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The Christian Science Monitor Weekly

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EUROPE'S GREEN GIANT

Freiburg im Breisgau, Germany

The promise and perils of the world's most ambitious energy transformation.

BY DAVID J. UNGER

MARCH 10, 2014 $4.00

GREEN GIANT

GERMANY HAS A BOLD PLAN for a clean-energy future. Private citizens are on board, even if they're paying a steep price – but industry is balking. The aim is to provide 80 percent of the nation's electricity with renewables by 2050 and provide the world a template for doing it, too.

In Germany's model clean-energy city, Freiburg im Breisgau, wind turbines on mountains in the Black Forest (top) overlook roofs with solar panels. Most buildings in the city have solar panels, like this residential complex (middle) that uses them as a facade. The city's modern trams (bottom) run on electricity generated exclusively from water, wind, and sunlight.

Freiburg is a medieval city – its daily market (left) spreads across a cobblestone square beneath a Gothic cathedral – but its modern clean-energy ethos has enabled it to cut carbon dioxide emissions by 20 percent in the past two decades.

The Gothic spire of Freiburg's cathedral, being refurbished here in February 2014, towers over the city's modern and medieval quarters.

Story by David J. Unger / Staff writer
Photos by Ann Hermes / Staff

FREIBURG IM BREISGAU, GERMANY

On the Black Forest's western slopes – in the land of cuckoo clocks and Brothers Grimm – there is a city that calls itself "green."

Rich silver deposits first lured settlers to Germany's Freiburg im Breisgau back in the 12th century, but today this quaint city is anything but medieval. Freiburg is a prototype for a clean-energy future that Germany is aggressively pursuing.

Nations across the globe are looking increasingly to wind, water, and the sun to power their economies in the decades to come. But Germany stands apart as a global leader in the industrialized world's push to limit fossil-fuel consumption. Forging a stable path to a post-carbon economy would be a watershed moment in human history – not to mention a tremendous economic boon for whoever finds the way. But it will not be easy to shift off the coal, oil, and natural gas that have powered global economic development for centuries.

In Freiburg – where silicon has overtaken silver as the city's focus – the energy transition is getting a trial run.

Solar panels line the train station's glassy facade, from which visitors alight into a bustling shopping district. Photovoltaic panels top the pitched roofs of churches, schools, and houses in sleepy residential quarters and help power the local soccer stadium and city hall. Students from all over the world study renewable-energy engineering at the University of Freiburg, established under the Habsburgs more than 500 years ago. After they graduate, they might get a job up the street at the Fraunhofer Institute for Solar Energy Systems, Europe's largest solar research facility.

Along the historical center's cobblestones, where Marie Antoinette traveled en route to live not-so-happily-ever-after in France, slick modern trams run on electricity generated exclusively from water, wind, and the sun. When this corner of old Europe was flattened in an air raid six months before the fall of the Third Reich, Freiburg's 13th-century cathedral was among a handful of buildings that survived – the Gothic *Münster*'s spire still soars over the sleepy square below but shares the skyline with wind turbines spinning on nearby peaks.

Freiburg's passion for alternative energy dates back to protests that blocked the construction of a nearby nuclear plant in the 1970s. But Ukraine's 1986 Chernobyl nuclear disaster further galvanized locals, and the green momentum grew as the threat of climate change came into focus.

Over the decades, Freiburg expanded its own clean-energy and efficiency infrastructure and worked with regional utilities that trade largely in wind, solar, and hydro power.

By 2011, when Japan's Fukushima Daiichi nuclear plant rekindled anti-nuclear sentiments and prompted the immediate shutdown

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of Germany's oldest nuclear plants, Freiburg had already cut its carbon dioxide emissions by nearly 20 percent from 1992 levels. And it aims to cut 20 percent more by 2030. But even as it has built an economy and identity around efficiency and renewable energy, Freiburg gets only about 5.5 percent of its electricity from locally generated, renewable sources. The rest is a mix of renewable and nonrenewable energy from regional utilities. Plans are under way to install additional wind energy capacity locally and enact more efficiency measures, with the goal of using 100 percent renewable energy by 2050.

It is difficult enough to transform how a quiet city's 230,000 residents heat their homes, cook their food, and light their streets. Doing the same for an industrialized superpower of 82 million is an entirely different affair. If Germany can demonstrate how to run a major economy on primarily sunlight, wind, and water, it would tip the global scales in favor of renewable energy and accelerate a worldwide shift away from fuels that contribute to global warming.

