PUTTING THE PIECES TOGETHER:
TRANSITION AND TRANSFORMATION IN GLOBAL ENERGY MARKETS

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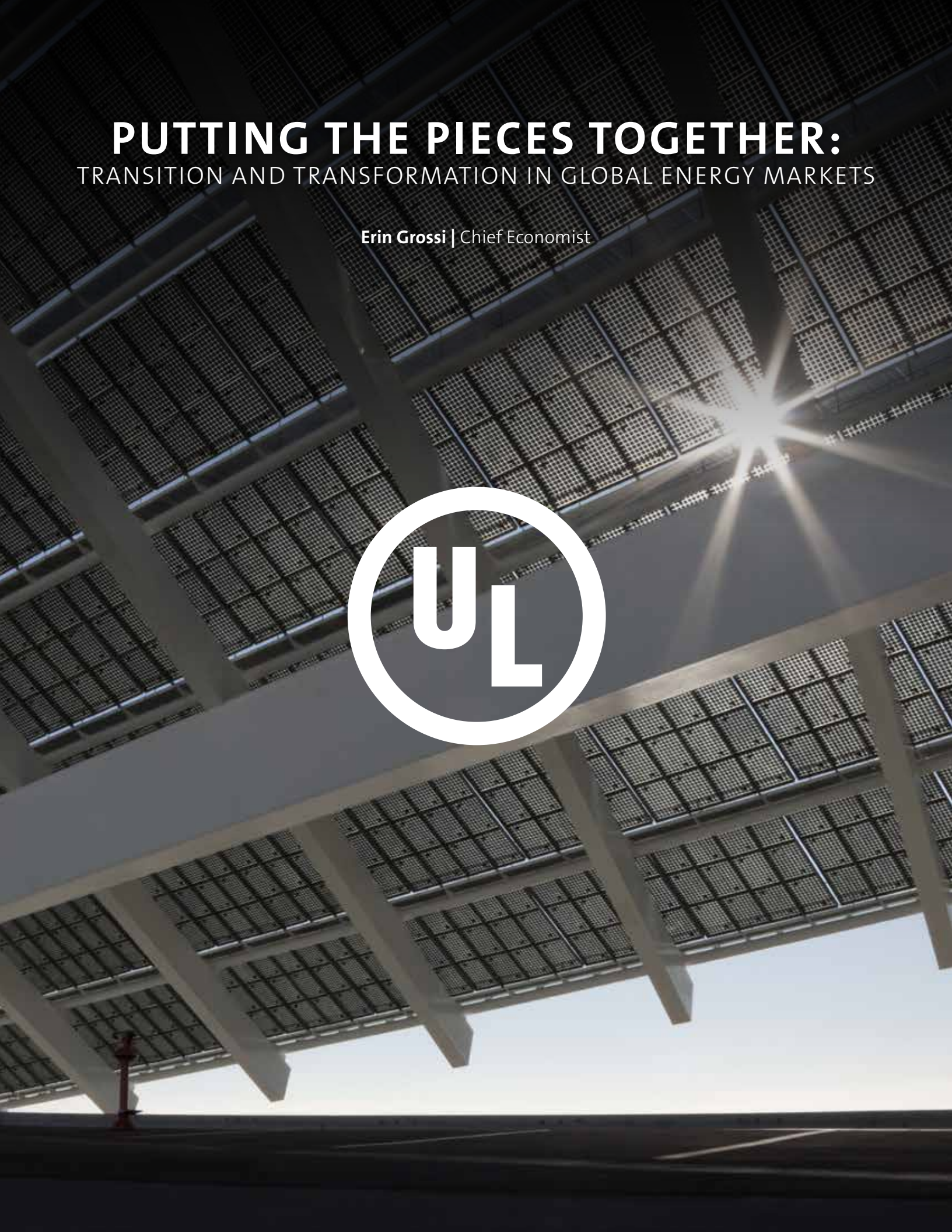

