

A Tale of Two Countries: Renewable Energy in Germany¹

It Was the Best of Times

[\[I\]n 2011](#) the German economy grew three percent and remained Europe's strongest, buoyed by a world-class renewables industry with 382,000 jobs (about 222,000 of them added since 2004, with net employment and net stimulus [both positive](#)). Chancellor Merkel won her bet that it would be smarter to spend energy money on German engineers, manufacturers, and installers than to send it to the Russian natural gas behemoth Gazprom. Germany's lights stayed on. The nuclear shutdown was *entirely displaced by year-end*, three-fifths due to renewable growth.

Do the math: simply repeating 2011's renewable installations for three additional years, through 2014, would thus displace Germany's *entire* pre-Fukushima nuclear output. Meanwhile, efficiency gains—plus a mild winter—cut total German energy use by 5.3%, electricity consumption by 1.4%, and carbon emissions by 2.8%. Wholesale electricity prices fell 10–15%. Germany remained a net exporter of electricity, and during a February 2012 cold snap, even exported nearly 3 GW to power-starved France, which [remains a net importer](#) of German electricity.² —Amory B. Lovins

It was the Worst of Times

“Businessmen say the *Energiewende* will kill German industry. Power experts worry about blackouts. Voters are furious about ever higher fuel bills. The chaos undermines Germany's claim to efficiency, threatens its vaunted competitiveness and unnecessarily burdens households. It also demonstrates Germany's curious refusal to think about Europe strategically.”³ --*The Economist*

Well, which is it? Is Germany's commitment to renewable energy leadership in building a new economy, or is it fiscal folly? Will it undermine German industry, or make it more competitive? Is the nuclear phase-out an invitation to make Germany more dependent on Russian gas, and to increase CO₂ emissions from coal? This paper takes a fresh look at the energy transformation in Germany, without predisposition, and argues there are lessons for Germany and for other countries in their remarkable commitments to decarbonize the electric sector.⁴

¹ By Hal Harvey, Energy Innovation LLC. www.energyinnovation.org hal@energyinnovation.org

² Amory B. Lovins, Rocky Mountain Institute, http://blog.rmi.org/blog_2013_04_17_germanys_renewables_revolution

³ <http://www.economist.com/news/special-report/21579149-germanys-energiewende-bodes-ill-countrys-european-leadership-tilting-windmills>

⁴ For a rich collection of analyses on Germany's *Energiewende*, see <http://energyinnovation.org/library/germany/>

What is the *Energiewende*?

Energiewende means energy transformation. It means different things to different people, but at its core is the German government’s policy to reduce CO₂ emissions by 80% by 2050. Woven into that environmental goal is a separate decision by the government, with 85% parliamentary support including strong majorities from all political parties, to phase out nuclear power. This is not, as some posit, a plan to replace nuclear with renewables: It is a plan to decarbonize the economy with a parallel requirement that nuclear must be phased out in the next decade. That is an important distinction, as will be discussed.⁵

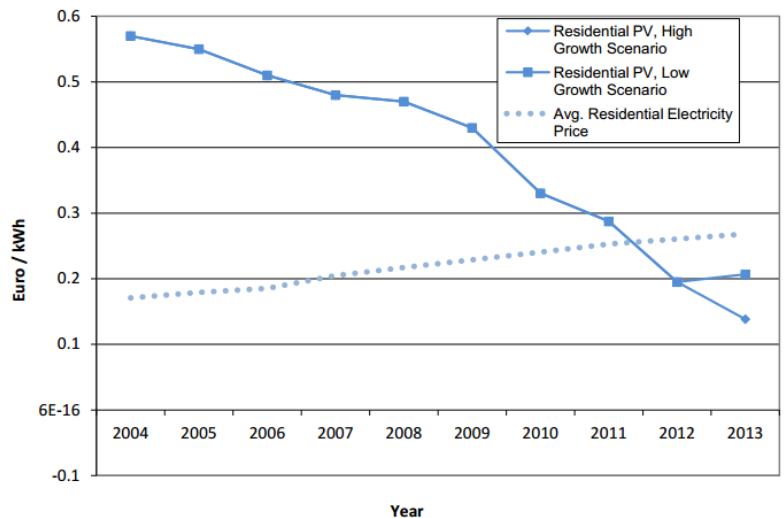
It is no small challenge to decarbonize the fourth largest economy in the world. Renewable energy has considerable obstacles: Wind and solar are highly intermittent, and, until recently, have cost far more than conventional power. Gas is a dangerous bridge fuel, because although it is less carbon-intensive when burned than coal, it makes Germany dependent on Russia for gas supplies, and that is strategically risky. Biomass, geothermal, and hydro are limited by geography and ecosystems. So meeting the goals of the *Energiewende* requires driving down the price of solar and wind, and that in turn requires rethinking the Germany power system—both its engineering and its market structure. And because electricity is central to every aspect of the economy, the transition must be done in an economically intelligent way.

