

Rough scaling calculations for replacing carbon fuels with zero carbon energy

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17 February 2022

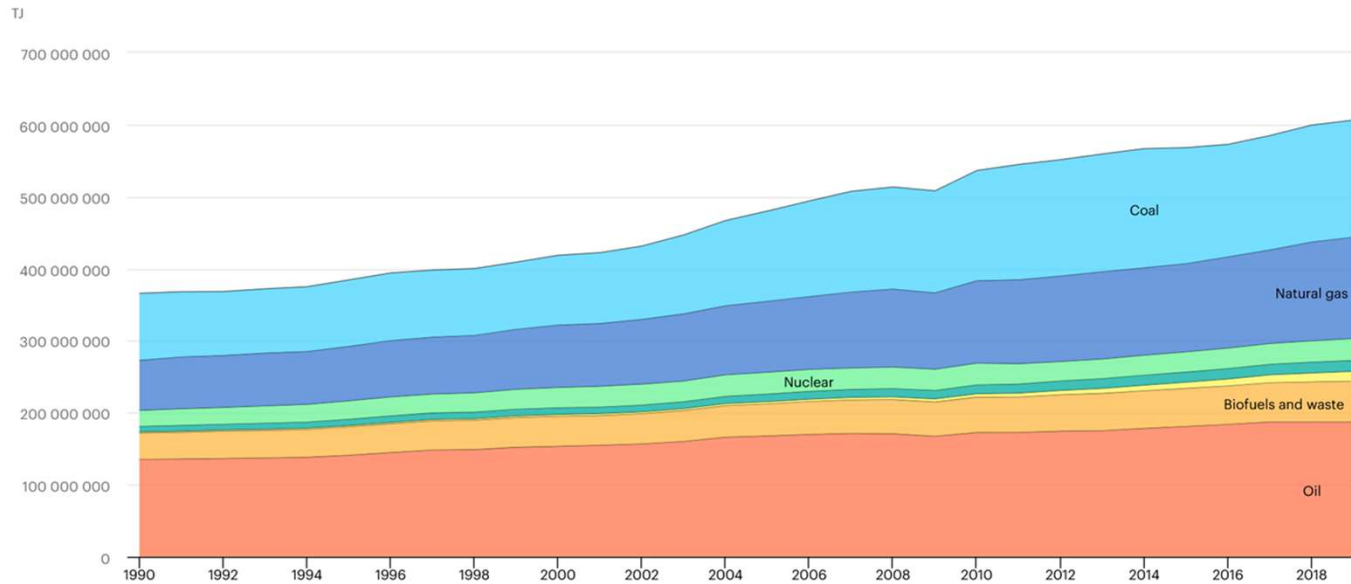
Presenter: Steven Blake

Assumptions

1. Electricity is the only available carbon-free way to deliver energy to end users
2. Hydrogen can be converted to energy at end use, but requires electricity to produce
3. Estimates here assume no nuclear power, only wind and solar

World Energy Consumption, 1990 to 2019

Total energy supply (TES) by source, World 1990-2019



Year	Combustion/Total
1990	91.5%
1995	90.6%
2000	90.4%
2005	90.9%
2010	91.2%
2015	91.1%
2019	90.3%