ABSTRACT

The industrialized nations of the world have made a number of mistakes in developing and deploying renewable energy sources over the years. Several publications produced by the National Academies of Sciences have pointed out examples of governments failing to sufficiently focus on and invest in technological research and the commercialization of product ideas generated in places like national laboratories, universities and think tanks. Instead, they have often favored the practice of making risky bets, subsidizing technologies that the market in certain cases did not perceive as valuable and was not prepared to absorb. Yet, for all of the errors documented in media headlines, today in 2015 it is clear to most constituents in the energy sector, and even in the broader mainstream marketplace in wealthy nations, that renewable energies are on the march and quickly gaining momentum. Germany deserves a lot of credit on the world stage for the progress renewable energies have made, primarily as a result of its own major bets on the technology. In fact, Germany's decision to close all of its nuclear power plants by 2022 brought about one of the biggest gambles ever made by an industrialized nation on renewable energy technology. The question of whether Germany would be able to meet its own tough climate change targets without harming its manufacturing and industrial sectors is a real and serious one, which many across the globe have asked and wanted to answer.

It was with this bold risk-taking on Germany's part and questions about its prospects for success that UL's Chief Economist engaged the energy ecosystem in Germany and the United States to understand why Germany, currently the fifth largest economy in the world, would take such a significant economic risk on renewable energy, why they believe they will ultimately be successful with it, and what the United States and other markets could contribute to and learn from the German experience with its attempt at an energy transformation. The result of this engagement is a clearer picture of what it takes to achieve transformative results in the energy sector, as opposed to a long, winding transition. What the research also makes clear is the way that technology innovations and digital disruptions in the energy space, developed and commercialized in the United States, are poised to put an energy transformation within reach for many more countries around the globe, including Germany. However, it is not as clear today whether or when this transformation will take place at home.

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PUTTING THE PIECES TOGETHER

UL's Chief Economist finds that the German experience with distributed power and renewable energy to date is evidence that the question of the *feasibility* of a technologically sound and economically responsible transformation has been answered. Germany continues to advance its energy agenda without any significant technological or economic disruption on the home-front in sight. Now, the biggest questions on the table are how best to combine Germany's engineering "know-how" on balancing the grid at scale with increasing levels of renewables being added, with US technology innovation prowess across a wide range of renewable energy products, in order to speed energy transformation around the globe and make it increasingly economically attractive in the process. As old methods, systems, and technologies fade and reach end of life, they will be replaced by new ones that carry with them the promise of new industry and value creation in the marketplace, not to mention the associated benefits for people and planet.

The distance between clinging to the old and embracing the new in the energy sector is ultimately closed through an evaluation and assignment of certain *values* and *beliefs*. Views about climate change and its causes, energy and its ties to national security, and a country's assessment of its own industrial strength and vitality shape related policy and market actions, and determine whether countries will achieve energy transformation and all the benefits associated with it, or will fall behind in a protracted transition process. While the United States and many other countries are still considering their options in this regard, Germany has gotten out ahead by making clear decisions based on its values and beliefs, and focusing on implementation. No matter where a country stands in terms of energy transformation, UL believes all can benefit from greater understanding of the process from an engineering and technology standpoint, as well as the related market implications. UL's Chief Economist invites all individuals and organizations who believe that an energy transition and transformation to distributed power with increased renewable sources of generation is taking hold across the globe to work with us to develop broad consortia efforts to address the important technology and innovation questions involved with securing smarter, resilient, environmentally-conscious and economically-viable energy systems for the future.

THE DECISION TO "TRANSFORM" DRIVES THE RENEWABLES MARKET

The rest of the world has kept an eye on Germany in recent years, as the country has set an astonishing pace for increasing the amounts of electricity generated by renewable sources. Indeed, the country passed the 30% marker in 2014, and plans to reach 40-50% renewables countrywide by 2025 and as much as 80% by 2050. While the United States produces far more renewable energy than Germany does in terms of overall quantity, it has so far only managed to get renewables to about 13-14% of total generating capacity, though most of that is big hydro today. The differences are vast between the two nations and many studies have illuminated issues of scale, policy, homogeneity, and the condition of existing energy infrastructures in order to dilute any "apples to apples" comparisons about the two national journeys toward a renewable energy future. That said, the biggest difference between the two in this regard, which is least often mentioned but actually most important is that Germany's federal government has made the decision to *transform* its energy market. The *Energiewende*, literally translated to English as "energy turnaround," is the name given to the combined set of intentions and policy prescriptions that have been developed to shift Germany to an energy portfolio dominated by renewable sources, energy efficiency and sustainable development.