What has happened so far?

12 years ago, Germany got 7% of its electricity from renewable energy—mostly from older hydro plants. Today, the country gets 24% of its electricity from renewable sources, mostly from wind and solar. That very big step was driven principally by the Government’s willingness to pay a predictable, higher price for electricity from wind and solar, in the form of “feed-in tariffs” (FiT). In the early days of the

Energiewende, the government offered more than 50 Euro cents per kilowatt-hour for solar PV—which can be compared to the 2000 retail electricity price in Germany of 20 cents. This first phase of the FiT was designed to drive down the price of solar and wind by creating an

Exhibit 20: FIT Rate for Small-Scale Systems versus Residential Retail Electricity Rates in Germany



⁵ <http://bit.ly/1303qmc>

investable return. (Note, per the chart above, that the price Germany has paid for solar PV has declined steadily, and is now less than a third of the original price. This point is not widely appreciated. It should also be noted that there are different FiT rates for different technologies, reflecting their place on the technology learning curve.)

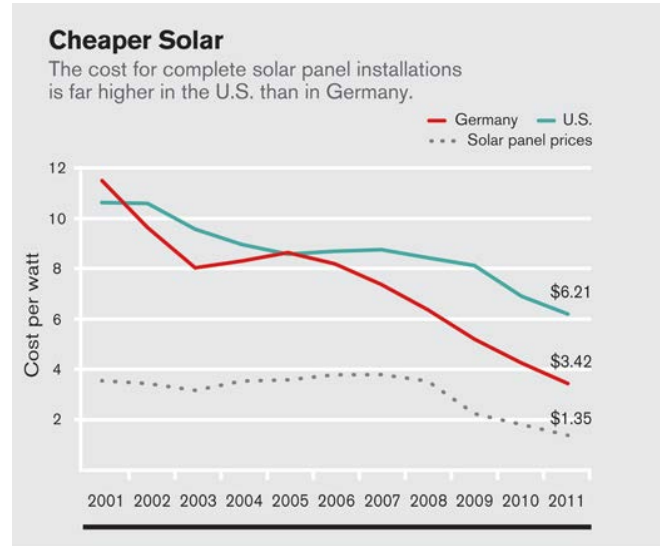
Driving down the price of solar and wind has been a holy grail for advocates of clean energy. For many years, the goal for solar was \$1 per watt for the capital costs of a PV panel. For reference, in 1979, the cost of solar was close to \$100 per watt.

Investments made in the last decade have let us finally hit that target. And this is a crucial point: The German (and Spanish, and several U.S. states) commitments to solar in the early, expensive years were not simply to purchase zero-carbon energy: **Their main point was to drive down the price, so that there would be vast amounts of clean**

energy available at a reasonable price in the future. Looking back at the *Energiewende*, the proper question is not whether the initial tranche of renewable energy was cost-competitive with other technologies, but whether the investment drove the price down enough to give the world new, affordable, clean technology options.

A look at the history of the energy field shows that, in fact, public investment in driving technologies down the price curve is actually the norm (as it is in health, electronics, transportation, and other realms).

The picture is no different in other countries. Every major energy technology has had its costs, or risks, or both, socialized in its early days in the United States. Our transmission and hydro systems were largely built by the federal government in enormous public works projects during the 1920s and 30s. Almost all the coal-fired power plants were built under rate-of-return regulation, under which ratepayers essentially guarantee investors' returns. Nuclear plants have had the same treatment, along with significant fuel, R&D, tax, and risk subsidies. Natural gas turbines were themselves developed with technology invented by the military for their jets. Even today's gas boom relies on 3D seismic imaging, directional drilling, and fracking, all of which were developed in large part with government funds and programs. The point is simply that governments across the world have their hands deep in energy markets, and always have. This of course does not justify uneconomic decisions or inefficient policy.



