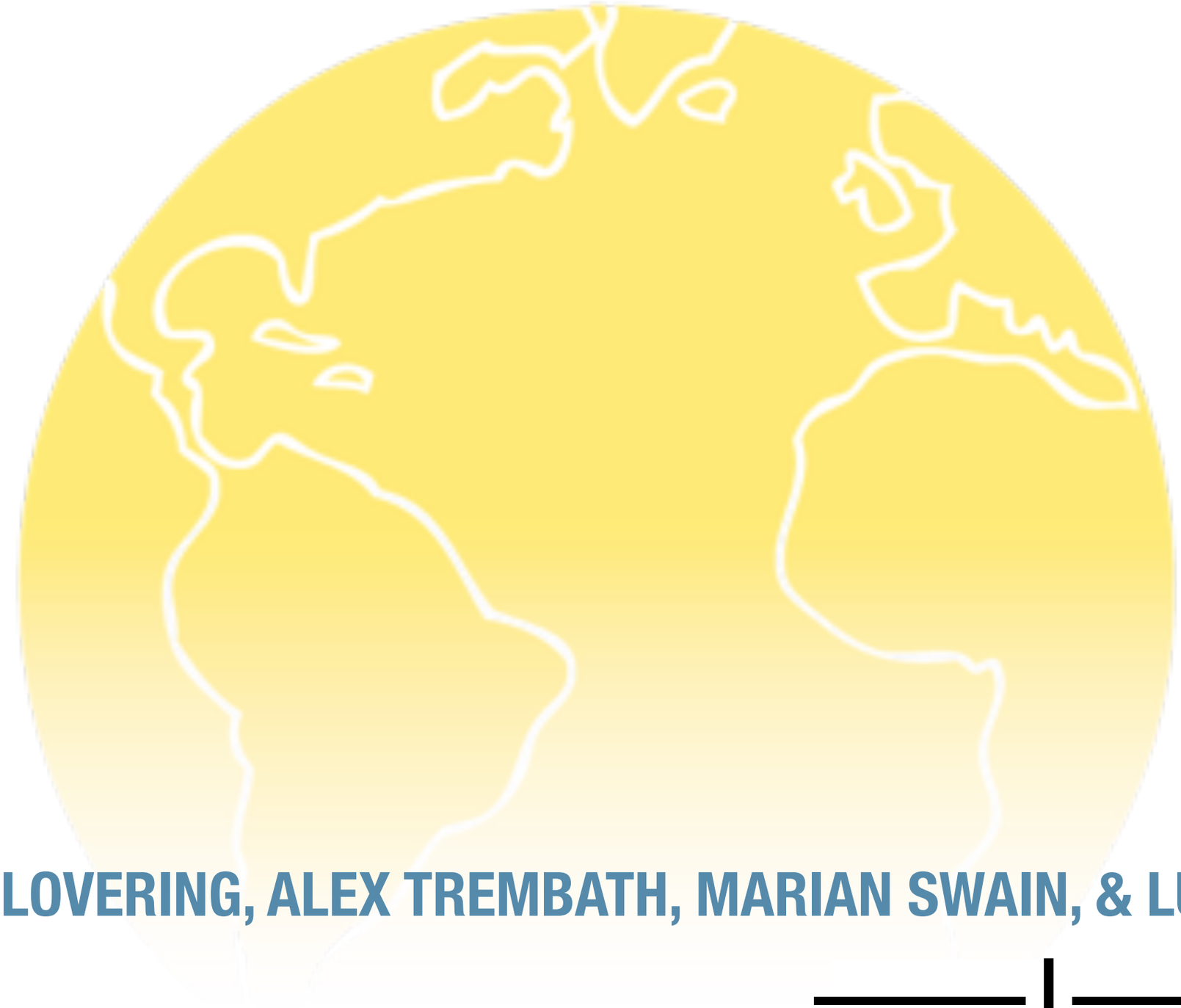
RENEWABLES AND NUCLEAR ENERGY

CLIMATE MITIGATION AND ENVIRONMENTAL FOOTPRINT



JESSICA LOVERING, ALEX TREMBATH, MARIAN SWAIN, & LUKE LAVIN

BREAKTHROUGH INSTITUTE

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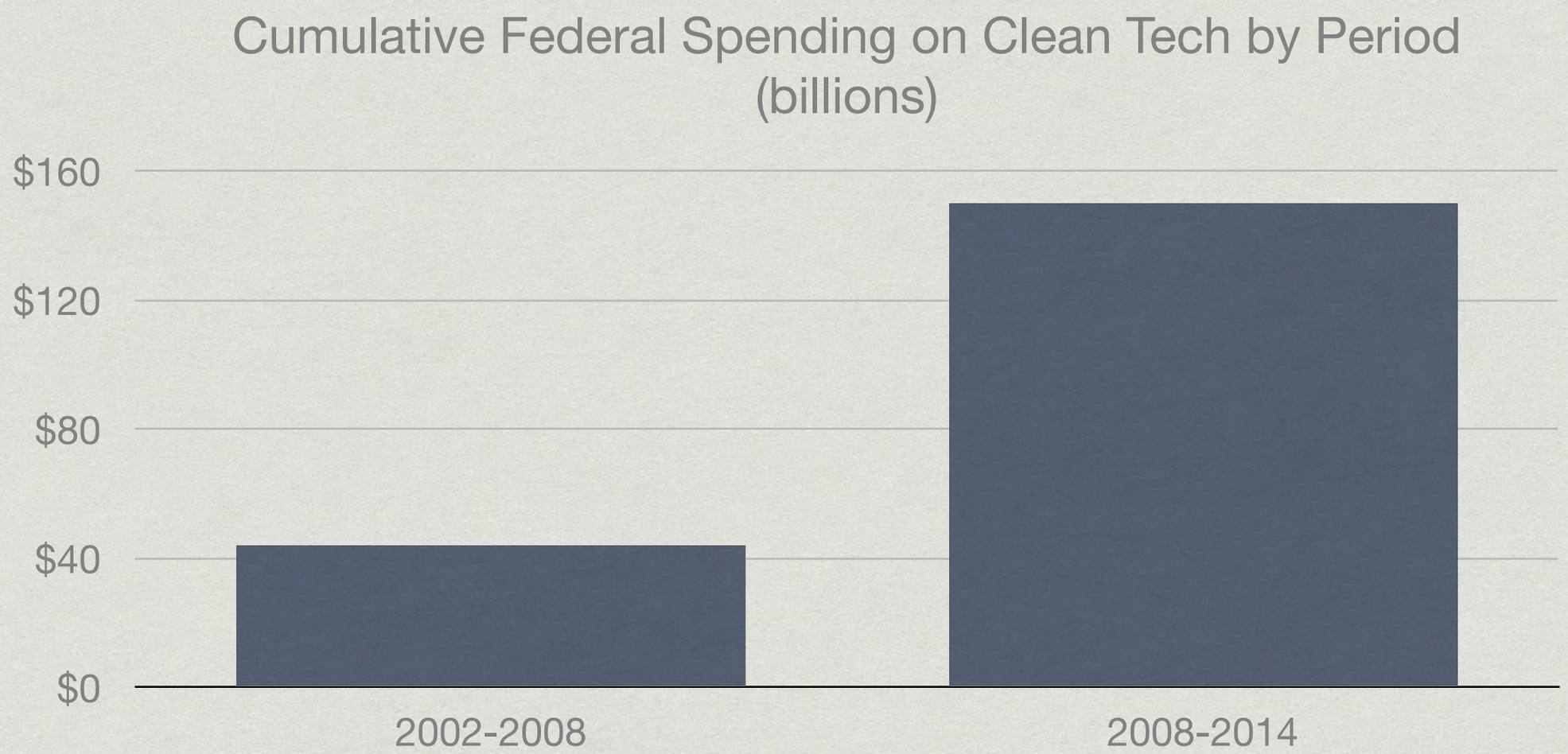
There have been major investments, cost declines, and deployment of solar and wind technologies.



Jenkins et al., Breakthrough Institute, "Beyond Boom and Bust," 2012

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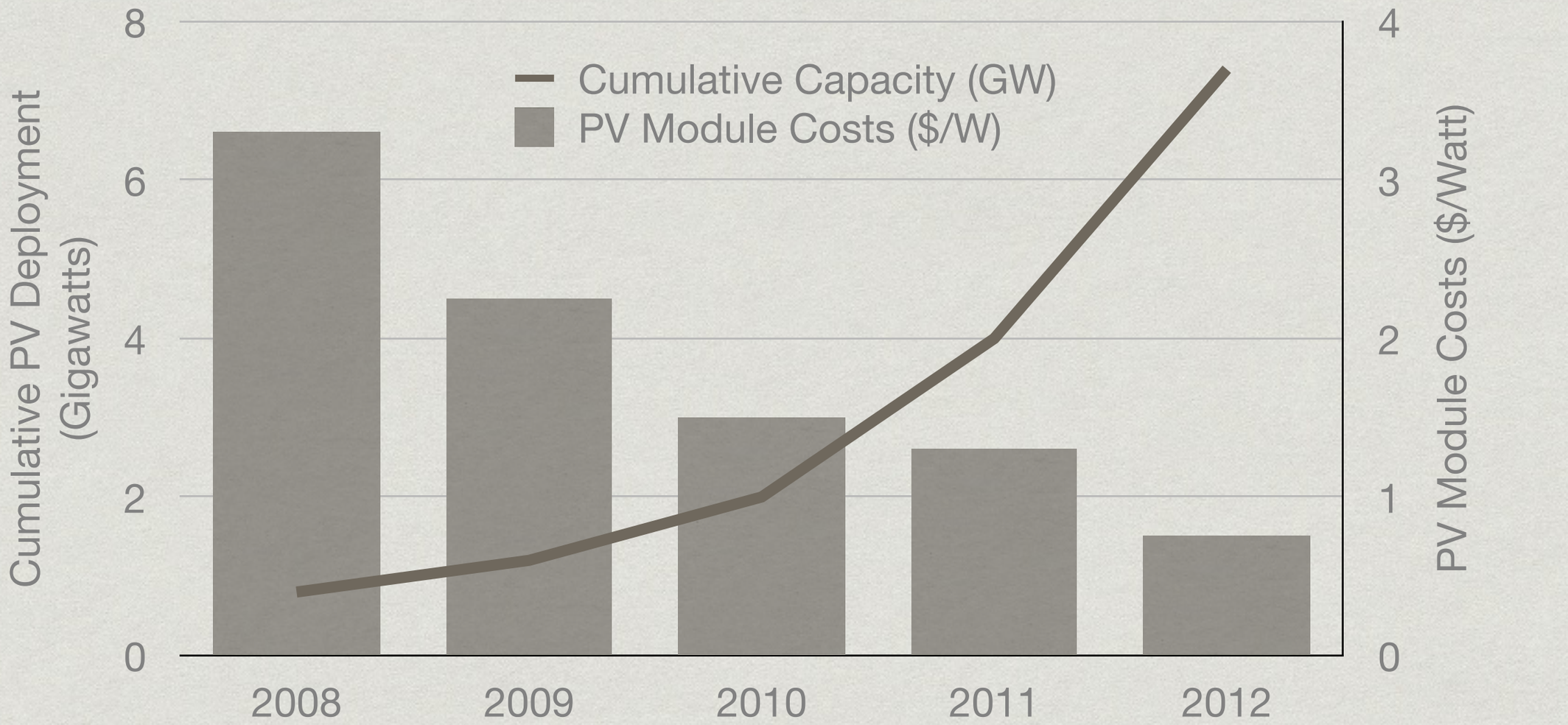
Costs have been declining and production has been growing for solar PV technologies.