Combustion includes:
Coal, Natural Gas, Oil
Biofuels and Waste

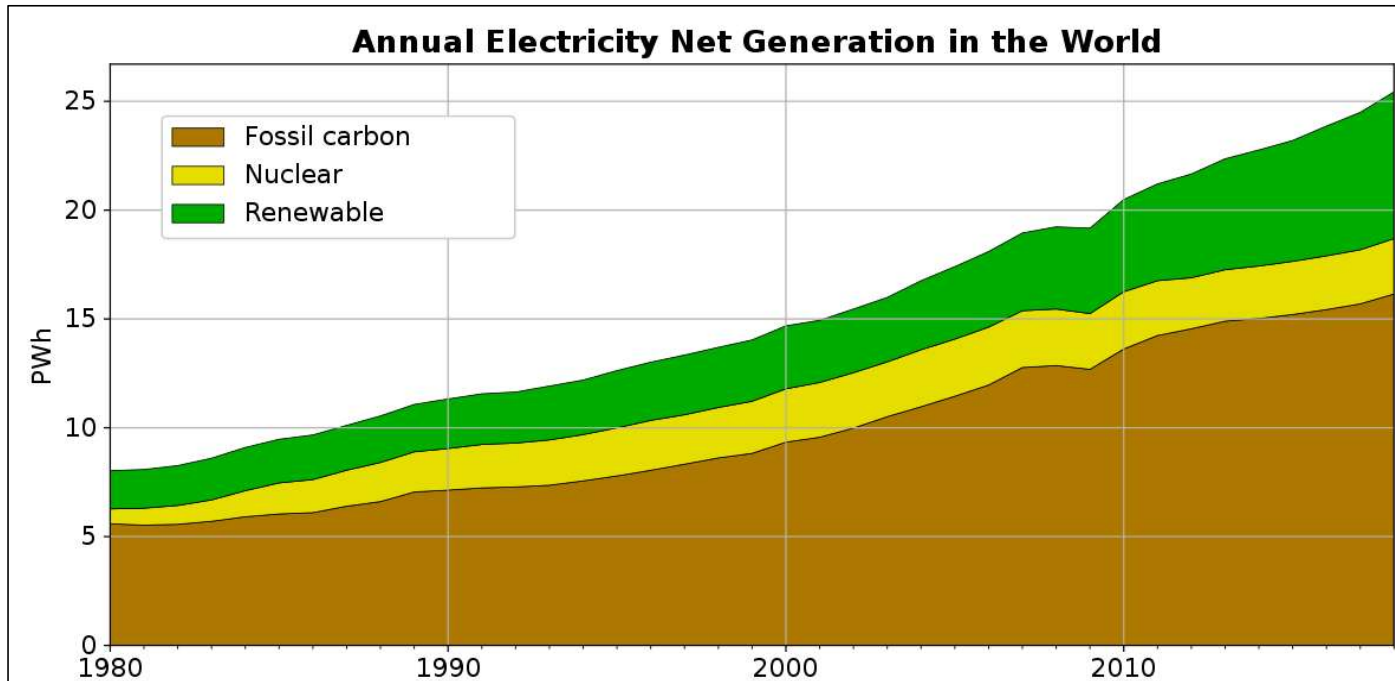
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● Coal
 ● Natural gas
 ● Nuclear
 ● Hydro
 ● Wind, solar, etc.
 ● Biofuels and waste
 ● Oil

After 29 years, 90% of the world's energy still comes from burning things

<https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource>

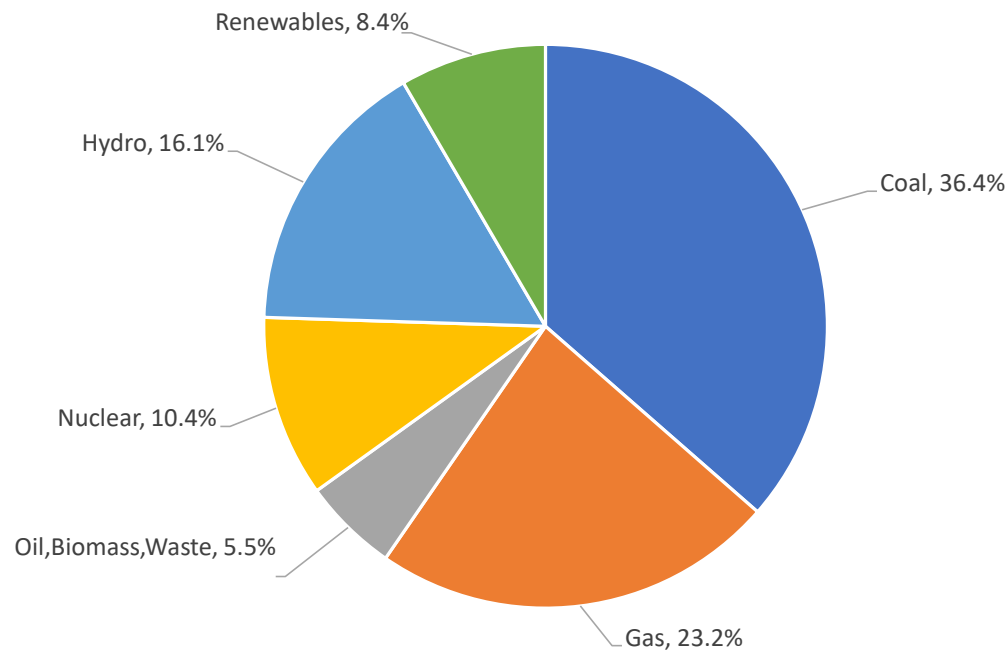
Electricity generation has made increasing use of renewables