Source: Lawrence Berkeley National Laboratory

Returning, then, to the *Energiewende*: If the goal of the first phase of the feed-in tariff was drive down the price of solar, it was, on that measure, a success. Solar prices have dropped more than 80%, and wind by about half, with German demand (and Chinese supply) a key force in that change. Indeed, Germany’s investments have made the prospect of clean, affordable energy a reality for the whole world.⁶

What about the costs of renewable energy?

German power is expensive. Today, German residential customers pay about 29 Euro cents per kilowatt-hour, close to three times the American rate. High power prices can hurt consumers and make industry less competitive.

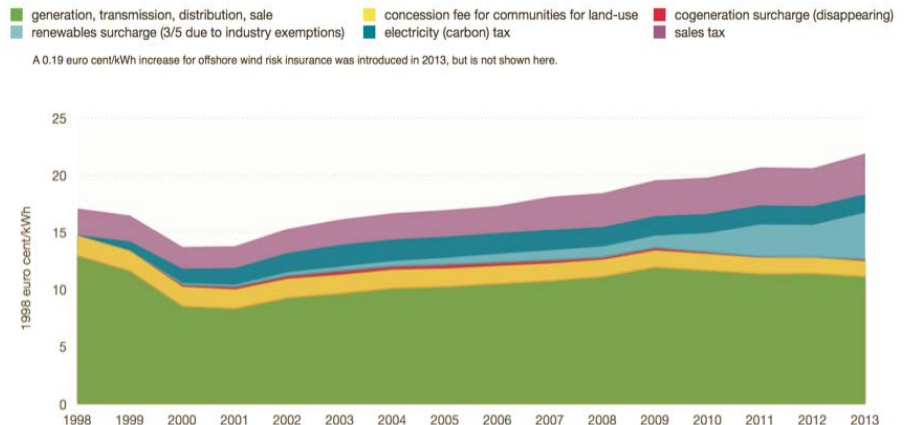
The price of residential electricity has several components:

Dominant, quite naturally, is energy—its generation, transmission, and distribution. Europe does not have cheap natural gas, like America. Taxes are the next biggest share, then the costs of the renewable energy tariffs, which now are about 20 percent of the total cost—and are the fastest rising share. The components of residential electricity price are shown in the graph on the right.

An interesting and ironic consequence of the German electricity market is that the large penetration of renewable energy has driven down the price of all electricity in the *wholesale* market, which negates some

Composition of German electricity price

for a 3-person household, 1998–2013



“Consumer prices for electricity in Germany have risen considerably in recent years. These price increases are partially attributable to a strong rise in the apportionment for the promotion of renewable electricity in accordance with the German Renewable Energy Sources Act (EEG). The EEG apportionment and associated Value Added Tax (VAT) currently account for approximately one-sixth of household spending on electricity.

Yet the increasing generation of power from renewables leads to decreased wholesale electricity prices. As a result, the net burden on the consumer – given effective competition – is lower than the [renewable energy] apportionment.” Source: Germany Institute for Economic Research, o. 6/2011, Volume 7, March 16, 2011, Page 1.

⁶ I have argued in other forums that this contribution is as important as all German foreign aid in transforming the global prospect.

of the costs of the feed-in tariffs. German authorities have found that this effect has driven wholesale electricity prices down one cent per kilo-watt hour, for savings of about \$5 billion Euro per year.⁷ In 2013, German wholesale power prices are down 27% compared to 2012.⁸ The German Institute for Economic Research now estimates that the discipline imposed by renewables on the Germany wholesale market will *exceed the costs of renewables* by 2020. In other words, if this analysis is correct, the entire system pays for itself in fuel and market cost savings.

The data shows that renewable energy is not the dominant driver of electricity prices in Germany, but that it is the fastest growing part—and that needs to be controlled. There are two other factors required to round out the picture: First, Germany has decided to insulate some 2000 industries from the renewable energy surcharge, and instead put all those costs on residential consumers. So the residential renewables surcharge is here is more than twice as large as it would be without this cross-sectoral subsidy. The other key point is that Germany has also used public policy to build one of the most energy-efficient economies in the world, so that energy *bills*, which after all are what people pay (no one pays a *rate*) are lower than most countries. The chart below shows Germany’s electricity cost as a percentage of household expenditures over the last 22 years.