Reproduced from: U.S. DOE , "Revolution Now: The Future Arrives for Four Clean Energy Technologies," 2013

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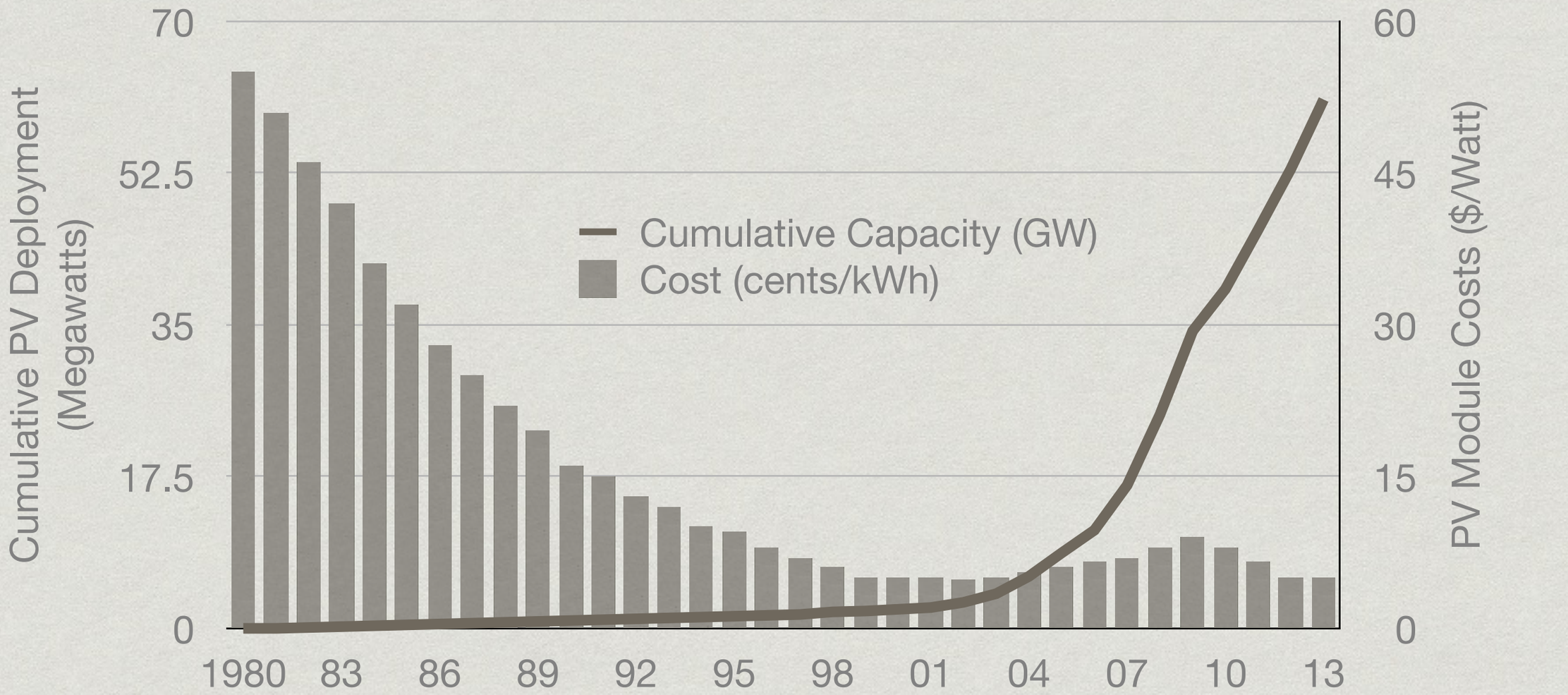
The story has been even more dramatic for wind, with deployment of wind turbines growing rapidly.



Reproduced from: U.S. DOE , "Revolution Now: The Future Arrives for Four Clean Energy Technologies," 2013

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But wind and solar still only provide a small fraction of our electricity supply.

From EIA Database

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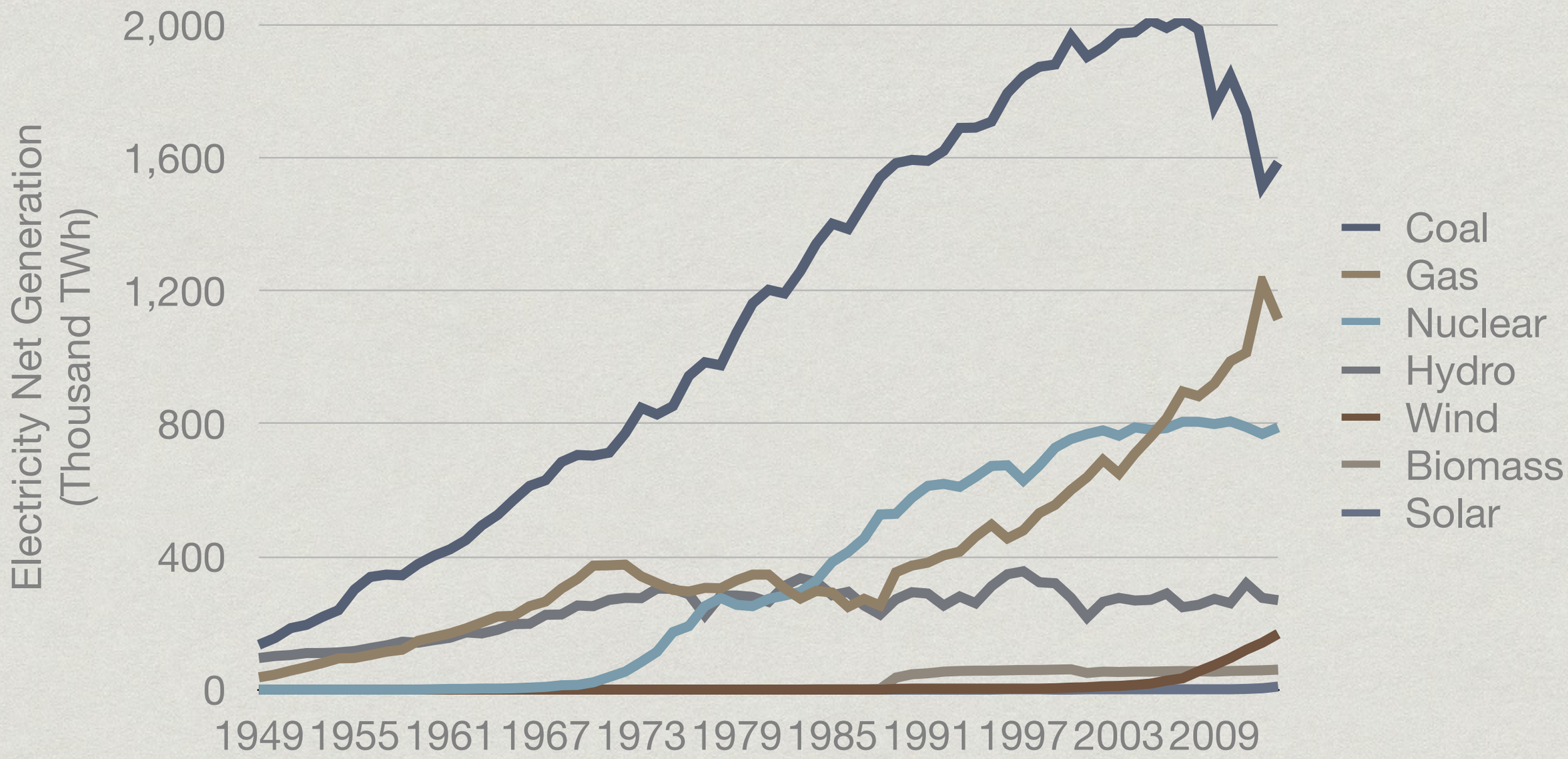
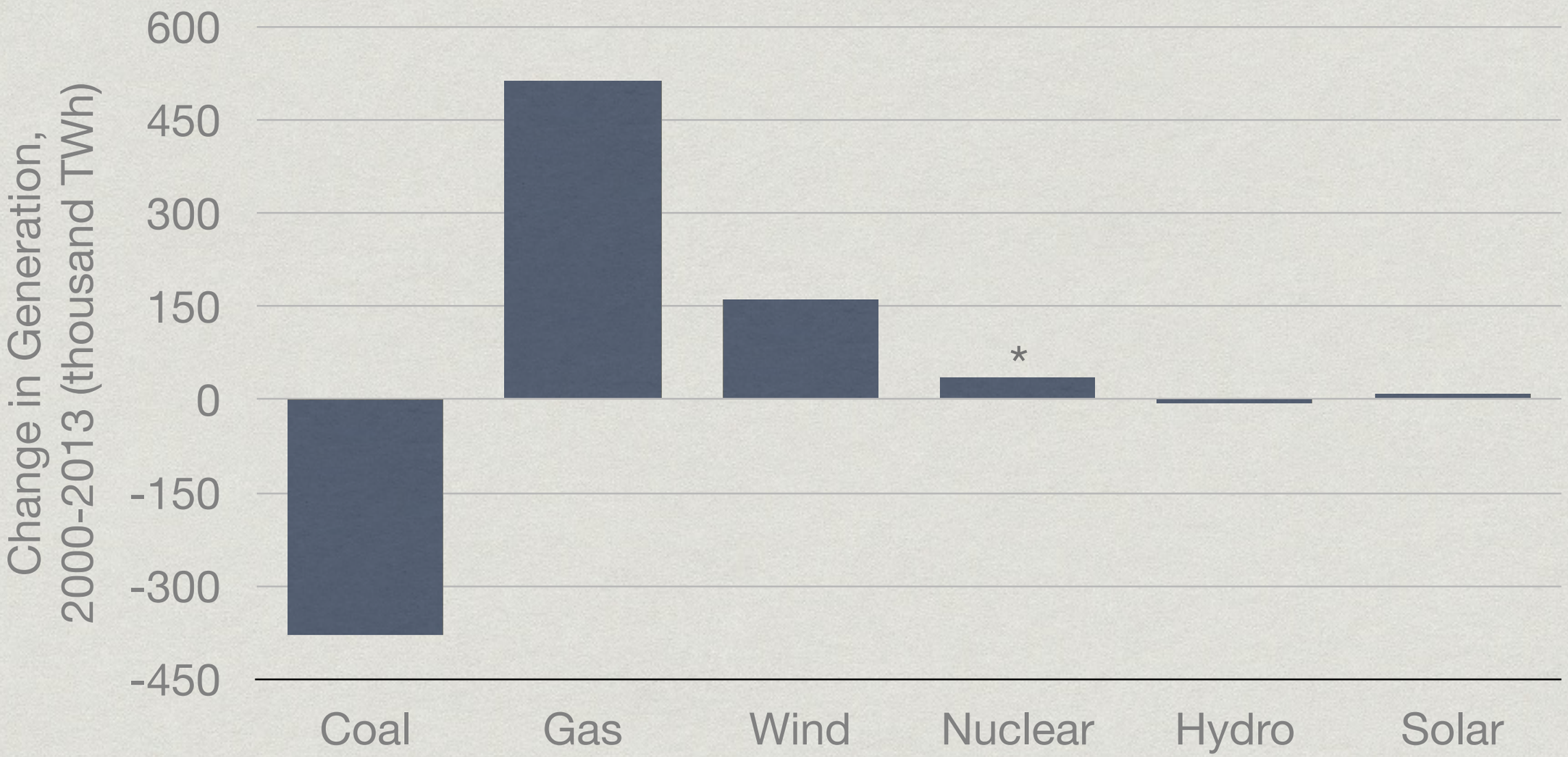
Fortunately, coal use has been on the decline in the US:



From EIA Database

However, that's mostly due to increased use of natural gas…



*Note that nuclear generation increased over this time period even though no new plants were built.

Breakthrough Analysis, Coal Killer, data from EIA database

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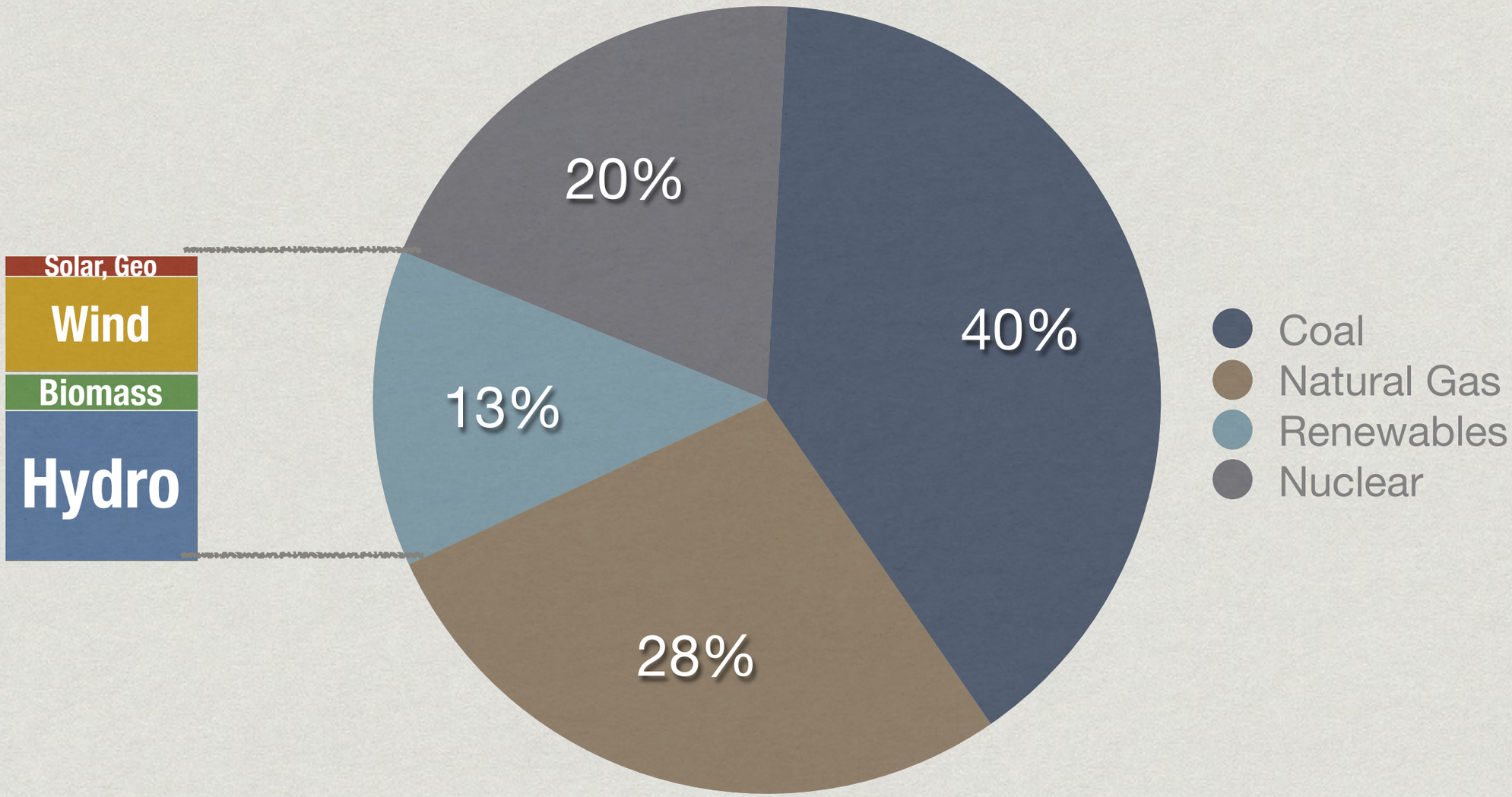
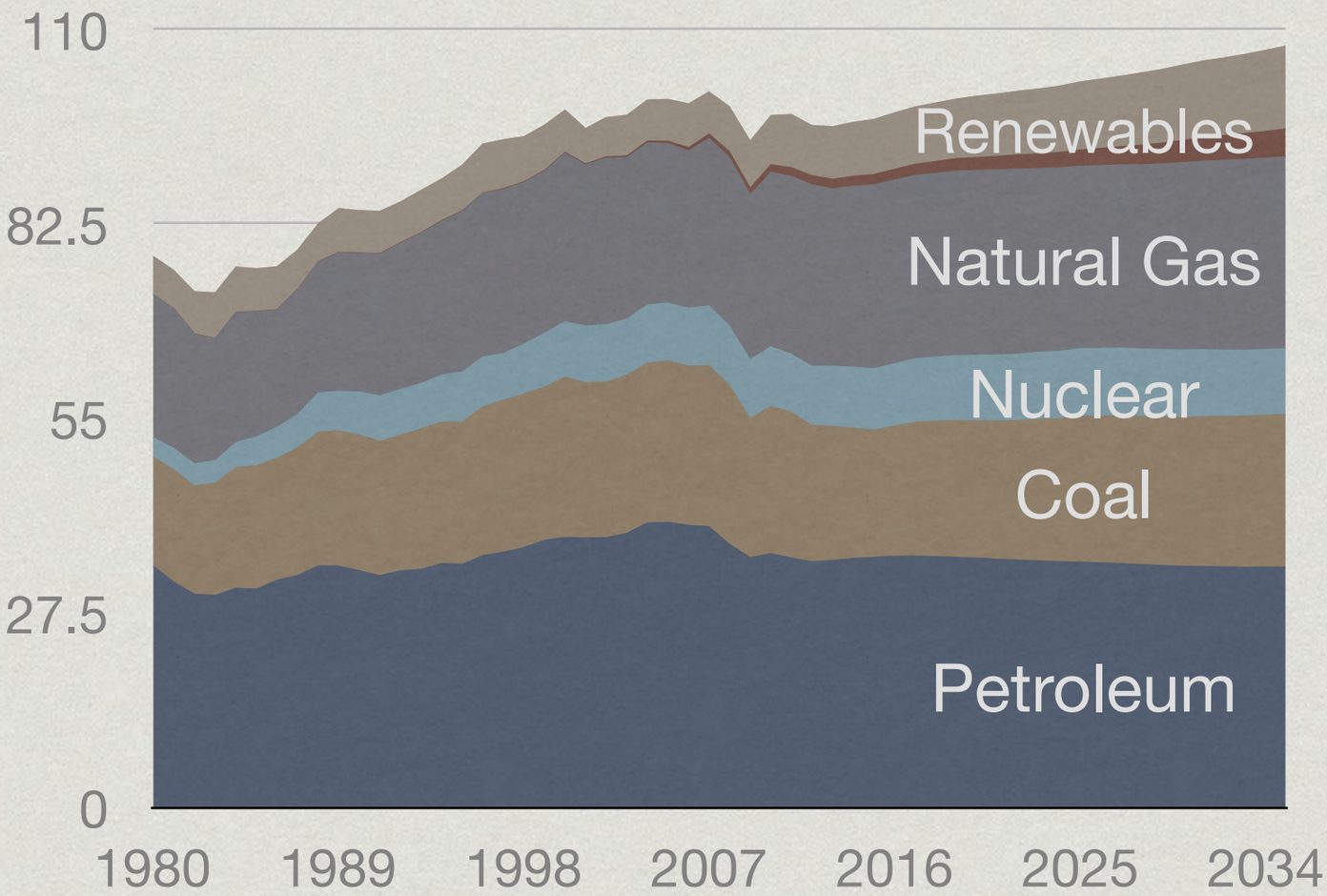
And despite the large growth in wind and solar in the last five years, over 60% of renewable electricity is still conventional hydroelectric and biomass, which many environmental groups oppose.