But, scaling from the graph, about 64% of generation is still from carbon based fuel

https://en.wikipedia.org/wiki/Electricity_generation

World electricity generation, 2019

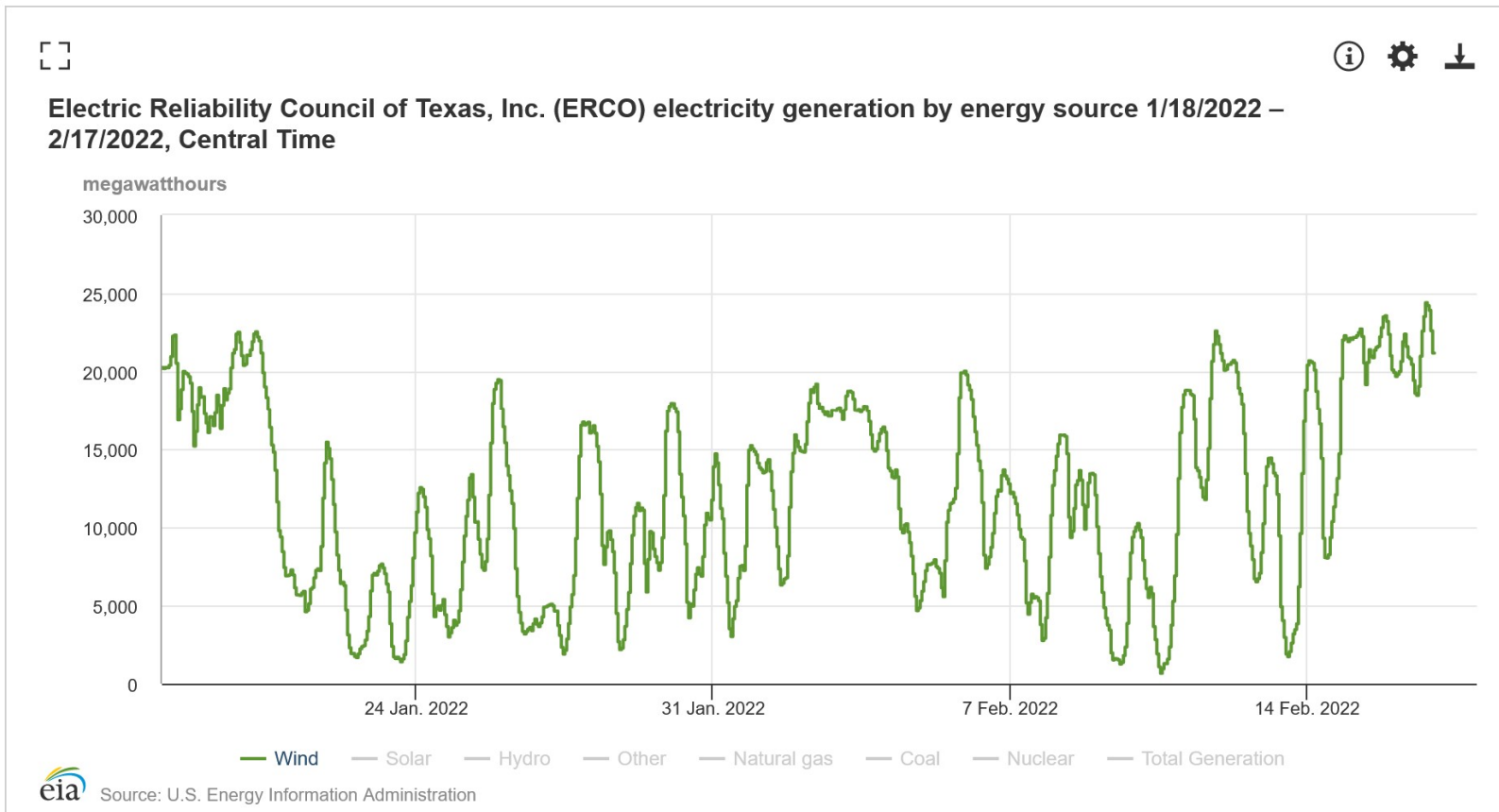


65.1%	Combustion
34.9%	Non-combustion

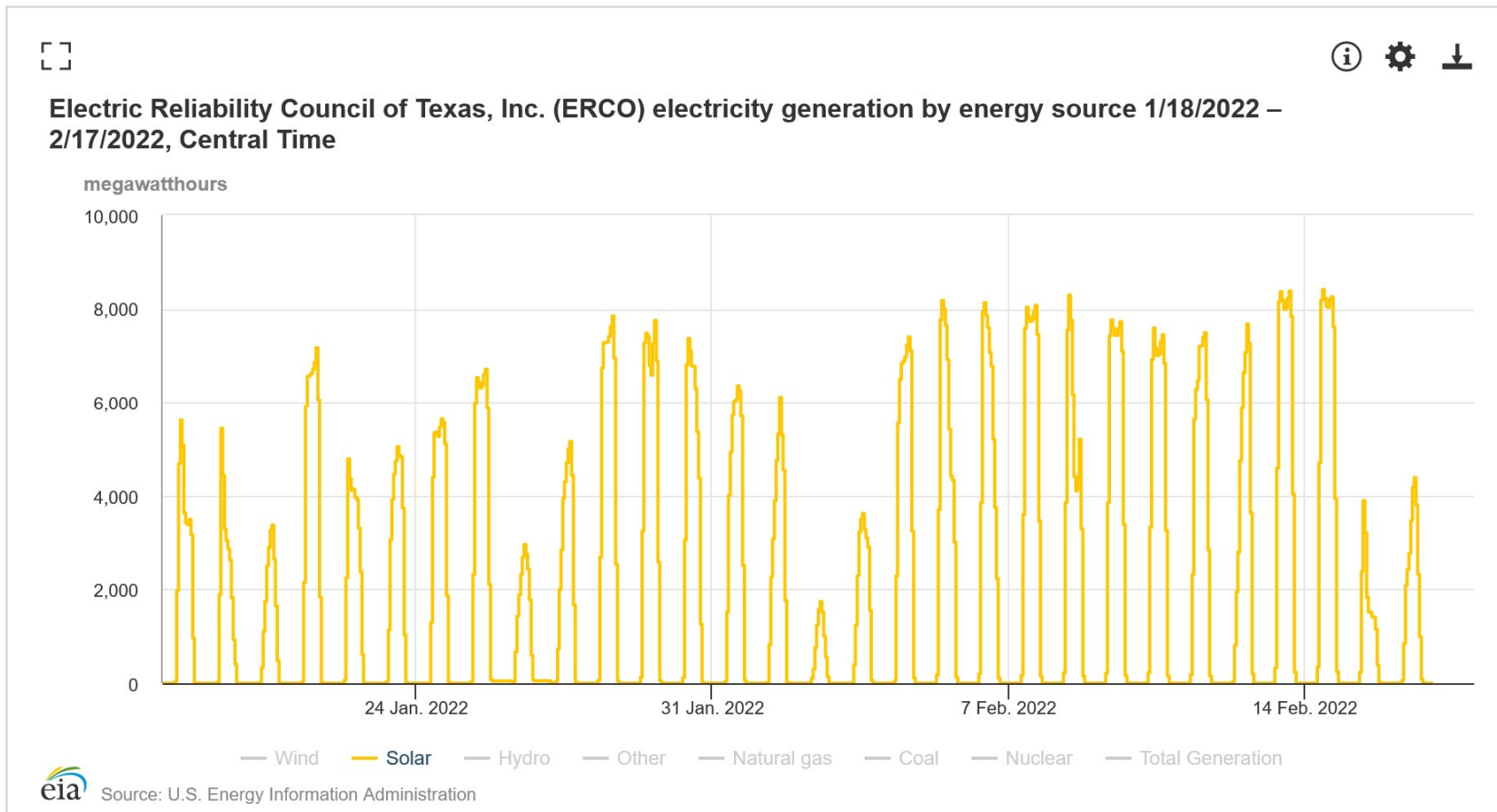
Without nuclear, Wind and solar would have to increase by a factor of 7.5 to eliminate coal and gas.

IEA (2020), *Global Energy Review 2019*, IEA, Paris <https://www.iea.org/reports/global-energy-review-2019>

But wind power is variable and unpredictable



And solar power is partly predictable but not controllable



How easy would it be to replace combustion electricity generation with wind and solar power?

Numerically, solar and wind would have to increase by a factor of 7.5 to replace coal and gas generation.