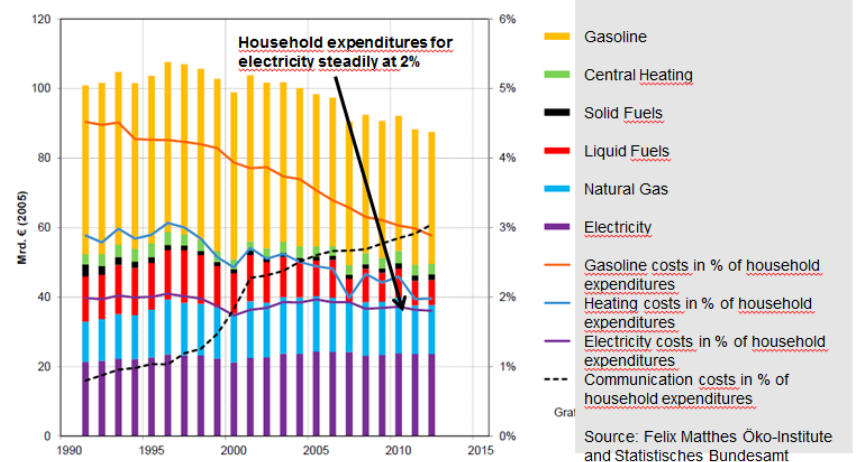
The opening pages of this memo argued that early subsidies for technology are justified if they drive down the future price of that technology—and on that measure, the *Energiewende* has been an unambiguous success. The next section argues that current residential electricity prices are about 1/6th higher than they would be without the commitment to renewable energy, but that is partly driven by cross-subsidies and will be significantly offset by their effect on wholesale electricity prices. But the test

looking ahead is whether the transformation can be completed without being too expensive. Starting this year, the Feed-in Tariff for solar, which drops every year, is expected to be below the cost of residential electricity. Of course this is not the full measure of solar costs: one still has to pay for transmission and distribution, for taxes, and for system resources that balance the variability of solar output. Still, solar is well on the way to reaching “grid parity.”

INSIGHTS INTO GERMANY’S ENERGIEWENDE



Development of Consumption Expenditures of Households (Adjusted for Inflation)



⁷ German Environment Ministry, http://www.bmu.de/fileadmin/bmu-import/files/english/pdf/application/pdf/broschuere_ee_zahlen_en_bf.pdf, page 44.

⁸ <http://www.bloomberg.com/news/2013-08-11/german-utilities-hammered-in-market-favoring-renewables.html>

Future path

The *Energiewende* is not static, and is by no means complete. One important feature of the current plans is the steady declination of the price of the feed-in tariff, with each step set triggered by a pre-specified volume sold. This is Germany's method for at once approximating a price-finding subsidy, for driving down the price, and for making a business environment conducive to serious investment. It could be argued that the U.S. states' systems of renewable portfolio standards are better at price-finding, but they are nowhere near as good at building a good investment climate. These are reasonable policy design questions.

Large-scale renewable energy requires a different power system—both in its physical characteristics and its market and business structures. This is the principal challenge facing systems that exceed 20 or 25 percent variable renewables penetration. In Germany, the key issues are:

- What kind of market structure must be designed to induce investments in “flexibility services”—that is, power plants that can ramp up quickly, then shut off quickly, to compensate for variability in wind and solar?
- What is the future for the utilities with large investments in coal and nuclear power? What is the business model for utilities with more complicated, diverse, decentralized, and variable set of power sources?
- How will the accelerated shutdown of nuclear power affect the energy system and power prices?
- What will the *Energiewende* cost?

Many of these questions will not be answered until time passes. But there are some early indicators, backed up by strong analytics.

New market structures

The German electricity market is an energy-only market, selling megawatt-hours in daily and weekly tenders, at units lasting up to an hour. This is fine for allocating power amongst existing power plants (although the near-zero marginal cost of renewables has played havoc on the pricing expectations of conventional power plant operators). But energy-only markets are not well suited for inducing construction of new power plants that may only run a few hundred hours per year, but which are crucial for balancing the variability of wind and solar.

