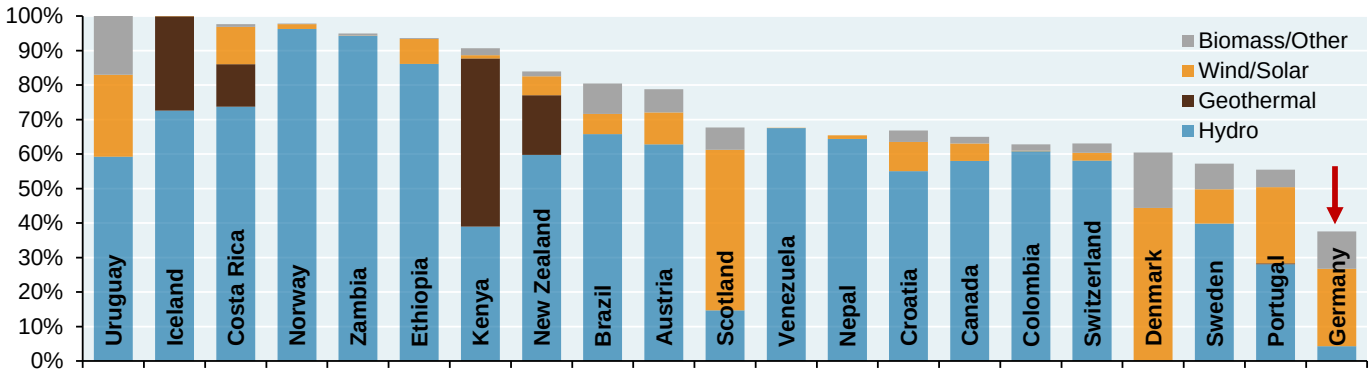
[3] Germany and Energiewende: a dispassionate assessment

If you look for opinions on Germany's Energiewende transition, you'll find articles that cite great success, and other articles like "*Energiewende: A disaster in the making*"[21]. The achievements and limitations of Energiewende are important to understand: Germany is seeking to generate 65% of its electricity from renewable energy without heavily relying on hydropower, as most countries with high shares of renewable power generation do (Denmark and Scotland are exceptions, and have among the highest ratio of coastline to land area in the world).

Countries with high renewable shares of electricity generally rely heavily on hydropower and geothermal energy
Percentage of electricity generation from all renewable sources



Source: IRENA, German Federal Ministry for Economic Affairs and Energy. Based on 2016/2017 electricity generation.

A few ground rules on what *doesn't* matter to me about Energiewende:

- I don't consider strains on German utilities to be a problem unless they lead to blackouts, brownouts or other substantial disruptions to the German economy (which aren't happening so far, see page 19)
- GHG emission comparisons shouldn't be established vs a year like 2009, when a global recession depressed output and associated emissions
- The fact that China's GHG increases could offset annual Energiewende savings in a few weeks is not an indictment of Energiewende per se
- Citing the numbers of birds killed by wind farms should be done in a proper context, as fossil-fueled generation produces its own (broader) set of environmental impacts

Here's what *does* matter to me in assessing Energiewende goals:

- The cost so far, measured by household and corporate electricity prices, subsidies and taxes
- What additional costs will be needed for transmission and/or distributed storage necessary to meet the 65% goal, and whether such costs and land-use requirements are viable politically
- What will Germany's GHG emissions look like once they are based on the new system (wind/solar backed up by coal plants, and without the nuclear power which once provided 30% of generation)

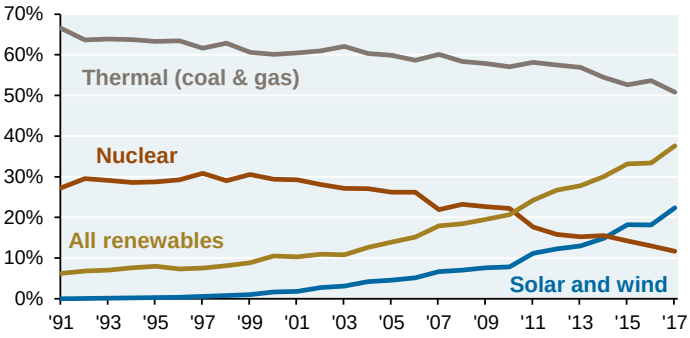
[21] Examples of **downbeat** articles on Energiwende:

- "*Germany's Energiewende: A disaster in the making*", Fritz Vahrenholdt, Global Warming Policy Foundation, 2017
- "*Why aren't renewables decreasing Germany's carbon emissions*", Forbes, October 2017.
- "*Energiewende: A tale of increasing costs and decreasing willingness to pay*", IAEE Energy Forum, 2017.
- "*Germany's Green Energy shift is more Fizzle than Sizzle*", Politico, October 2018.