THE BIGGEST DIFFERENCE BETWEEN THE TWO…IS THAT GERMANY'S FEDERAL GOVERNMENT HAS MADE THE DECISION TO *TRANSFORM* ITS ENERGY MARKET.

While it is true that the *Energiewende* has a strong policy connection and is led by Chancellor Angela Merkel herself and her administration, the fact that the desire to phase-out nuclear power completely and restructure the energy sector is now shared by at least 85% of the German population is something that does not get enough recognition. Indeed, even as the German regulator overseeing the transformation, the Federal Ministry of Economics and Technology (*Bundesnetzagentur*), describes that German customers have endured a variety of cost increases, including a Renewable Energy Surcharge (RES) increase from 0.9 cents per kilowatt hour in 2000 to 6.17 cents per kilowatt hour in 2015 to support the infrastructure transformation, the majority of the country remains solidly supportive of the technological shift that is taking place. Dr. Nadia Horstmann, Head of the Section on International Energy Coordination for the agency says that "German customers do feel the impact of the green revolution and want to see that prices will eventually go down. 2015 marked the first year that RES charges actually did go down in over a decade, but while it may stay steady or decline slightly in the future, it will never get back to previous price levels."

Why is the vast majority of the German population supportive of shouldering the economic burden of transforming its energy system and influencing the global one?

There are a number of reasons, but four emerged as most prominent in our conversations across the country with key stakeholders in Germany's vast energy ecosystem.

1 The German populace generally values the environment and is concerned about the contributions to climate change made by its old fossil-based energy system.

2 Most Germans agree that nuclear power as a clean substitute for fossil fuels poses concerning challenges, including the safety issues most recently highlighted by the Fukushima Daiichi disaster of 2011 in Japan or by Chernobyl in 1986. Germans are also concerned about how and where to dispose of nuclear waste, not to mention the ties between nuclear technology and nuclear weaponry that bring with it serious international security issues.

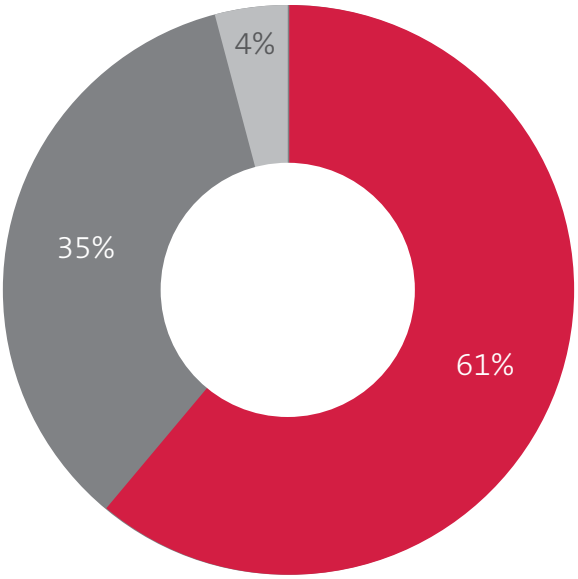
3 Germans typically agree that achieving higher degrees of energy independence is beneficial to the country's national security goals, including relief from the high costs of natural gas in the region.

4 Perhaps one of the most evident reasons Germans are supportive though is because the country is approaching the effort as an engineering challenge that their experts already feel confident they can solve and will eventually master. In so doing, they will create new, productive industries in the country that will create value and bolster the economy well into the future.

AS A WHOLE, THE COUNTRY (THE UNITED STATES) IS LESS IN A STATE OF *TRANSFORMATION* AND MORE IN A STATE OF *TRANSITION*.