But solar and wind are intermittent, and their availability only averages about 35%

Therefore, solar and wind generation would have to be increased by 22 times to come close to replacing coal and gas

There would be an added expense for transmission lines to move the power from remote locations to load centers

Texas alone spent \$6.5 billion on new transmission to accommodate added wind power, but Texas still needs a large fleet of conventional generation to keep the lights on.

Huge land and offshore area are needed to build this much capacity.

Scaled up to the entire world, expenses would be astronomical.

Replacing oil with wind and solar is a bigger problem than replacing electricity

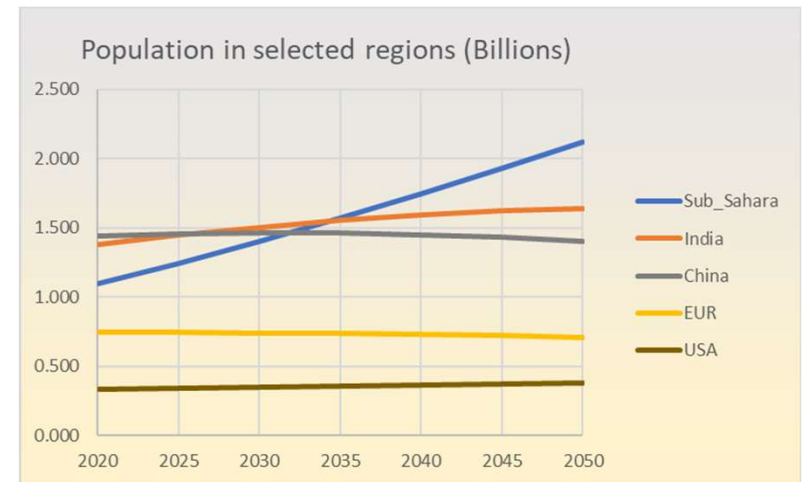
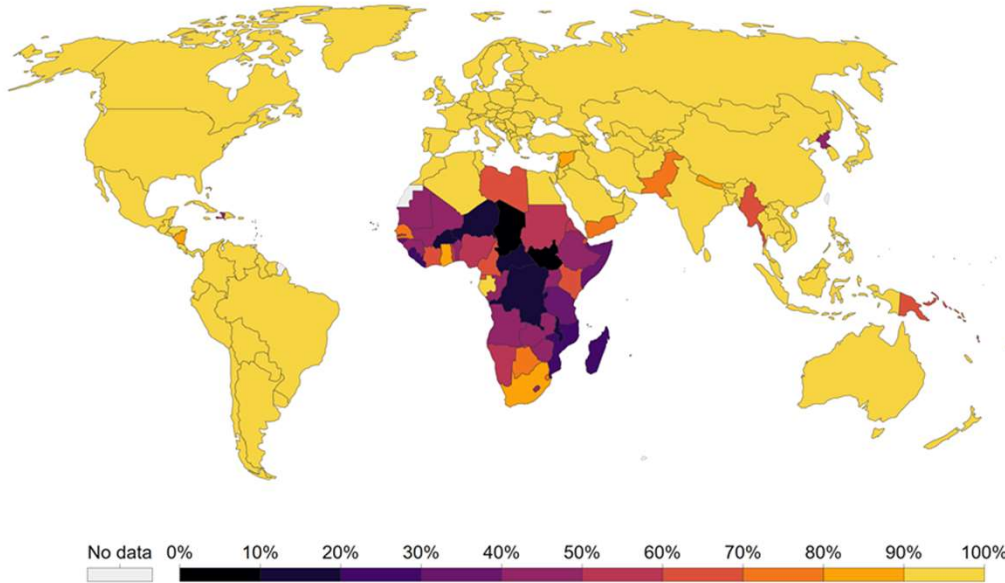
- Transportation energy is provided by petroleum.
- In 2019, world oil consumption was 187,364,800 Terajoules
- Which is equivalent to 52,045 TeraWatt-hours per year
- Total world electrical generation in 2019 was 26,951 TWh
- So, in gross terms, it would be necessary to add twice the world's 2019 electric generating capacity to be able to replace petroleum with electric generation

The areas where people are underserved with energy have a very high population growth rate

Electricity access, 2019

Share of the population with access to electricity. The definition used in international statistics adopts a very low cutoff for what it means to 'have access to electricity'. It is defined as having an electricity source that can provide very basic lighting, and charge a phone or power a radio for 4 hours per day.

Our World in Data



Source: World Bank

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