What has Energiewende accomplished so far?

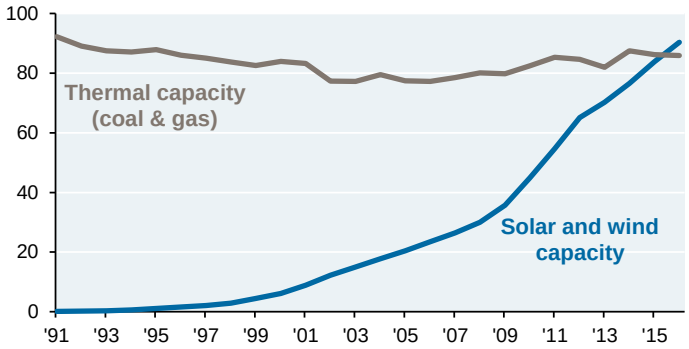
Energiewende's primary impact has been the substitution of solar and wind for thermal and nuclear power generation. When including all forms of renewables, Germany's renewable generation reached 38% in 2017, which is quite an achievement for a country with only a 4% hydropower share.

Renewables and the decline in thermal and nuclear generation, Share of total electricity generation, Germany



Source: German Federal Ministry for Economic Affairs and Energy. 2017.
All renewables includes solar, wind, hydro, biomass and waste.

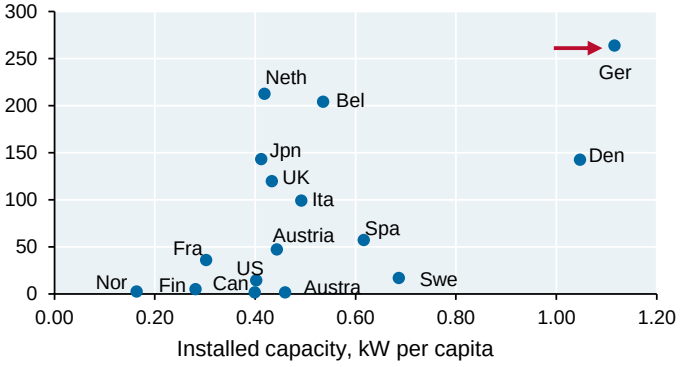
Germany's wind and solar capacity build-out now matches its thermal capacity, with more to come, GW



Source: German Federal Ministry for Economic Affairs and Energy. 2017.

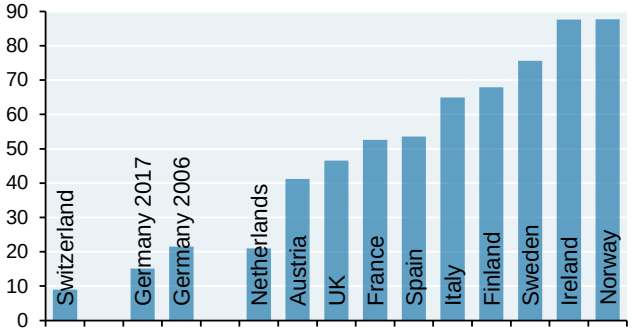
Germany's wind and solar footprint is the largest in the developed world when measured vs population and land area, and this is before Germany shoots for 65% renewable generation by 2030. High wind/solar penetration rates sometimes raise concerns about grid reliability, but so far, this hasn't been a problem. German power outages are actually *down* since 2006, and Germany's 15 minute average annual outage figure for 2017 was practically the lowest in Europe by a wide margin.

Germany has the largest wind/solar footprint
Installed capacity, kW per square km



Source: BP Statistical Review of World Energy. 2018.