From EIA Database

And EIA only projects a small growth of renewable energy over the next decade



From now until 2035, EIA projects that renewables will grow from 7%-11% of total primary energy in the US. But that 11% includes hydro and biomass.

From EIA Press Release, 1/24/2012, http://www.eia.gov/todayinenergy/detail.cfm?id=4690

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That's because there are huge barriers to the deployment of renewables that are rarely discussed…

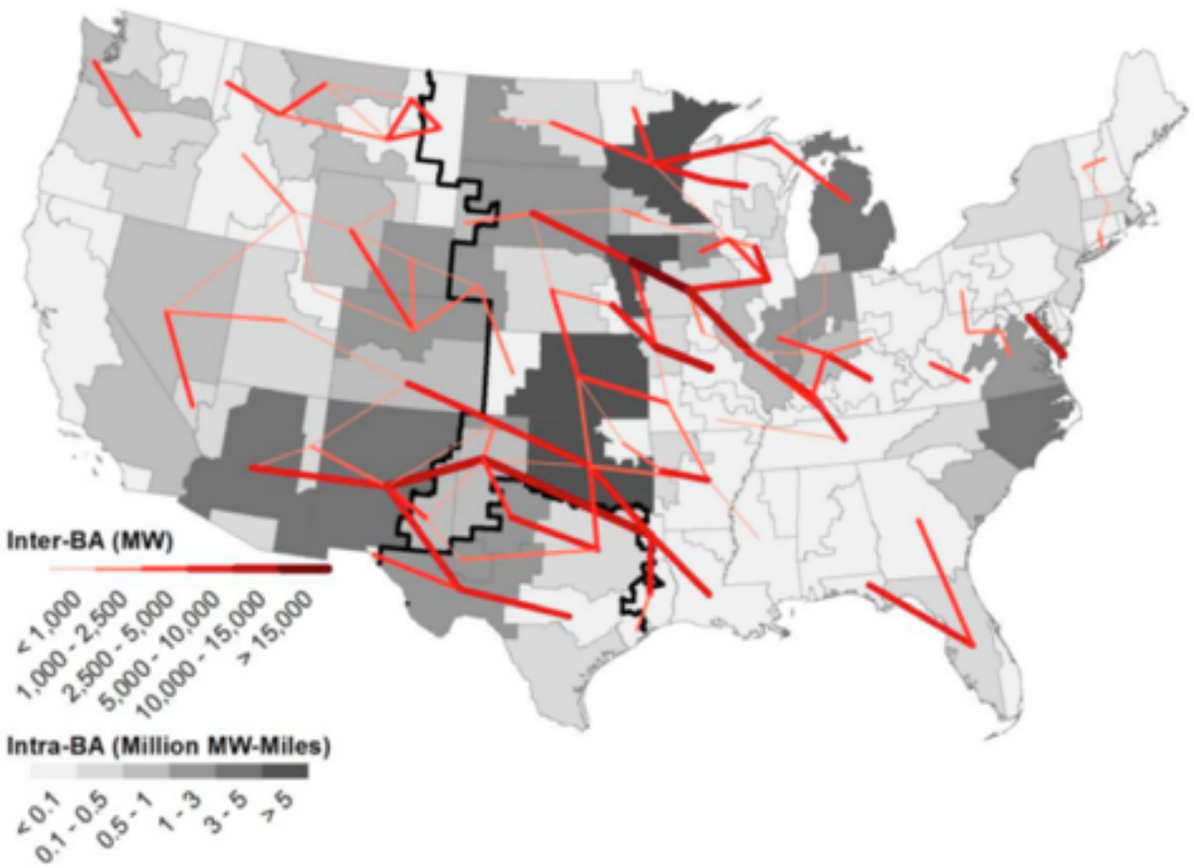

Figure ES-9. New transmission capacity additions and conceptual location in the 80% RE-ITI scenario

As the US National Renewables Energy Laboratory concluded, if renewables were to supply 80% of US electricity, the size of the US transmission network would need to double.

National Renewable Energy Laboratory. (2012). Renewable Electricity Futures Study

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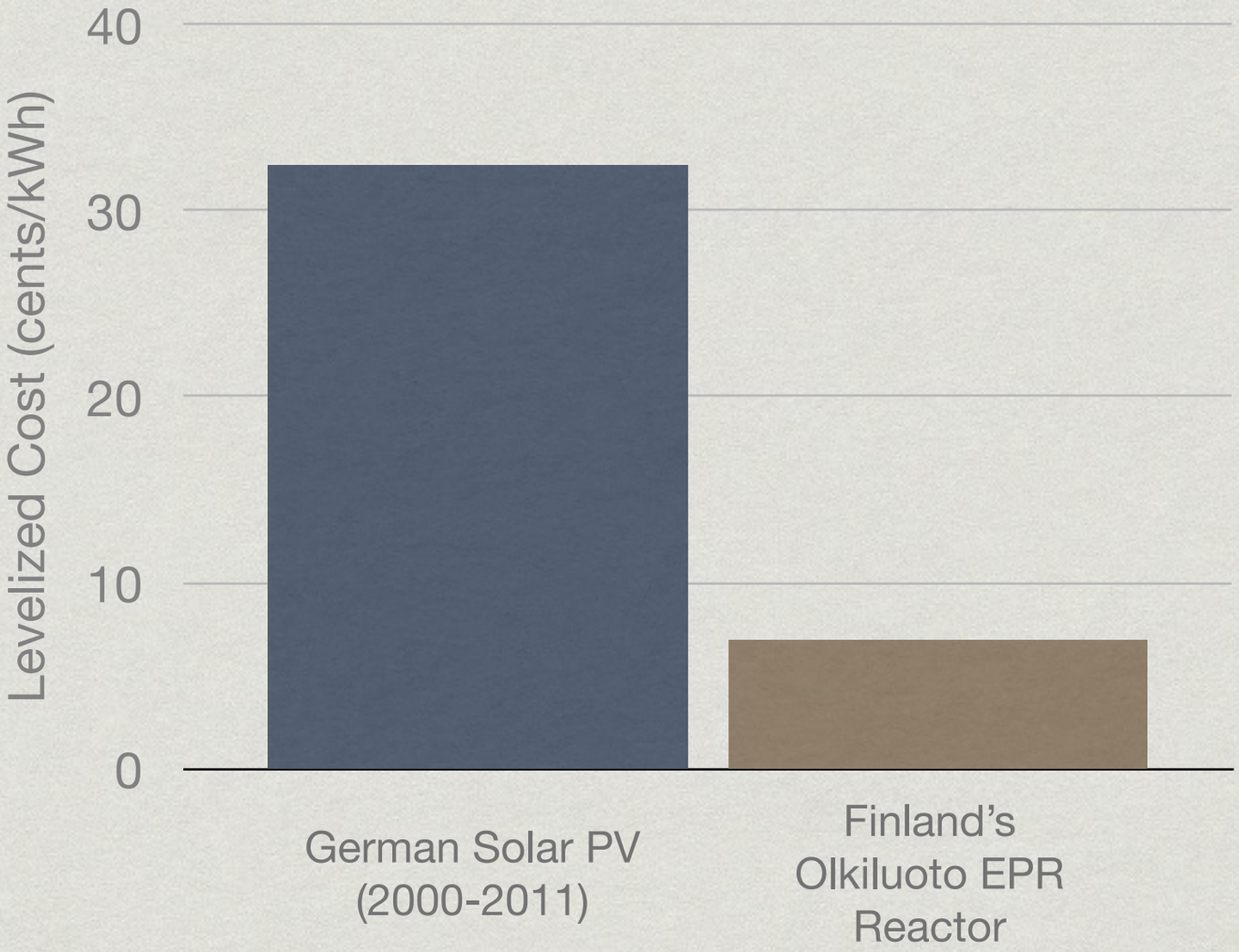
And state subsidies disguise the true costs of renewable deployment. For example, Breakthrough compared the cost of the very successful German solar program with the Finnish Olkiluoto nuclear reactor, which is one of the most expensive and over-budget nuclear power plants to be constructed.



The German solar program is lauded as a great success, while the Finnish EPR is derided as proof that nuclear is doomed. Yet, when looking at the levelized cost to produce electricity, German solar is ***four times*** the price of the over-budget Finnish nuclear plant.

Breakthrough Analysis, "Cost of German Solar Is Four Times Finnish Nuclear," 2013

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Yet many prominent reports proclaim that all -or most- of our energy can be provided by renewables alone…

- **Greenpeace:** World can phase out 80% of fossil fuels and eliminate nuclear power.
- **World Wildlife Fund:** World can be 100% renewable energy by 2050.
- **Jacobson & Delucchi:** World can be 100% wind, water, and solar by 2030. No biomass, no nuclear.
- **Sierra Club:** US can phase out fossil fuels by 2030, start phasing out nuclear after that.
- **National Renewable Energy Laboratory:** 80% of US electricity from renewables in 2050.
- **International Energy Agency:** BLUEMap Scenario, 50% of global energy from renewable in 2050.

Greenpeace, Global Wind Energy Council, & European Renewable Energy Council. (2012). Energy [R]evolution: A Sustainable World Energy Outlook.

Jacobson, M. Z., & Delucchi, M. A. (2011). Providing all global energy with wind, water, and solar power. Energy Policy.

WWF, Ecofys, OMA. (2011). The Energy Report: 100% Renewable Energy by 2050.

National Renewable Energy Laboratory. (2012). Renewable Electricity Futures Study

IEA. (2010). Energy Technologies Perspective: Scenarios & Strategies to 2050.