An alternative, carefully specified “flexibility markets,” would pay operators to run power plants that are fairly clean, but that can ramp up their generation in short order to provide system stability. This idea is under discussion in the German government and with groups like *Agora*. We can expect some concrete proposals in the next year or so. Flexibility markets could include super-efficient gas turbines, renewable energy sources with storable fuel, such as biomass or some hydro, or technologies on the demand side, such as dispatchable air conditioning. There may be some storage technologies that compete as well.

These questions are coming to the fore in other jurisdictions with high penetration of renewables—such as Texas and California. Two papers on designing flexibility markets are available in the July and October 2013 issues of the *Electricity Journal*.⁹

Finally, it is important to note that the grid itself can act as a great offset to renewable energy variability. The larger the grid, both in geography and capacity, the easier it is to balance any part of it. Expanding the European grid is a crucial step to integrating high quantities of renewable energy.

Utility Business Models

The advent of competition in the electric sector wiped out the old cost-plus mentality of the utility industry, and left them, on the whole, with one conventional option for new power plants: gas turbines, which have relatively low capital costs, are easy to site and build, and come in relatively small modules. Some utilities are adding significant renewables to their portfolio, though they have not been leaders in this. Now, carbon standards, efficiency gains, and nuclear phase-out threaten the utilities' legacy investments: many will face sharply reduced sales but only modestly reduced costs.

German utilities have so far reacted by diversifying into other markets, maximizing revenues from their existing plants, and adding renewable energy capacity. But the future does not look rosy for them. German utility stocks have plummeted in recent months.¹⁰

“A significant part of our business model is now facing new challenges,” RWE Chief Financial Officer [Bernhard Guenther](#) said in an interview, without being specific about halts or jobs. “Whatever we do in terms of cost and capex-cutting won't fully compensate the profit loss we see in conventional power generation.”¹¹

Germany needs healthy utilities. And renewable energy needs a system integrator to ensure that a diverse portfolio of supply and demand resources is intelligently dispatched, and that the whole system is reliable. Building a flexibility market, per above, is a crucial step in this direction. In some other regulatory systems, utilities work on the demand-side of the market, installing customer energy efficiency, and make good money at it. Still others have utilities in charge of system optimization. Which of these should be done, and how, is not clear, but it is clear that the current process will only make the utilities' financial situation worse. Many argue that this is just fine: Like AT&T of old, monopolies with *de facto* state protection should fade away. Others worry about keeping a vast, complex, and crucially important system operating well without utilities.

⁹ Gimon, Eric, Sonia Aggarwal, and Hal Harvey, (2013), A new approach to capabilities markets: Seeding solutions for the future. *Electricity Journal* 26 (No. 6, July). See also: Hogan, Mike, (2013), Aligning America's Power Markets. Forthcoming in the *Electricity Journal* (October).

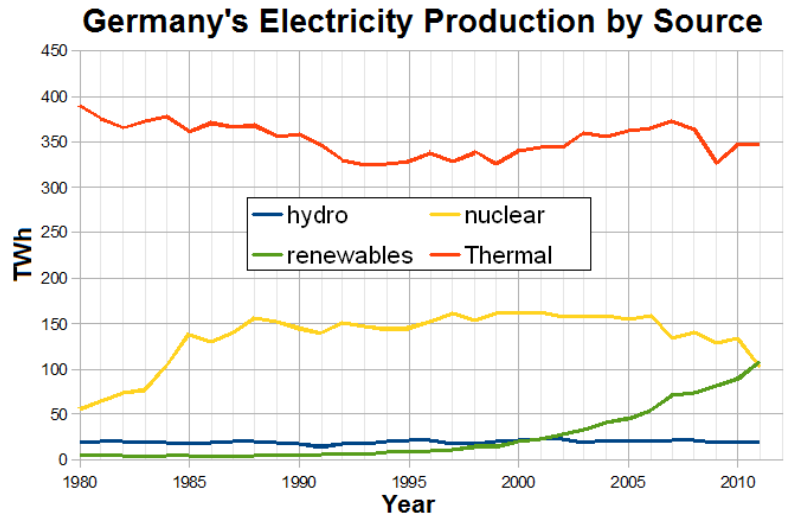
¹⁰ <http://www.reuters.com/article/2013/08/06/germany-utilities-idUSL6N0FV1FX20130806>

¹¹ <http://www.bloomberg.com/news/2013-08-11/german-utilities-hammered-in-market-favoring-renewables.html>

Nuclear Power

In 2011, in the wake of Fukushima, Chancellor Angela Merkel set policy to close all of Germany's nuclear reactors. Six were closed quickly, and two that had been previously shut down were permanently pulled off line.