Average annual power supply interruption
2016 minutes (including exceptional events)

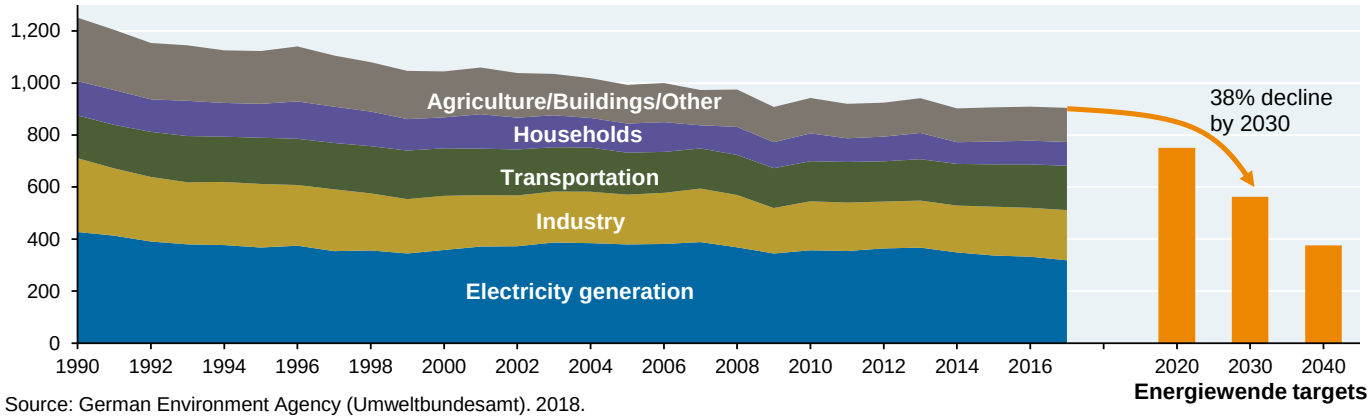


Source: Council of European Energy Regulators Benchmarking Report, 2018. The following countries had interruptions over 100 minutes per year: Bulgaria, Latvia, Greece, Estonia, Croatia, Poland and Romania. According to the EIA, the comparable US figure was 128 minutes.

What about GHG emissions? Progress is slower than Germany was hoping for. The Energiewende goal is a reduction in GHG emissions of 40% vs a 1990 baseline by 2020; the decline plateaued at 28% instead. The primary reasons for the plateau:

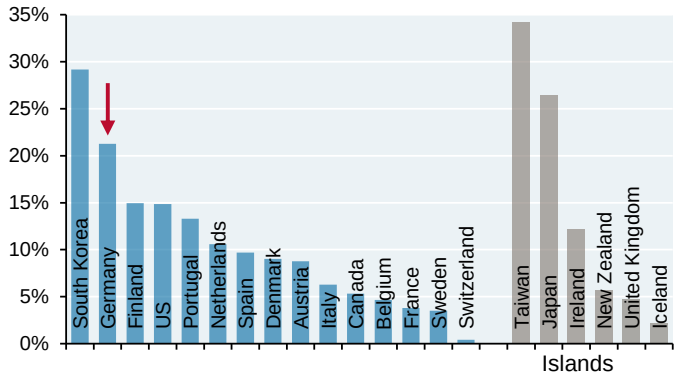
- While solar and wind generation ***capacity*** now matches thermal capacity, solar and wind intermittency result in lower relative amounts of renewable electricity ***generation***
- The renewable share of electricity generation rose from 10% in 2001 to 38% in 2017, but GHG emissions from electricity only declined by 14%. The explanation: during the same period, the **nuclear** share of generation dropped by 17%, slowing the decline in reliance on coal. Germany still has one of the highest coal shares of primary energy of all developed non-island nations, and its decline will continue to be gradual if Germany's last 7 nuclear plants are de-commissioned as planned by 2022
- There was a large GHG decline following the **collapse of East Germany's** inefficient power and industrial sectors; this process was mostly played out by the year 2000
- **Electricity generation is only 40% of total primary energy use in Germany**. Transportation emissions are roughly unchanged since 1990, as increased kilometers traveled offset improvements in vehicle efficiency, and since electric vehicles were only 1.5% of total German car registrations in 2017. Industrial and agricultural GHG emissions are also roughly unchanged since 2000.
- Germany considered a levy on coal plants emitting more than a certain amount of CO_2, but backtracked after union and utility protests. Further GHG reductions may have to come from incentives for industry to invest in more efficient machinery (uncertain benefits and timing)

German GHG emissions decline has stalled since 2008
GHG emissions by sector, million tonnes of carbon dioxide equivalents



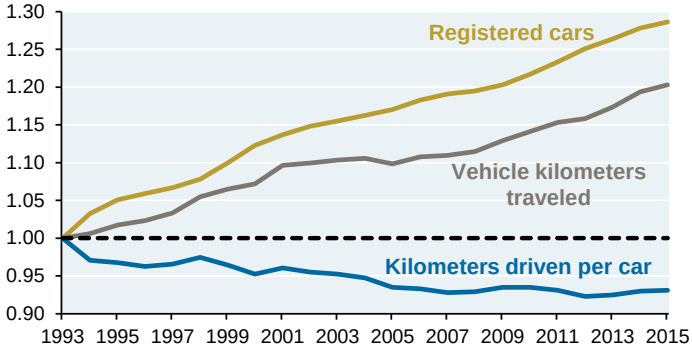
Source: German Environment Agency (Umweltbundesamt). 2018.