With its *Energiewende* – or "energy transition" – Germany aims to be nuclear-free by 2022 and generate 80 percent of its electricity from renewable sources by midcentury. It has made significant progress, but a transition of such scale does not come without cost. Germans pay some of Europe's highest electricity bills, and those costs threaten to uproot the country's strong manufacturing base. Utilities struggle to integrate intermittent power sources like the sun and wind onto an electrical grid designed for baseload power like coal and nuclear. It is why a growing number of leading voices in Germany – including Chancellor Angela Merkel herself – say that the world's most ambitious energy transformation is in need of an overhaul.

Germans may not be thrilled about the *Energiewende*'s cost or how it is implemented, but they are unified in a push for clean energy as few other nations are. Even while 70 percent of Germans polled in February by the German Association of Energy and Water Industries said they expect increasing electricity prices, nearly 90 percent said the energy transition is "important" or "very important." A tradition of conservation and naturalism in Germany dates back to the nature-loving artists of the Romantic Movement. Modern catastrophes have reinforced a uniquely German taste for alternative energy. For weeks after the Chernobyl nuclear disaster, Germans were warned not to consume certain foods and drinks for fear of radioactive contamination.

"I want electricity from renewables," says Astrid Mayer, founder of the Freiburg Future Lab, which offers training programs on sustainable urban development. "I support them, so I don't care if I pay 6 cents [8 US cents] more per kilowatt-hour. Of course, not everyone thinks that way, but a lot of people in Freiburg do."

What happens when the world's fourth largest economy completely retools how it keeps the lights on? Nobody knows, but everyone is watching. The *Energiewende*'s promise is enormous: a low-carbon, nuclear-free economy powered by fuels cleaner and safer than the coal, oil, and natural gas that made possible today's modern, globalized world. As global emissions of heat-trapping gases rise unchecked, most developed countries plan to decarbonize their economies. Germany stands to gain an enormous advantage by doing it first.

"There's no master plan which we could follow," says Hubertus Bardt, head of energy and environment research at the Cologne Institute for Economic Research. "We're like a big research project, and we hope others can learn in the future and other countries can benefit."

Employees at Freiburg's Fraunhofer Institute for Solar Energy Systems, Europe's largest solar research facility, are bathed in sunlight filtered through solar panels.

Where sustainability is the norm

That research plays out in Vauban, Freiburg's "sustainable model district," an experiment in collaborative planning and eco-friendly urban development. City officials, urban planners, and local residents came together more than a decade ago to transform 94 acres of a former French military base into a neighborhood where they felt they could live well – and well within their means. Here, efficiency is an expression of self-reliance. Sustainability is not a niche or a trend; it is a self-evident norm.

"It's a part of us," says Andreas Konietzny, an architect and resident who participated in the original planning process. "It's not that we discuss it every day. It's the basis of us coming together."

The quarter's modern, low-rise homes consume a fraction of a typical household's energy use and are powered largely by rooftop solar panels. Cars appear on Vauban's narrow, leafy streets only to make quick pickups and deliveries. The rest of the time the cars – there are only about 16 of them per 100 residents – are parked in solar-powered garages on the quarter's edge. Where most neighborhoods build driveways, parking spots, and gas stations, Vauban has gardens, parks, and playgrounds. Its roughly 5,300 residents walk to work or school, or they bike or take the tram. Most of the time, a passing bicycle's whoosh is all that breaks the bright neighborhood's calm.

Vauban certainly isn't for everyone, Mr. Konietzny admits, and not everyone can afford the upfront premium its residents pay for expertly designed homes. And, of course, even Vauban isn't a perfect post-carbon oasis, free of fossil fuels. Its local combined-heat-and-power plant was designed to run on wood chips but now relies mainly on natural gas. Surely hydrocarbons are present in the plastics and other materials in buildings and everyday goods.

But if the rest of Germany is serious about its national clean-energy push, it can learn a lot from the people of Vauban. For Koni-

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etzny, the quarter's appeal has to do with scale. Most everything he and his family need is just a walk away, he says, and decisions about power and development are made locally by the residents themselves.

"The human being comes back to his size," Konietzny says, searching in English to articulate the appeal of his life in Vauban. "I don't know how to express it."

Translating 'Energiewende'

In English, *wende* means "change, turning point, or revolution." *Energiewende* is commonly translated as "energy transition," and sometimes as "energy transformation." Eicke Weber, director of Freiburg's Fraunhofer Institute, prefers the latter.

" 'Transition' sounds like something that would happen regardless," says Dr. Weber. " 'Transformation' is a process that you work at."