The remaining nine are to be phased out by 2022. Nuclear power was producing about 20 percent of Germany's electricity before the shutdown, so this raises questions about the economics, the carbon impact, and the impact on system stability. As the chart to the right shows, the jump in renewable energy has more than offset the reduction in nuclear power—although from a climate perspective, it would have been better if the renewables shut off coal.



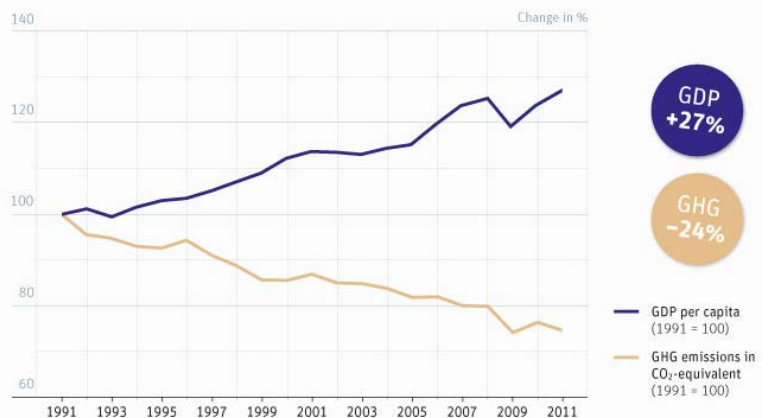
The background to this decision is important. The nuclear shut down was actually established as policy under Chancellor Schroeder more than a decade ago. Merkel reversed this when she came into office, and then reversed it again after Fukushima. Nuclear power is decidedly unpopular in Germany—which suffered directly from fallout from Chernobyl. It has inspired protests of up to 250,000 people. The bottom line is that nuclear power was politically infeasible after (and probably before) Fukushima.

¹²With that in mind, what does the shutdown mean? First, it means that fairly reliable, carbon-free baseload power is now gone. Replacing it will cost money. But for context, remember that these plants were scheduled to shut down for ageing reasons anyway, within a decade beyond the new 2022 deadline, so the issue of shutdown was not whether, but when. In the U.S., several plants are being shut before their planned expiration because of mounting maintenance and repair costs, so that extra decade in Germany may have been speculative in any event. The rapid

Germany: growing economy, declining emissions

Change of GDP and GHG emissions in Germany, 1991–2011

Source: BMU, BMWI, Destatis



¹² <http://energytransition.de/>

expansion of renewables means that even with the eight reactors shut down, Germany is exporting more power than ever.

Did the nuclear power shutdown lead to a renaissance of coal, as some claim? In terms of coal plant construction, the answer is clearly no, since no new coal plants have been announced since the nuclear decision. New plants commissioned years ago did come online, causing a blip in German carbon emissions, but this is temporary. The other factors driving 2012 coal use in Germany were: (a) gas prices jumped, causing a 15% reduction in gas consumption, and (b) it was an exceptionally cold and dark winter. Even so, the 2012 coal use was lower than any year 1990-2007.¹³

Conclusion

There is no doubt that the accelerated phase-out of nuclear power combined with the strong carbon targets for the utility sector make for a complex transition. True, so far, the growth in renewables has more than offset the nuclear reduction, and CO2 emissions trends are pretty well on track. Renewables costs are dropping still. But Germany will have to reinvent power markets, build more transmission lines, and think deeply about a new business model for its utilities. The cost of this transformation can be kept to quite reasonable levels—and part of that cost containment is in building a steady, sound, reliable market for investors, so they can drive down prices.

Germany has helped make solar PV and onshore wind into affordable, and nearly market competitive technologies. This success has made it possible to decarbonize the electricity sector—which is an amazing and crucial opportunity. But that transition raises other challenges—on variability, business models, and more. It is crucial that these be answered intelligently and quickly. Many other jurisdictions have, or will soon have, the same challenges, so developments must move quickly from state to state, country to country. We need the transition to succeed—in Germany, in Texas, in China, and ultimately everywhere.

¹³ Rocky Mountain Institute debunks several myths about the Germany energy transition at http://blog.rmi.org/separating_fact_from_fiction_in_accounts_of_germanys_renewables_revolution