 megawatt-hours per capita similar to Singapore)

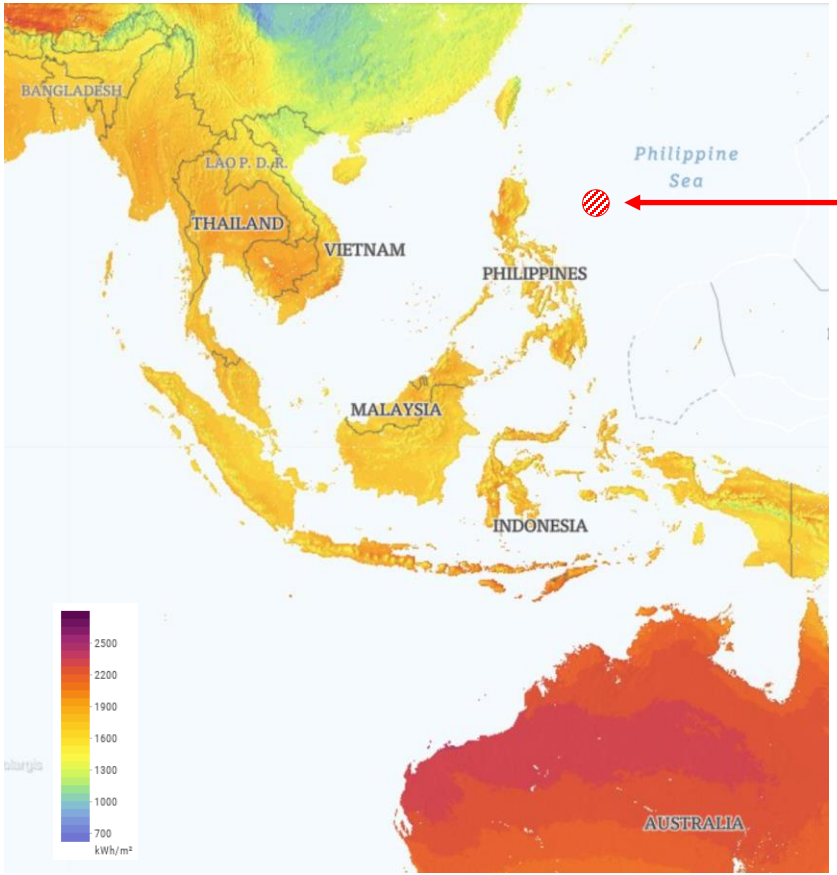
Data source: IEA Data & Statistics https://www.iea.org/data-and-statistics

Energy and environmental challenges

- Proved coal and natural gas reserves: 44 gigatonnes & 4.6 trillion cubic metres < 20 years
- Annual carbon emissions from electricity & heat production: 644 megatonnes > 4400 megatonnes p.a.
- Annual premature mortality related to coal-fired power: 20,000 deaths > 100,000 deaths p.a.

Data source: IEA Data & Statistics https://www.iea.org/data-and-statistics; BP (2020) *Statistical Review of World Energy*; Koplitz et al. (2017)