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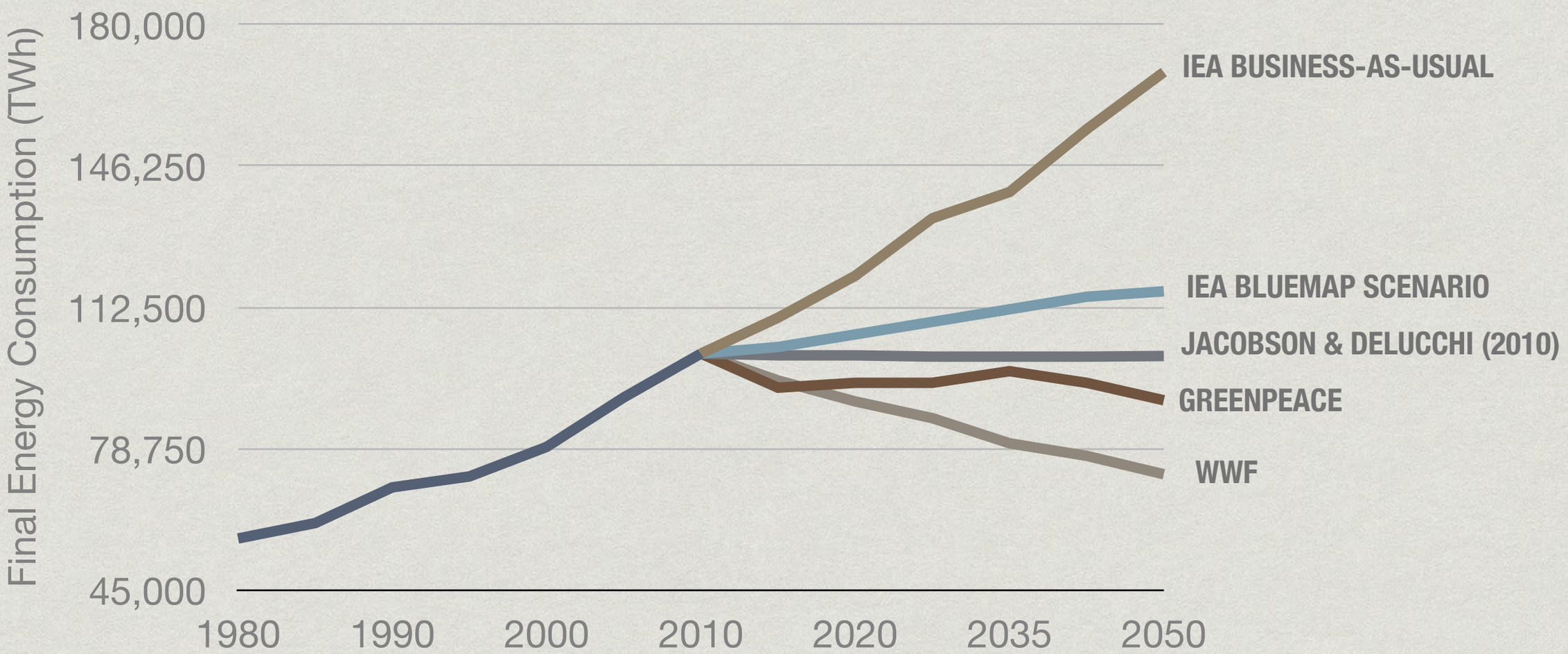
Yet Breakthrough's analysis of these scenarios uncovered a large number of hidden assumptions that didn't get much press. For example, global energy consumption is assumed to decline dramatically in many renewables-heavy scenarios, even as population and GDP grow significantly.



From EIA Database and the referenced reports.

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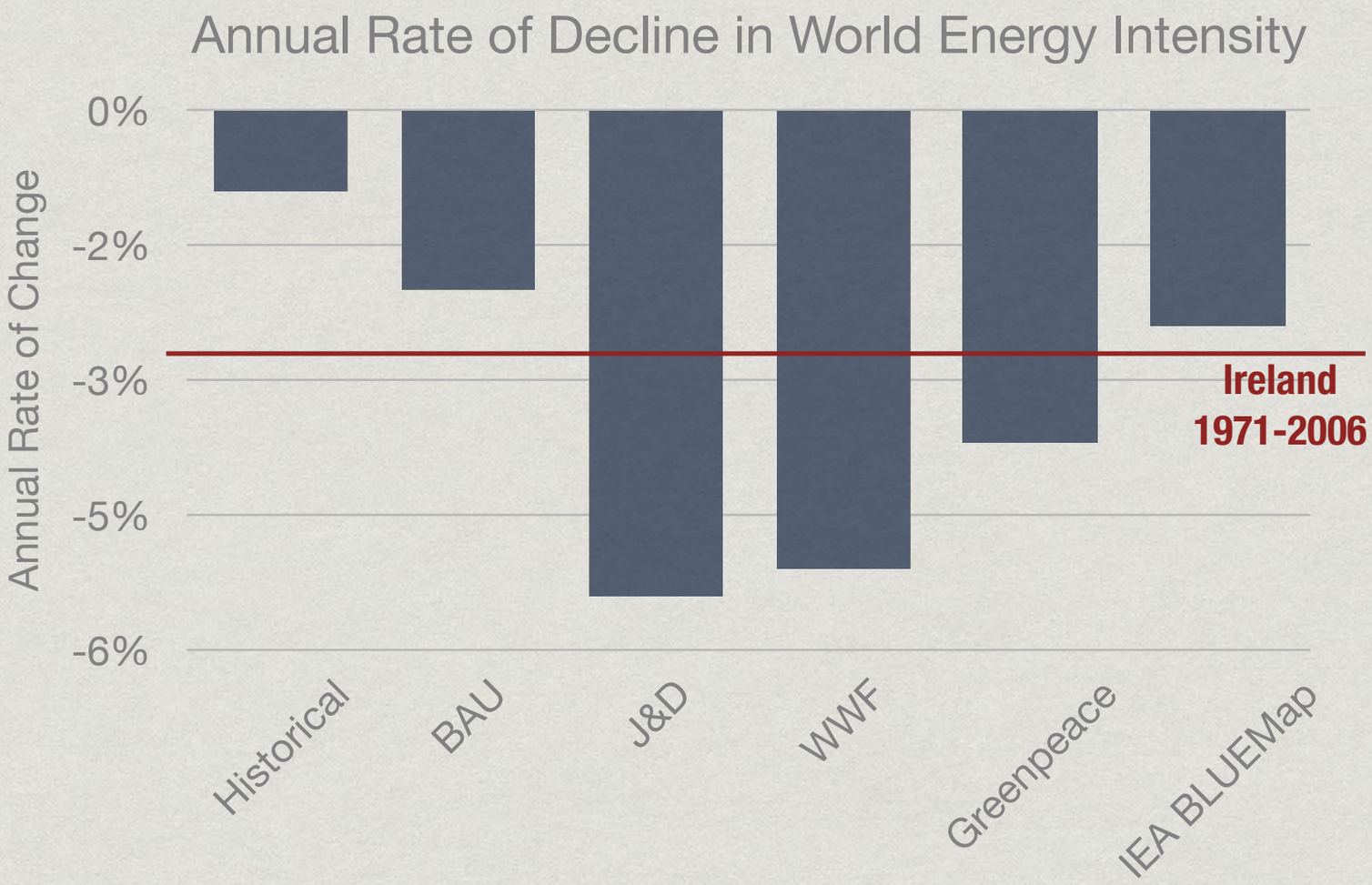
To achieve these stark reductions in global energy use, the renewable-heavy scenarios rely on ahistorical trends in energy intensity improvements (energy per unit of GDP).



Energy intensity declined at 0.9% annually from 1980-2010. Yet, the IEA projects that energy intensity will decline at more than 2% annually for "business-as-usual". And the various scenarios assume even more aggressive declines in energy intensity. For comparison, the country that reduced energy intensity the fastest was Ireland from 1971-2006, at an annual rate of ~2.7%. This was achieved mostly through reducing their domestic manufacturing and building up their information technology sector.