Even utility representatives in Germany today agree that the energy transformation is both technically achievable and inevitable. Clemens Cremer, Group Expert on Energy Economics and Markets for EnBW, one of the four national utilities, indicates that it was only in the last five years that the company realized the energy transformation in Germany was going to be a lasting policy. He notes that the country was more divided on the issue in the 1990s and EnBW, like the other major utilities, was waiting for a Conservative regime to come to power and make revisions. It was not until 2010 that they realized the policy would be permanent. "Even in 2008, when I joined the company, we did not really feel the energy transition. The investments we were making in renewables were based on an old mentality. For instance, since off-shore wind is expensive and not open to many other investors, we focused there first." Today, Cremer notes that EnBW is engaged in a massive race to reinvent itself through innovation, considering new products and services it could offer in home automation, wind farm maintenance, and even smart street light design. "We need to learn how to work with customers in different ways. For a long time, we were known for providing reliable power," says Cremer. "People have much more demanding expectations today for utilities, including providing energy innovation."

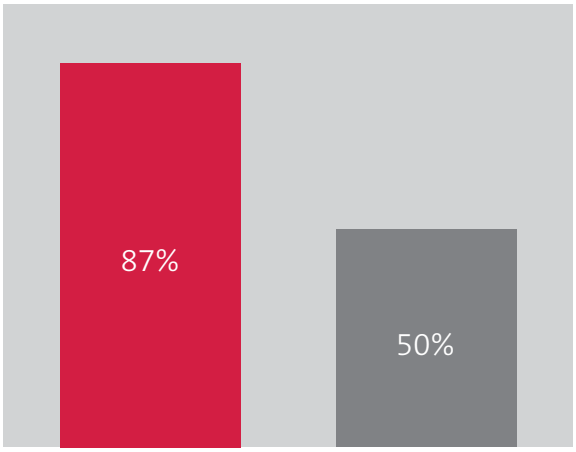
While Germany has definitively announced its intention to *transform* its energy system and has taken major steps to actualize that goal, the United States as a country has not yet done these things. There are forward-leaning states like California, Hawaii and New York that are really pushing hard from both a regulatory and a market perspective to achieve massive changes to make their grid systems more sustainable, and even cities like Burlington, Vermont and Aspen, Colorado that have taken similar actions independent of their states. But, as a whole, the country is less in a state of *transformation* and more in a state of *transition*, with largely uncoordinated approaches being taken in uneven ways and in fits and starts across the nation. US President Barack Obama has been consistently supportive of a transition in the energy sector away from carbon emitting fossil fuels and toward clean and renewable ones that are better for the planet throughout his presidential term. In November 2014, the United States and China announced the countries would meet a target of reducing greenhouse gas emissions by 26-28 percent below 2005 levels by 2025 and increase the share of non-fossil energy sources to 20% by 2030. In August 2015, the US Environmental Protection Agency finalized a Clean Power Plan as a strategy to combat climate change that involves decarbonizing the power sector. The Plan has measures that collectively are estimated to achieve 32 percent reduction in carbon pollution, mainly from retirements of coal-fired and relatively inefficient natural gas or oil-fired power plants, accounting for one-third of domestic greenhouse gas emissions.