Solar energy resources

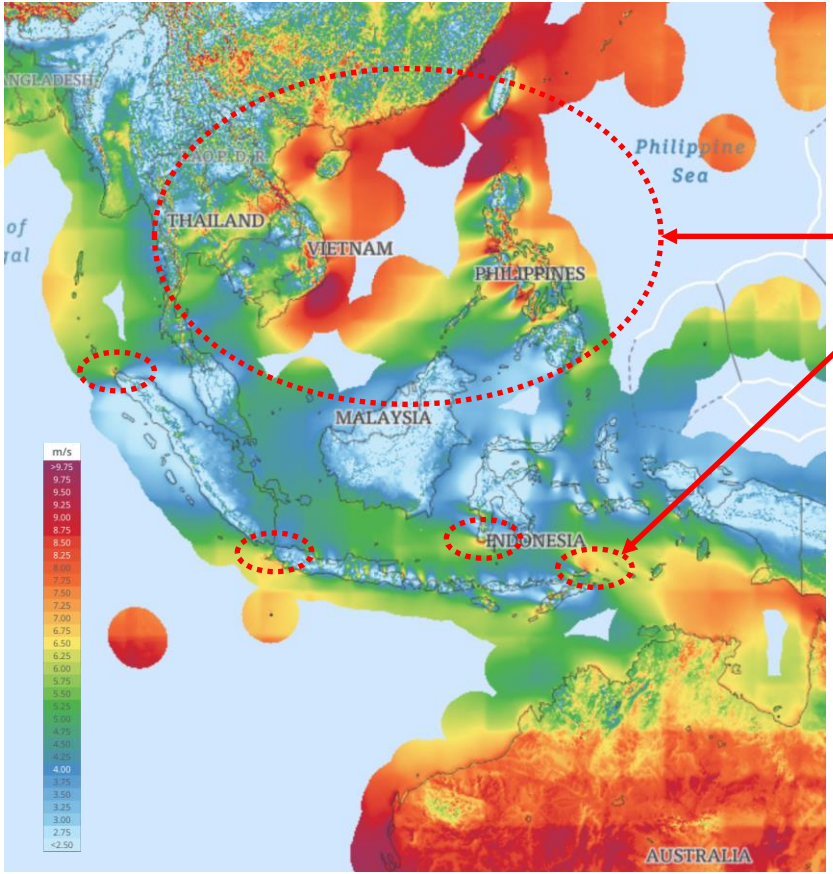


Land/water area required to power Southeast Asia with solar photovoltaics *

* Assuming an energy conversion efficiency of 20% and an average capacity factor of 15%

Image source: Global Solar Atlas https://globalsolaratlas.info/map

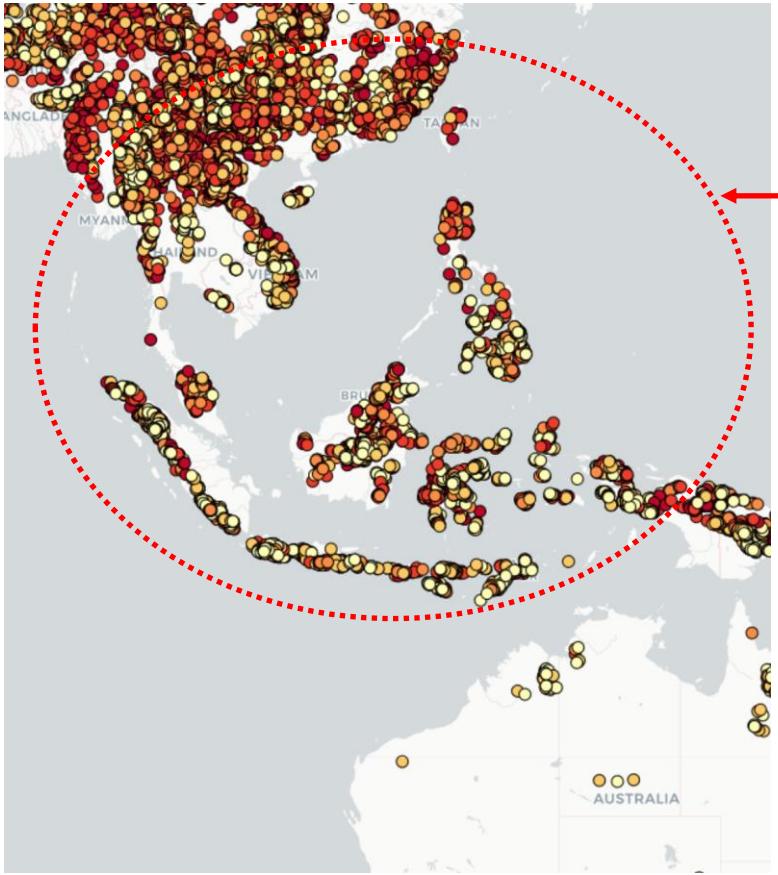
Wind energy resources



Significant wind resources are widely distributed in the northern countries, but only exist in few regions in the southern countries.