From EIA Database

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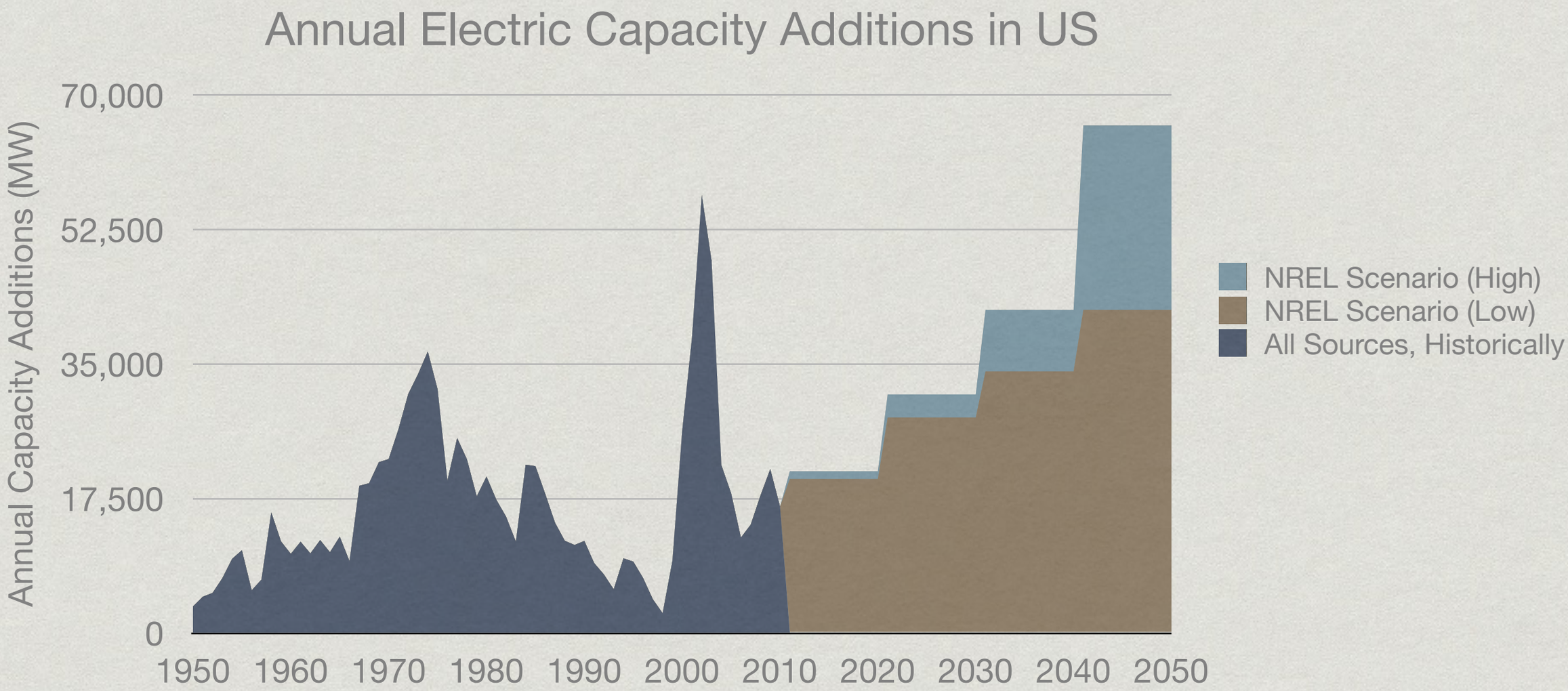
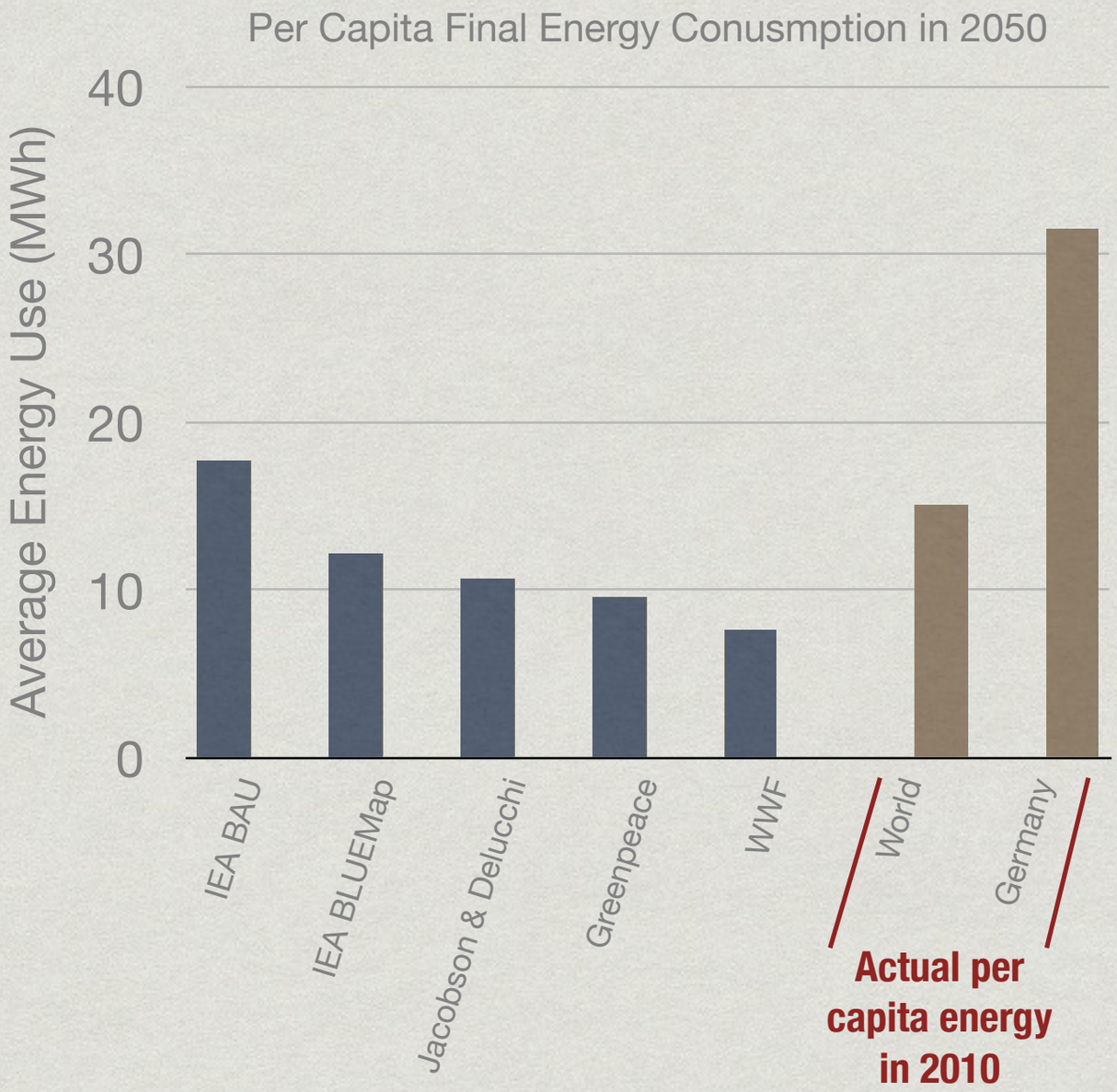
And the amount of capacity additions - how many power plants need to be built every year - is much also faster than historically achieved.



Breakthrough Analysis of EIA data and NREL's Renewable Electricity Futures Study

In addition, absolute energy consumption per capita is expected to drop in these scenarios, which is bad news for the world's poor.



This chart shows the average final energy demand per person as projected in different decarbonization scenarios. Note that all are lower than current global averages, even though one billion people currently lack access to electricity. Thus, these scenarios are assuming a continuation of this energy poverty through 2050.

For comparison, we also show average energy consumption for Germany today, because Germany is considered a very energy efficient, environmentally concerned country.

Breakthrough analysis of various decarbonization scenarios and data from EIA database

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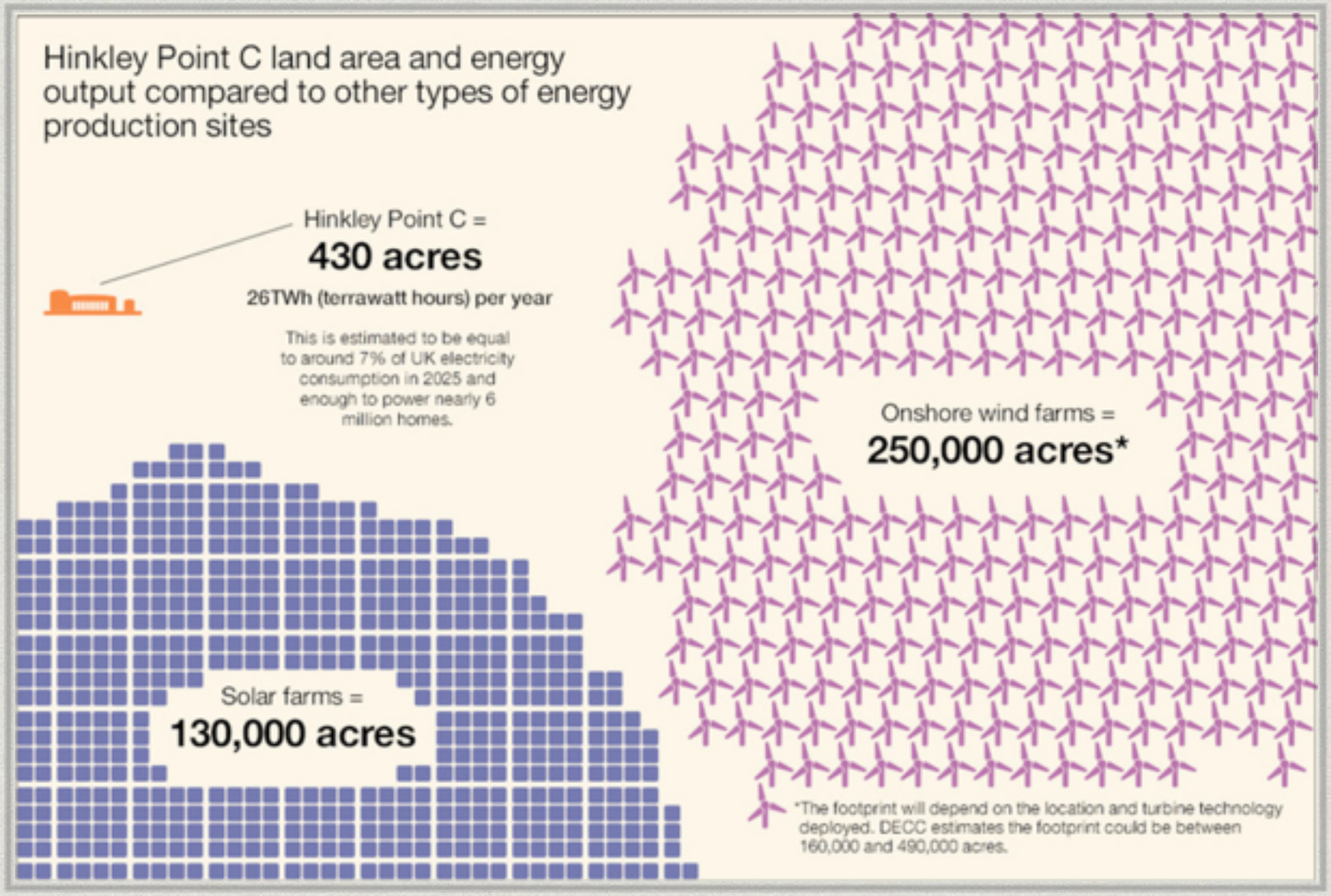
While the climate benefits of renewables are well-known, the environmental ***detriments*** of distributed renewables like wind and solar are rarely publicized.



The UK's Department of Energy and Climate Change made this graphic to show why they were investing in new nuclear power. They immediately had to take it off their website due to complaints from renewables organizations that it was "unhelpful."

From the UK DECC website, on the day the Hinkley Point C nuclear deal was announced.