Coal as % of primary energy in developed economies



Source: BP Statistical Review of World Energy. 2018.

Germany: more cars offset benefits from more efficient engines and more efficient use; Index, 1993 = 1.0

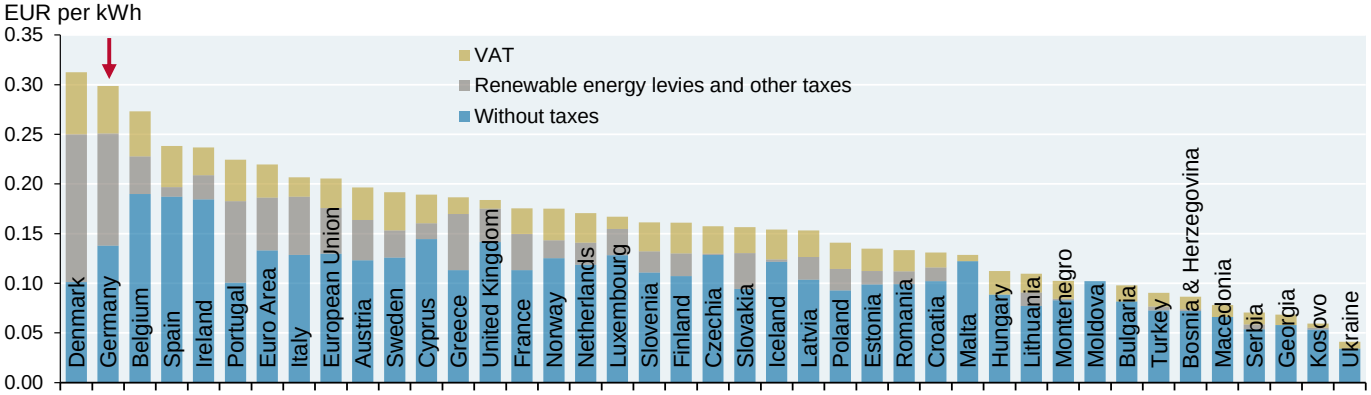


Source: German Aerospace Center Instititue of Transport Research. 2017.

The biggest Energiewende question relates to costs incurred so far, costs that still remain (due to transmission infrastructure and substitutes for nuclear power), and the political willpower needed to finance them. German household electricity costs are among the highest in Europe, and this is *before* additional transmission, nuclear substitution and higher renewable penetration costs are incurred. German household incomes are similar to France, Ireland and the UK, in which case higher German electricity prices are also higher in relative terms. However, Italian and Spanish household incomes are lower, so their real burdens are closer to Germany than they appear in the chart.