Image source: Global Wind Atlas https://globalwindatlas.info

Pumped-storage hydro (off-river)

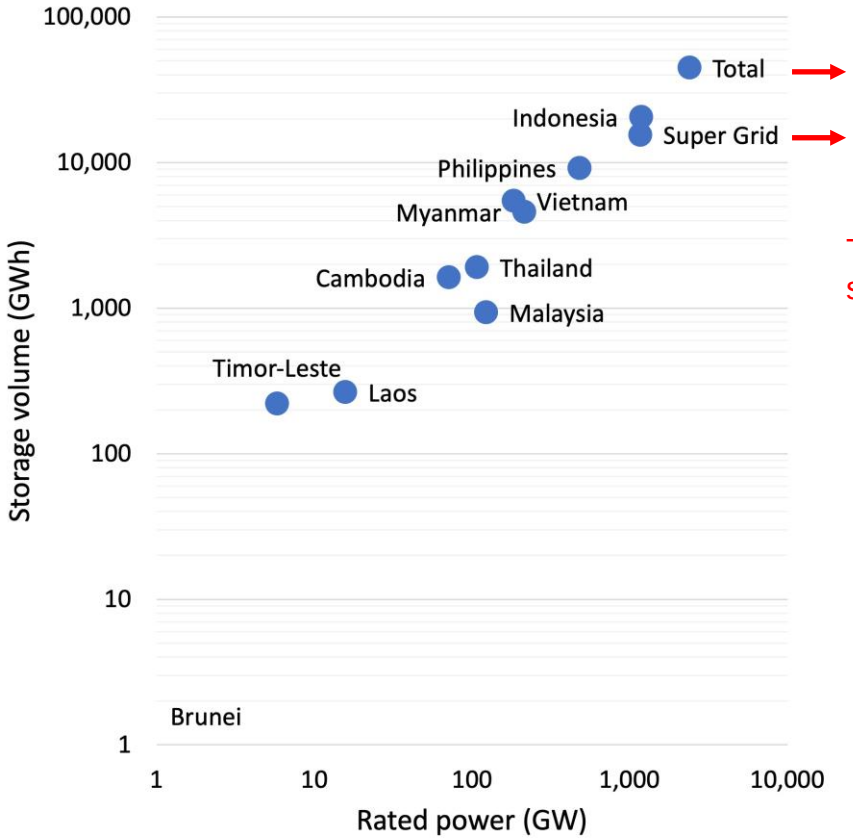


Large resource potential: 2 million gigawatt-hours

- No raw materials availability or supply issues (compared with battery storage)
- Low water consumption and moderate environmental footprints (compared with on-river hydropower)
- Long service life > 50 years

Image source: Global Pumped Hydro Atlas http://re100.eng.anu.edu.au/global/index.php