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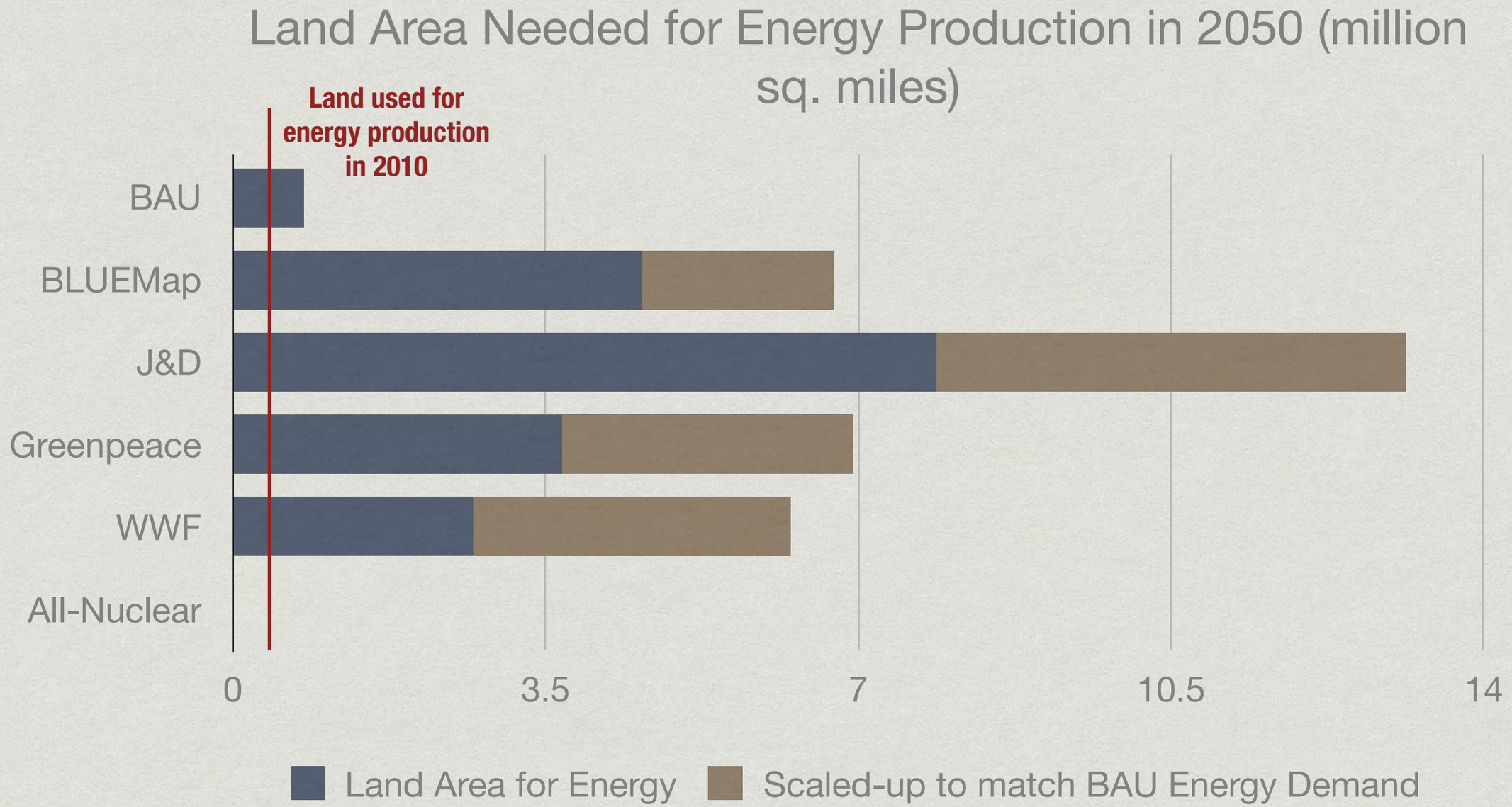
And Breakthrough's analysis of popular renewable scenarios uncovered dramatic land use requirements for renewable energy in 2050.



Breakthrough analysis, data from EIA database and referenced scenarios

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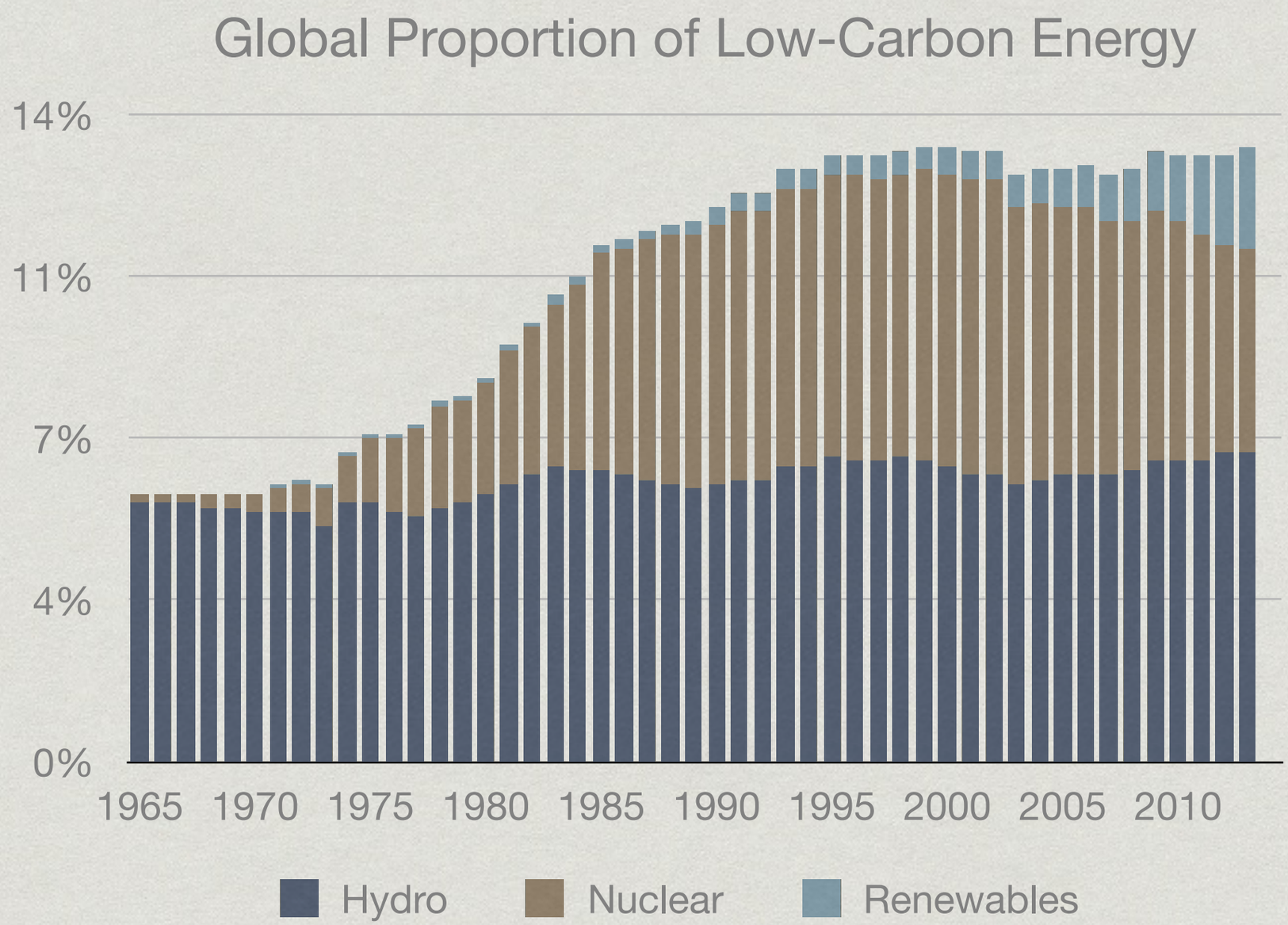
Which explains why global clean energy has been stagnate for decades, we're investing in the most challenging and least-scalable clean energy sources.



Before 1950, almost all low-carbon energy on the globe was from hydroelectric dams. Starting in the 1960s, nuclear power scaled up quickly. But since the mid-90s, clean energy has stalled at ~13% of global energy supply. Renewable deployment cannot keep pace with expanding fossil fuels and nuclear shut-downs.

Inspiration from Roger Pielke Jr., data from BP Statistical Dataset

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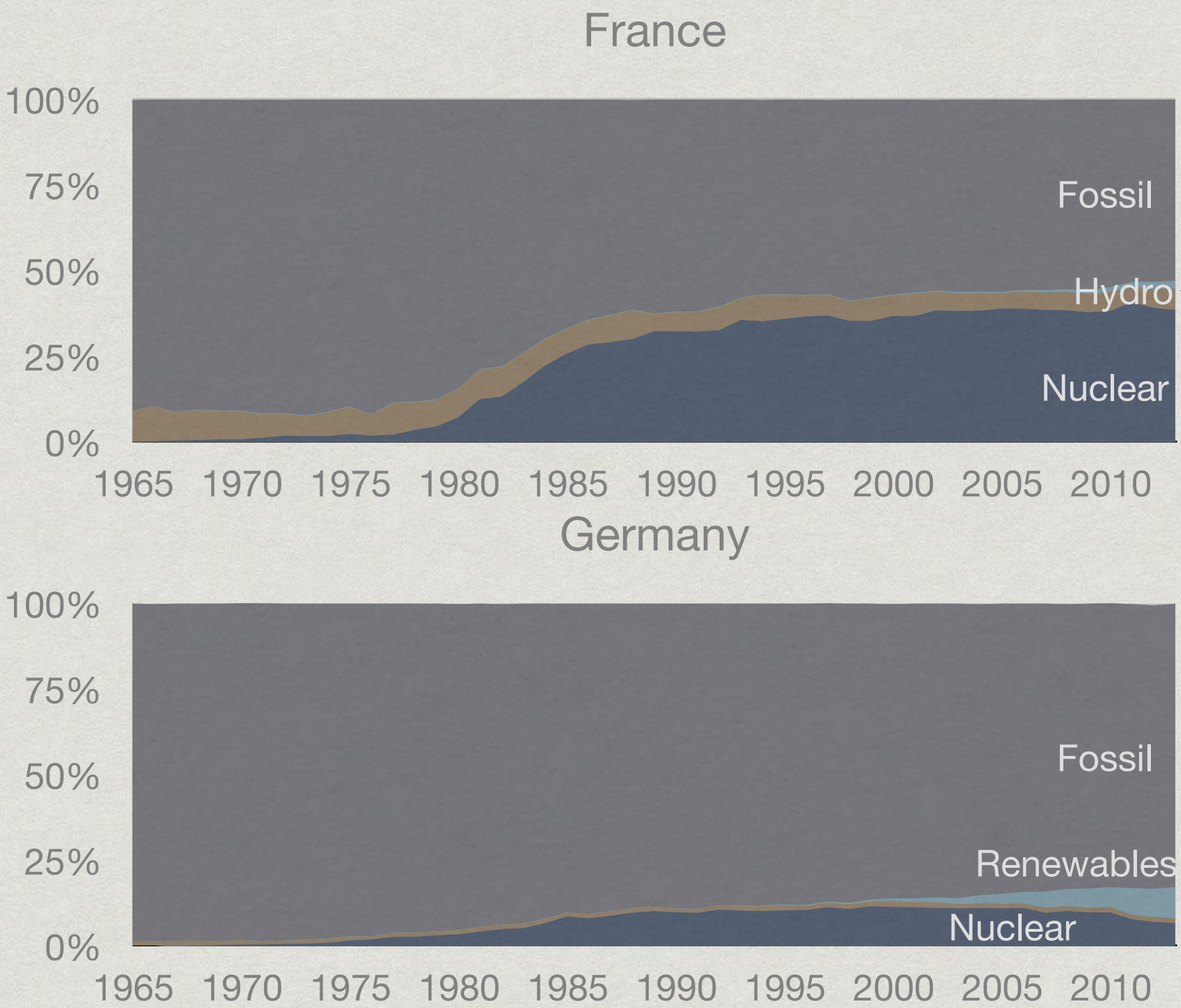
As an example of this effect, look at how these energy transitions differ between nuclear-focused France and renewable-focused Germany:



FRANCE GETS 47% OF ITS ENERGY FROM LOW-CARBON SOURCES IN 2013, MOSTLY FROM NUCLEAR

GERMANY ONLY GETS 17% OF ITS ENERGY FROM LOW-CARBON SOURCES IN 2013, AS RENEWABLES REPLACE NUCLEAR

Breakthrough analysis, data from BP Statistical Dataset

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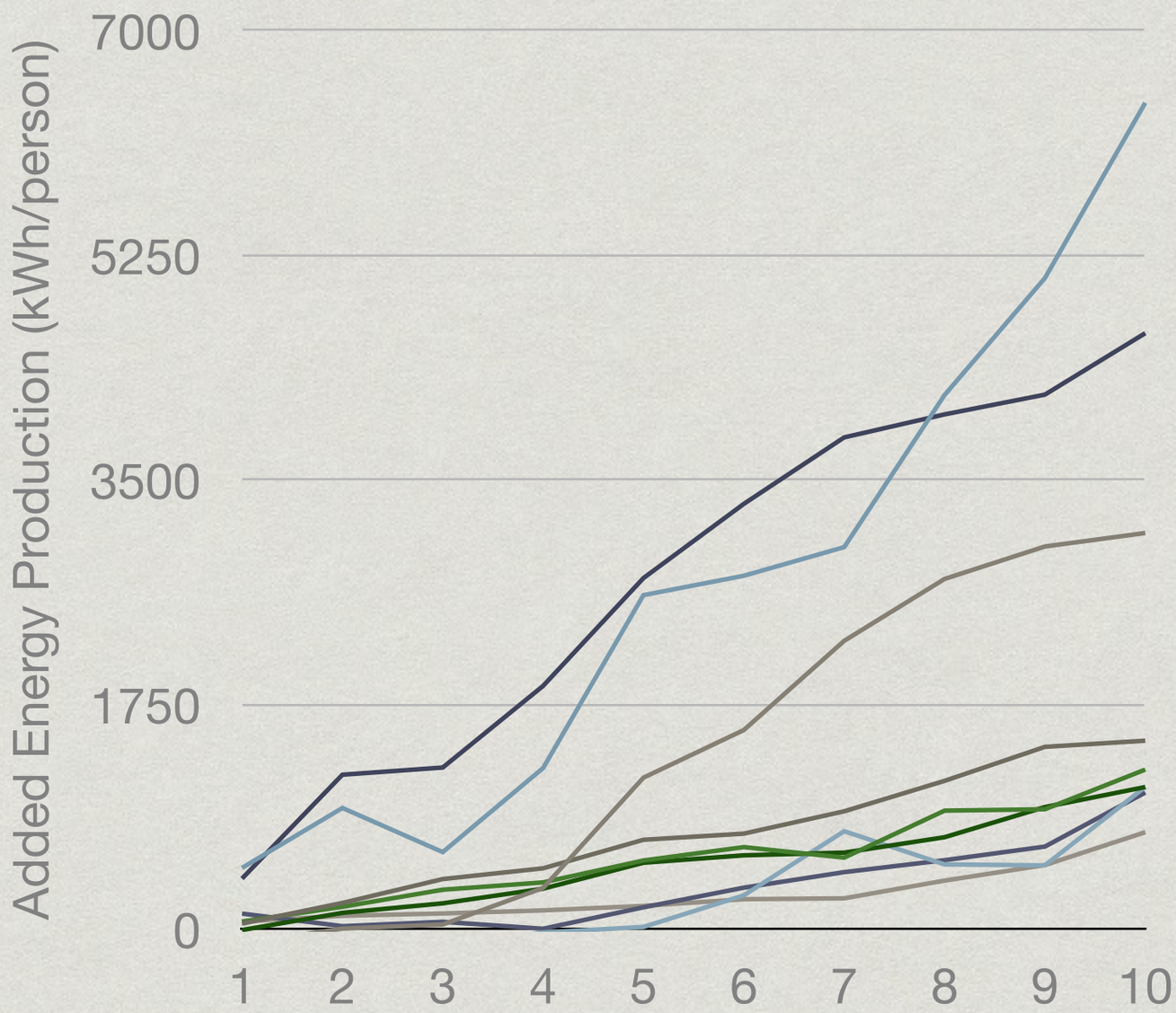
If renewables cannot scale fast enough to address climate change, what can? Just nuclear.



This chart shows how much energy a country can add in a decade per person. Countries that made a big push for nuclear added more than double the amount of clean energy as similar efforts from renewables, even in recent years

Breakthrough Analysis of BP Statistical Dataset

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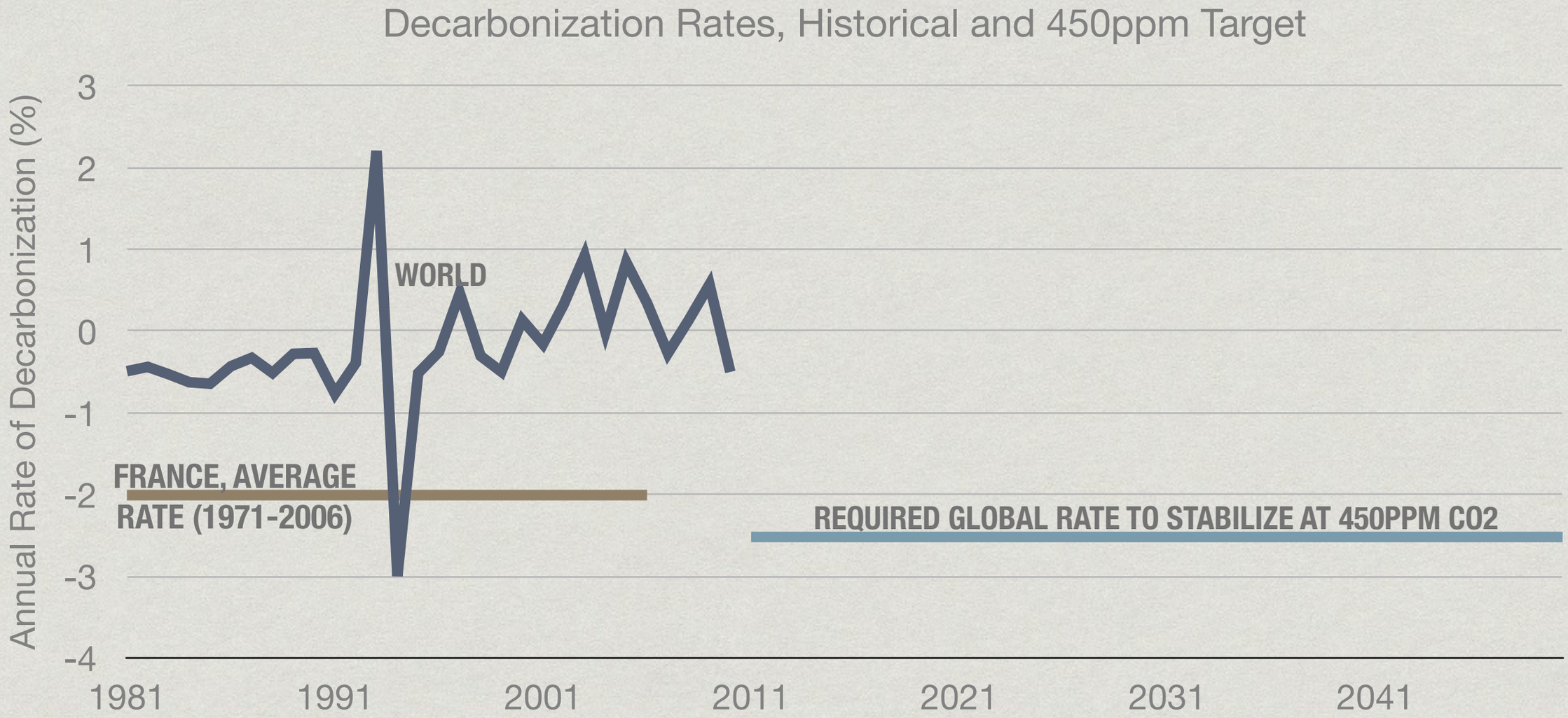
In fact, the only countries that have scaled clean energy fast enough to meet aggressive decarbonization targets -those set to limit global warming to 2 degrees - are those that relied on nuclear power. So, if we're asking what is the best way to tackle climate change, Breakthrough's analysis shows that nuclear power is the clear winner.



Only France has maintained annual decarbonization rates large enough to make a dent in climate mitigation. For the world to meet a climate stabilization target of 450 ppm, every country in the world would need to make a similar push for nuclear power.

Breakthrough Analysis of BP Statistical Dataset