Electricity prices for household consumers

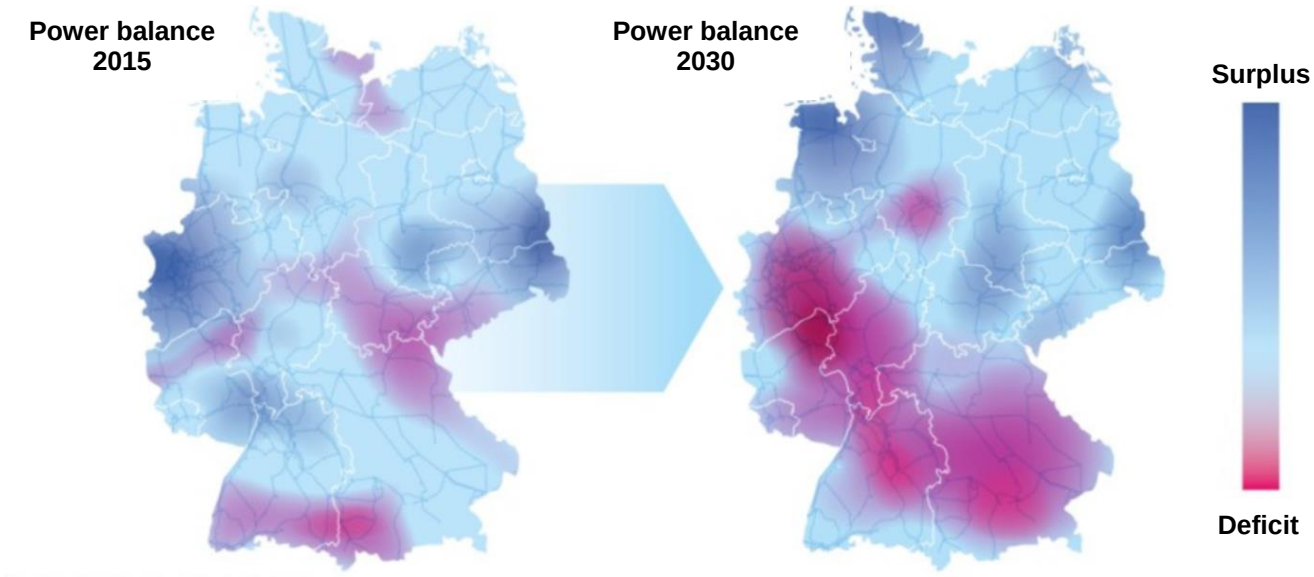
EUR per kWh



Source: Eurostat, Q2 2018.

Here's a visual of the **supply-demand gap** today, and the one that may exist in 2030. The growing purple supply deficit reflects the expected gap between wind supply in the North and energy demand from population centers in the South.

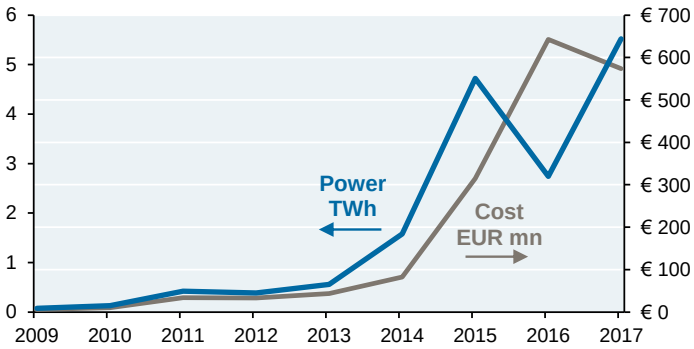
German regional power deficits expected to rise by 2030



Source: Ampriron GmbH. 2015.

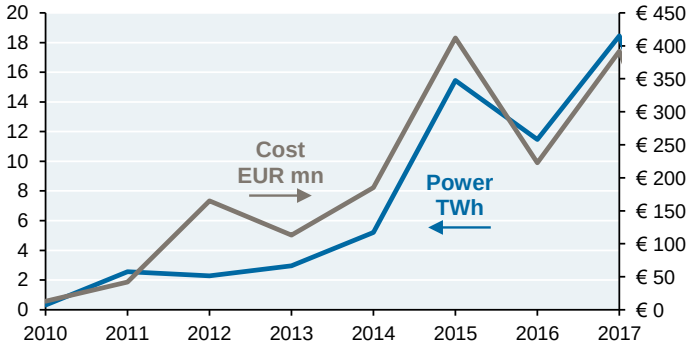
The current supply-demand gap has already resulted in a rise in **discarded renewable production** (which results in feed-in tariff payments to wind producers to compensate them anyway), and in "**redispatch costs**" required to compensate Southern power producers to generate electricity at times of low electricity prices. According to the German Federal Network Agency, annual tariff and redispatch costs due to grid stabilization efforts could rise to EUR 1 billion by 2020, and that's before nuclear plants are shut down, and before increased EV penetration in Germany[22].

Discarded renewable production for which German wind and solar producers are still paid



Source: Bundesnetzagentur Monitoring Reports. 2017.

Redispatches: grid shortages which require extra payments to above-market producers



Source: BDEW, Bundesnetzagentur Monitoring Reports. 2017.