Energy storage requirements

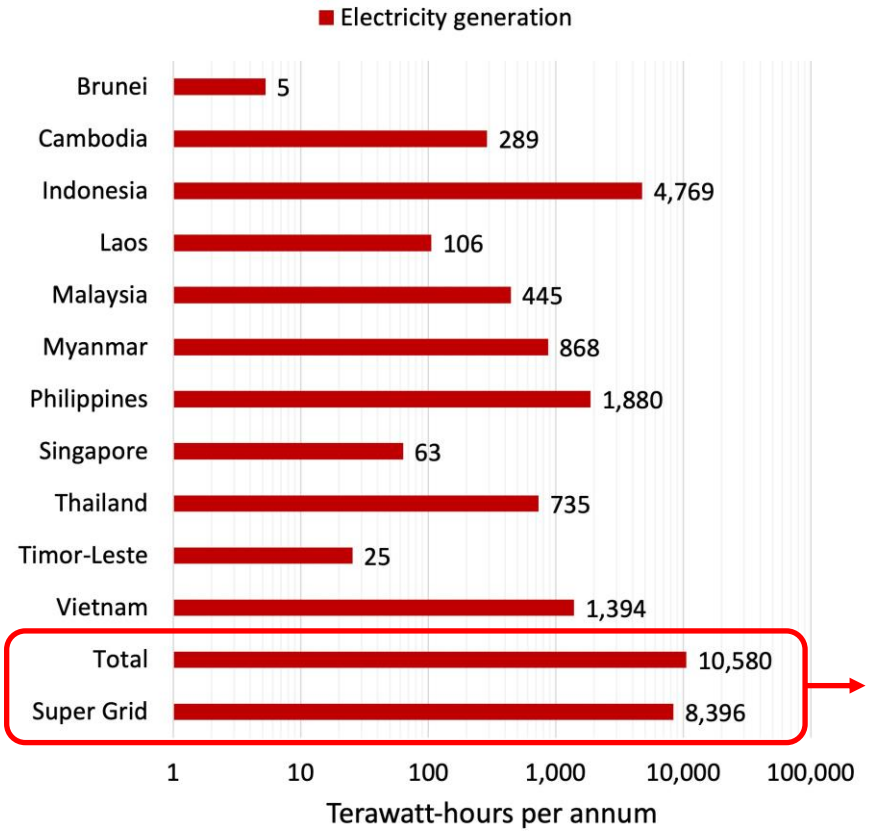


2400 GW, 45000 GWh

1200 GW, 16000 GWh

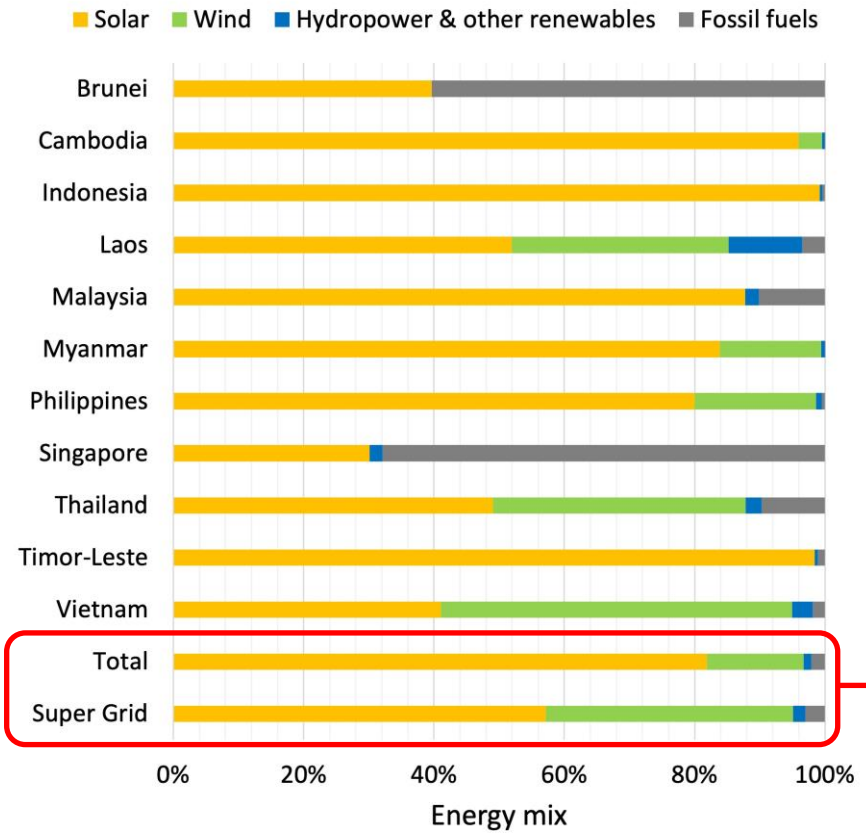
The storage requirements are more than halved in the Super Grid scenario, due to the sharing of renewable energy resources.

Electricity generation



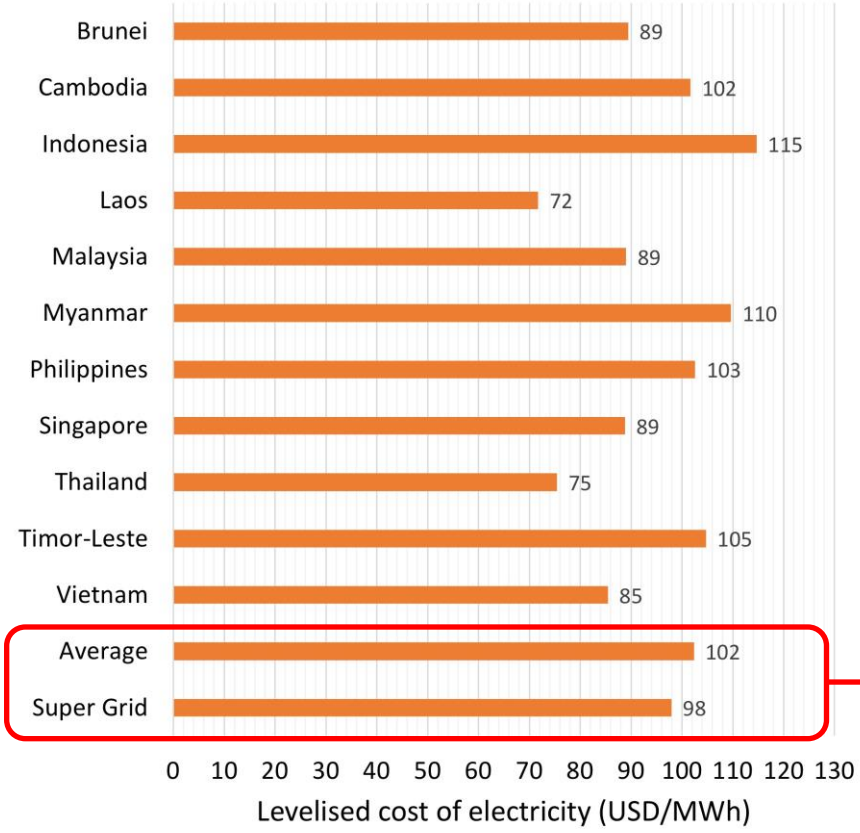
Renewable energy supply can be effectively smoothed out through the Super Grid, so the energy spillage is minimal.