The Germans have their work cut out for them. Many millenniums passed before coal overtook wood as the world's dominant energy source. It took about a century for oil to replace coal. Germany aims to make its energy switch in a matter of decades.

The *Energiewende* calls for renewables to provide 35 percent of the nation's electricity by 2020, up from about a quarter today. (The US is at about 12 percent.) It should rise to at least 50 percent by 2030, and at least 80 percent by 2050. Combined with efficiency targets, these measures should cut emissions by 80 to 95 percent of 1990 levels by 2050. It plans to do it all without carbon-free nuclear power, which it will eliminate by 2022.

Renewables grew from producing 6.2 percent of Germany's electricity in 2000 to 23.5 percent in 2012, according to government data. Germans avoided burning the equivalent of 111 million tons of CO_2 in 2012, and avoided 496 terawatt-hours of energy imports, saving $13.6 billion. Investors spent $26.5 billion on German clean energy in 2012, sustaining about 377,800 jobs.

Germany isn't the country closest to having a 100 percent renewable economy. That title probably goes to Iceland. Others, such as Scotland and the Philippines, also aim to shift very quickly off fossil fuels. But those are small countries with vast wind and geothermal resources. Germany has the biggest economy in Europe with a gross domestic product of $3.7 trillion, and it gets very little sun for a country determined to use it for power.

Paying the bills in East Berlin

East Berlin's Stalinist concrete is a departure from the quaint cobblestone of Freiburg and Vauban's bright, übermodernism. Here, on a quiet street cordoned off by dead ends in the borough of Pankow, is the office of Renate Stark.

Her employer, Caritas, is a Roman Catholic charity that was one of the few organizations from the West that served the poor in Soviet-occupied Berlin. After the Berlin Wall fell, Ms. Stark came here from Stuttgart, far from the front lines of the cold war. That distance proved valuable in earning the trust of Berliners scarred by the paranoia of life in the German Democratic Republic.

"They know I'm not a communist. I'm not Stasi," she says, referring to the secret police that permeated all levels of East Berlin society.

These days Stark's foremost concern is the rising cost of electricity. German consumers bear the brunt of the *Energiewende*'s financial burden through a surcharge on their utility bills. Those funds pay for the above-market prices renewable energy producers earn for electricity as an incentive to build more wind and solar utilities. A boom in renewable construction has sent that surcharge steadily upward in recent years, rising from almost $0 per kilowatt-hour in 2001 to $0.07 per kWh in 2013. In 2014, it is expected to rise 19 percent more, to $0.08. All together, funding the transformation will cost Germans an estimated $32.1 billion in 2014 alone.

For many, it's a small price to pay for a cleaner energy mix, and prices should theoretically level off as renewables continue to get cheaper. But for Stark's clients today, those are very real euros and cents. Low-income households spend a higher share of their income on electricity and often cannot afford the upfront costs of new, efficient appliances that protect others from high energy costs.

"They haven't the money, and they come here [and] say, 'I cannot pay,' and we try to help them," says Stark, who isn't opposed to the *Energiewende* but believes the cost falls too heavily on the poor.

It has gotten worse in the past three years, Stark says. People you might not expect to see asking for help – people with jobs and stable homes – are showing up at her door. Nearly 1 in 5 Germans was living in poverty in 2012, according to government data, and 16 percent of the population was at risk of falling into poverty, up from 15.2 percent in 2008. Federal unemployment benefits cover some energy costs, but Caritas says it should be increased by $12.73 per month – or 27 percent – to better match today's energy costs.

To help, Caritas trains the long-term unemployed to help other jobless people save on their energy bills. They do home energy audits, offer simple conservation tips, and provide energy-efficient light bulbs free of charge. The program can save low-income households as much as $136 a year, according to Caritas.

Industry sounds the alarm

In the darkest hours of the 2009 eurozone crisis, Germany served as Europe's controversial creditor, shoring up its neighbors' sinking economies. Germany's strong manufacturing base helped weather the storm. Lacking its own wealth of natural resources, Germany has long sustained its export-oriented economy by mak-

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'[Sustainability is] a part of us. It's not that we discuss it every day. It's the basis of us coming together.'

– Andreas Konietzny,
an architect and resident who participated in the planning of the Vauban quarter, Freiburg's 5,300-resident 'sustainable model district,' where cars are largely banned and sustainability has become the norm

ing the cars, appliances, and machinery loved around the world (think BMW, Miele, and Siemens). Those industries require a lot of energy, making cheap, stable power a prerequisite for a strong Germany and, by association, a strong Europe.