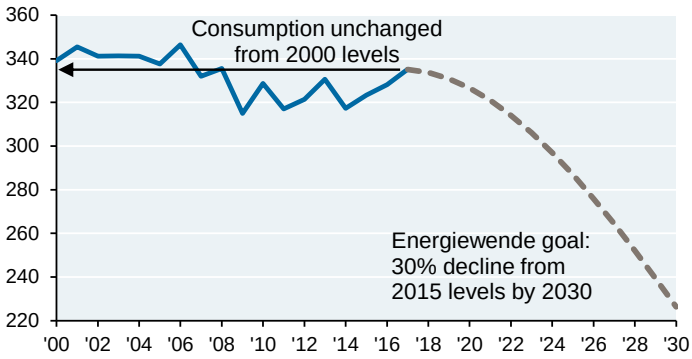
German grid imbalances are not just a problem for Germany. German grid congestion is already putting pressure on Eastern European grids through unwanted power surges and blockages at the border. New cross-border connections to Belgium and Scandinavia may reduce some of these pressures.

To reduce curtailed renewable generation and re-dispatch costs, Germany will need to upgrade its transmission infrastructure. This includes upgrades to large transmission lines, and also to the low and medium voltage distribution grid that incorporates storage capacity and electric cars. The latest estimates we have seen: a need for 4,650 km of transmission lines by 2025, **only 900 km of which have been built so far**. As in the US, this process has been bogged down by citizen protests affected by transmission line construction, as well as by German states (e.g., Thuringia) that are suing in an effort to have them relocated to neighboring states. Burying cables underground might reduce the political disputes, but at a substantial increase in cost. More wind turbines could be built in the South, but so far, this has been met with a lot of political resistance.

[22] If 30% of Germans bought EVs and plugged them in to recharge when they get home from work, consultancy Oliver Wyman estimates that Germany's electricity grid could collapse. Much greater grid management planning would be needed for EVs to function as electricity storage devices in connection with surplus renewable generation.

Energiewende's goals are much broader than the electricity grid. One key objective is a 30% decline in primary energy use from 2015 to 2030. The challenge, as illustrated in the first chart: German primary energy use is basically **unchanged** since the year 2000, casting considerable doubt on this 2030 goal. German energy *efficiency* has improved (along with other developed nations), but overall energy use has been roughly constant.

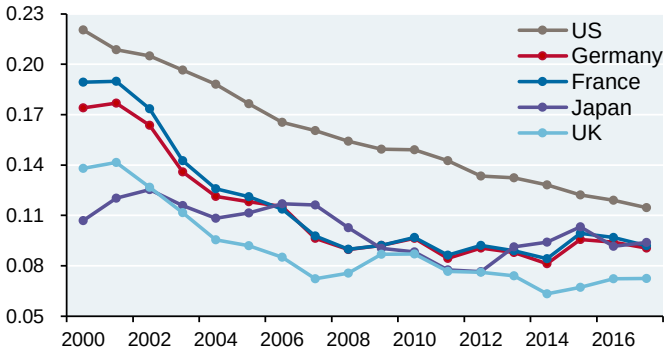
Germany primary energy consumption, Mtoe



Source: BP Statistical Review of World Energy, JPMAM. 2018. Dotted line indicates pathway needed to reach 30% primary energy decline goal.

Energy intensity

Mtoe of primary energy per unit of nominal GDP



Source: BP Statistical Review of World Energy, Haver, JPMAM. 2018.

In the latest self-assessment of Energiewende by the Federal Government's Expert Commission, the **lack of progress outside power generation is readily acknowledged**. The assessment assigned the lowest grades ("unlikely to meet 2020 target") to transportation energy use, changes in the fuel mix, expansion of transmission grids and overall primary energy use.

So, here's the bottom line on Energiewende:

- Can Germany reach 65% renewable power generation by 2030? Sure, but it may require considerable further increases in electricity prices and other economic costs[23], **and** increased political will to build the transmission infrastructure necessary to get there. As a reminder, 80% of the necessary transmission infrastructure is still on the drawing board
- Will Germany be able to cut GHG emissions in half by 2040, which relies in part on a 30% decline in primary energy use? Highly unlikely, given the very slow pace of de-carbonization apart from the electricity grid, and the extent to which greater *demand* for energy offsets improvements in energy intensity, improved gas mileage in cars/planes, more energy efficient devices/machinery/buildings, etc
- Germany's newly announced goal of phasing out all coal/lignite by 2038 seems completely unrealistic given all the issues explained above

[23] German regulators may consider 35 cents/kWh as a resistance point for households in terms of what they would be willing to pay for electricity, particularly since energy taxes are regressive by nature. If so, Germany may have to increase electricity prices on its **industrial users instead**, whose prices are also close to the highest in the industrialized world at 12.5 to 15.5 cents per kWh. While nuclear decommissioning costs may not show up in electricity prices directly, they are also a large cost borne someplace in the energy ecosystem.

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