Energy mix



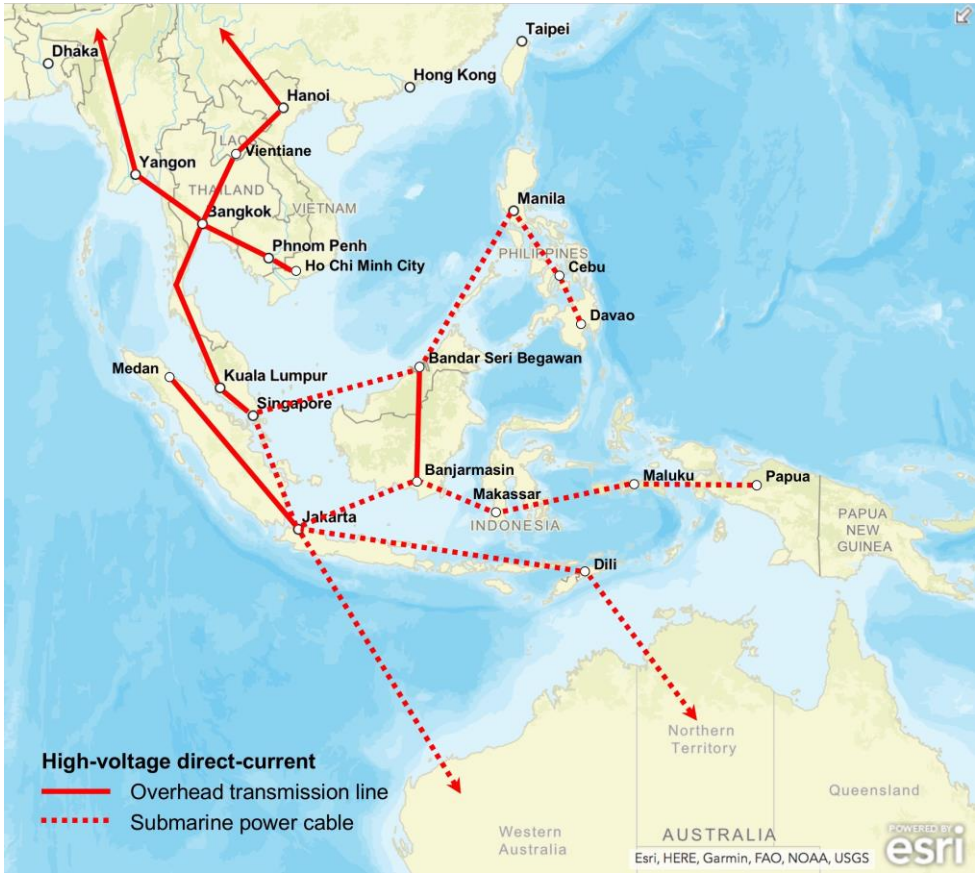
The Super Grid allows moving of wind energy from north to south, and therefore it can promote wind energy integration.

Levelised cost of electricity



Despite a large investment on the transmission infrastructure, the cost figure decreases in the Super Grid scenario.

Summary



The “Asia-Pacific Super Grid” is:

- Technically feasible through HVDC technology
- Cost-competitive, compared with the national electricity markets operating separately.

The benefits of building a fully integrated electricity market are multiple:

- Electricity generation facility decreased by 20%
- Wind energy integration increased by 70%
- Energy storage requirements reduced by 65%

Further reading:
https://doi.org/10.1016/j.energy.2021.121387