It's why Germany has taken pains to protect industry from rising costs associated with the *Energiewende*. Energy-intensive industries are mostly exempt from the special surcharge that has driven up the cost of the retail electricity used by most homes and businesses. Still, Germany's industrial power prices remain among the highest in Europe and 2-1/2 times those in the natural-gas-rich US, according to IHS, an international consultancy.

Chief executives and industry associations warn of an industrial exodus, particularly if Germany decides to abandon the industrial exemptions.

"With significantly lower energy prices in North America, rising electricity costs lead to a competitive disadvantage for German products on the world market," a spokesman for BASF, a leading chemical company headquartered in Ludwigshafen, Germany, said in a statement e-mailed to the Monitor. The long-term result would be a relocation of energy-intensive companies abroad, the statement added, reducing domestic economic activity and rippling across those companies' suppliers and customers.

In 2012, BASF doubled its investment in the US to about $1 billion a year, and plans to spend $4 billion more through 2017. The lure is America's abundance of cheap natural gas – a fuel used to generate electricity and a vital feedstock for BASF's chemical processes. The concern is that more German companies will think twice before building new plants at home.

"Germany is a location for industry – and industry needs competitive electricity prices," the Federation of German Industries warned in an October 2013 report. "Yet prices here have reached a level that keeps German companies from competing internationally."

Paradoxically, renewables actually cause the raw costs of wholesale electricity to fall because there are no fuel costs, as there are with coal or natural gas. But average electricity consumers pay the extra surcharge to fund all the upfront infrastructure costs and to guarantee the *Energiewende*'s fixed, incentivized price renewable producers get for their electricity. So as renewables expand, wholesale prices of electricity fall, but retail rates go up to cover the premium rates for added clean-power producers. Clean energy has become, in the words of the German Renewable Energy Federation, a "victim of its own success." For some, it's a price worth paying.

"You have to be very aware of a cost a society can bear, but you also have to be aware of the alternatives," says Martin Pehnt, head of the energy department at the Institute for Energy and Environmental Research in Heidelberg, Germany. "If you have a society dependent on fossil fuels for the next 20 years, you will have other risks and costs."

Quirks in the grid

The sun shone brightly, and strong winds blew through Germany on a sleepy Sunday last June. Solar panels and wind turbines electrified nature's forces all the way from Mecklenburg-Vorpommern in the north down to Baden-Württemberg in the south. Between 2 p.m. and 3 p.m. alone, renewables produced a record 29.6 gigawatts – 61 percent of the nation's total electricity supply. It was a triumph for the *Energiewende*, and a nightmare for utilities.

Suddenly, there was a vast supply of power and little demand to consume it. Since electricity cannot be easily stored and ramping down coal plants is expensive, the sudden spike in renewable power threatened to overwhelm the grid. Power suppliers scrambled to find buyers for all the wind and solar power, sending wholesale electricity prices plummeting to negative $136 per megawatt hour (essentially, utilities with excess electricity paid other utilities and wholesale power buyers lacking electricity to take the surplus off their hands). The grid survived intact, and the average consumer wouldn't have noticed anything different, but what happened in the wholesale electricity markets that day underscores the complexity of using intermittent sources on a grid designed for predictable, baseload generation.

"A valuable commodity is disposed of like waste and, to top it all, citizens as electricity consumers have to pay for it in the end," says Werner Wenning, chairman of the supervisory board of Germany's biggest utility, E.ON, in an undated statement posted online. "It is high time for a general revision of the energy turnaround; cosmetic changes will not do."

The transformation has upended traditional utility business models. For decades, power generation was centralized among a handful of companies. Now, it is spread across thousands of local cooperatives and individual producers. Utilities have long relied on the predictability and flexibility of coal and natural gas. But it is difficult to bottle sunlight or wind for later, complicating the balance of supply and demand. Renewables lower the wholesale price of electricity, meaning utilities get less in return for what they generate.

Share prices of Germany's biggest utilities, E.ON, RWE, and EnBW,

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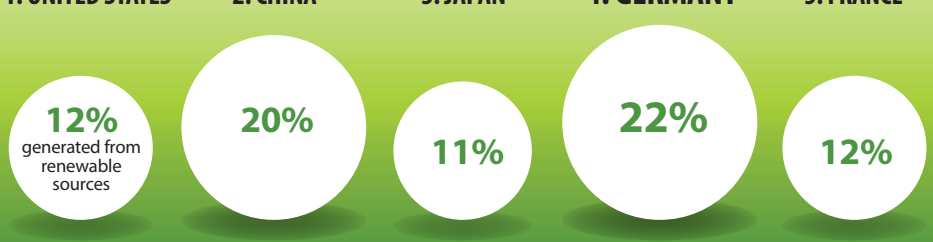
HOW CLEAN IS THEIR POWER?

The amount of electrical power generated from renewable sources, such as wind and solar, in the top 5 nations with the highest GDP is growing. Germany's aggressive programs – which mandate 50 percent by 2030 and 80 percent by 2050 – may blaze a path for other powerful economies.



SOURCES: EIA 2011 data, World Bank

RICH CLABAUGH/STAFF

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have plummeted over the past three years. In the first nine months of 2013, E.ON's net profits were cut in half, and RWE expects a similar scenario in 2014. Not everyone feels sorry for them. Major utilities were slow to take advantage of the incentives for wind and solar, owning a mere 5 percent of the country's renewable capacity in 2012. The remaining slice was divided among banks, industry, businesses, and farmers, with the largest share – 35 percent – owned by private citizens.

"It is a quintessential rearguard battle," says Paul Hockenos, a Berlin-based writer who has covered the *Energiewende* since 2010. "This was a business decision. They made a bad decision. Now they're paying for it."

Utilities are also burning more coal. Last year, German coal-fired generation was at its highest in more than two decades, according to preliminary figures from EnergieBilanz, an electricity industry association. Cold winters, cheap imports, and underpriced carbon credits have boosted production of the most carbon-heavy fuel. Greenhouse-gas emissions rose 1.6 percent in 2012 and are projected to have risen again in 2013. Emissions are still well below levels of a decade ago, and most analysts expect the broader trend to continue downward, but the recent rebound is easily the most counterproductive outcome of a national strategy aimed at doing precisely the opposite.

Despite all this, Germany's electrical grid is one of the stablest in Europe, experiencing only about 45 minutes in planned and unplanned outages in 2012, according to the Council of European Energy Regulators. The question is what happens on very sunny and windy days when renewables make up not a quarter of electrical capacity, but 50 percent, 75 percent, or more. None of the *Energiewende*'s challenges are intractable. Solutions exist, but they require a considerable investment of money, time, innovation, and political will.

Shoppers (left) purchased sausages at the weekly market in Freiburg's eco-friendly Vauban quarter in February. The neighborhood of 5,300 residents was designed so that all the basic needs of the residents can be reached by biking or walking. Many of Vauban's homes were designed with both older and disabled people in mind. Resident Kitty Weis (below) has lived there for more than 15 years and plans to stay as long as possible.

The other 'wende'

Germany's new grand governing coalition between Chancellor Merkel's center-right Christian Democrats and the center-left Social Democrats has already outlined a plan to raise, but cap, targets for renewable production. Special support for some renewables will probably be curtailed in an effort to rein in costs, and heavy industry may have to start paying more to support the *Energiewende*. A major reform of Germany's renewables law is expected later this year.

That debate will unfold in a building that bears the scars of a world pulled apart by totalitarians. The Reichstag's stone walls are pockmarked with the bullets of Red Army soldiers who stormed the parliament building, capturing it room by room. When the battle ended, they climbed the roof high above a Berlin in ruins, and unfurled a flag emblazoned with a hammer and sickle.

Half a century later, it was renovated with an eye toward transparency. The Soviets' anti-German graffiti stayed, and a glass-and-mirror cupola was added to funnel sunlight down onto the parliamentarians below. Over the years, a couple of other features have been added: Rapeseed grown outside Berlin fuels four combined-heat-and-power biodiesel generators that provide half of the building's electricity needs. The heat naturally produced during that process is captured and reused to provide all of the building's heating needs. During winter, cold water is stored, to be pumped back up for cooling in the summer. Solar panels cover 3,200 square feet of the Reichstag's roof.

Just yards from the Reichstag is where the Berlin Wall once stood. Its collapse in 1990 had such a singular effect in history that Germans have come to refer to it simply as "Die Wende" – the revolution, the change, the transformation.

With its *Energiewende*, Germany tries for a completely different, but equally unprecedented, "wende." Humans have powered civilization for centuries by burning the organic remains of prehistoric plants and animals. The future promises cleaner energy, but it will not come easily. Given its unique relationship with history, perhaps Germany is uniquely qualified to undertake such a dramatic break with the past. It will not be the only one to try.

"The energy transformation has really started now globally," says Weber of the Fraunhofer Institute, "but there's still a lot to do. The question is still open: What country will lead this transformation? What country will provide the technology, and – at the end of the day – flourish from it?"

■ *Travel for this report was partially funded by the German-American Fulbright Commission.*