61% of Americans believe the earth is getting warmer

35% of Americans disagree

4% Other



87% of scientists believe human activity is driving global warming

50% of Americans believe human activity is driving global warming

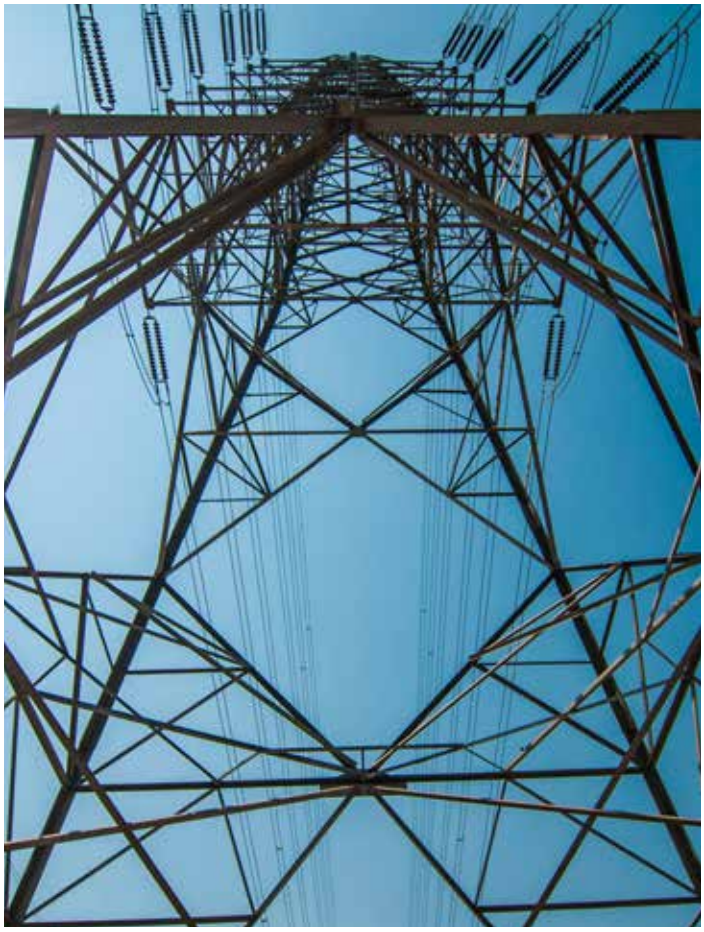
However, while the Clean Power Plan commitment to greenhouse gas reductions emissions may seem to some like a real mandate for *transformation* in the energy sector, the fact is the proposals were weakened by persistent political divisiveness on climate issues and because they were shaped in light of the series of legal challenges that are sure to follow its implementation. The views of the American public at large are changing about the value of the environment. Climate change, though, remains an issue where most people are divided along ideological lines. A 2014 Pew Research study on Political Typology found that 61% of Americans believe the earth is getting warmer, compared to 35% that disagreed. While 40% said they believe the warming is caused primarily by human activity, 18% of the public said they think the warming is primarily the result of natural environmental patterns.

A 2015 Pew Research study comparing a sample of responses from average citizens with a sample of responses from scientists connected to the American Association for the Advancement of Science (AAAS) noted some gaps in perceptions between the two groups that have not changed much since the prior poll was taken in 2009. For instance, while 87% of the scientists said that human activity is driving global warming, only half of the American public (50%) in that poll ascribed to this view. Yet another 2014 Pew Research Poll conducted along with *USA Today* on public views about global threats and America's role in solving them showed that climate change issues are closely aligned with political affiliations. For Democrats, global climate change registered among the greatest threats for 68% of them, while just 25% of Republicans viewed climate change as a major threat. Most Republicans said global climate change is either a minor threat (32%) or not a threat (40%) at all. It is unsurprising then that the 2012 Republican field of presidential candidates were made up of climate change skeptics, and as the 2016 field is shaping up, the climate skepticism remains.

This lack of consistency around fundamental principles of climate change and its causes, not to mention its relative value or importance with respect to other major national and global security issues that require action means that the United States is left with something short of a *transformation* mandate. Instead, we find groupings of people at the state or city level that either share an ideological affiliation to the environment and combatting climate change (e.g. California; Hawaii; and Aspen, CO), and thus champion increased renewable technologies and advanced grid systems, or are more driven by the potential economic and security advantages afforded to citizens from a smarter and more effective and stable grid system (e.g. New York). The 2012 devastating weather event known unofficially as "Super Storm Sandy" in New York caused extremely destructive power outages that caused political leaders to examine distributed technologies more carefully in order to create a more resilient grid system. Realizing that they could potentially get ahead in the marketplace and take economic advantage of the wave of distributed technology and information technology resources exploding onto the market caused New York officials to identify economic reasons to drive a change in that part of the country. Even though a 2013 Gallup poll revealed that economic arguments do resonate with Americans, causing 75% of them to register support for more solar power, and another 71 percent to favor further development of wind power, there remain many disconnects on the overall drivers of energy system changes, or the *why* behind a change movement.

James "Jim" Chen, Vice President of Regulatory Affairs for Tesla Motors, believes that national security concerns should be driving more of an effort to overhaul the national energy system than they do today. "Half of our oil comes from overseas, with a significant portion of that coming from the Middle East and if it gets shut down, that is essentially economic warfare. We maintain a substantial military presence in the Persian Gulf to maintain the oil lines. We are spending tens of billions of dollars a year in the Middle East region, the same one that gives rise to terrorism and terrorist regimes." Of course, arguments like these have been articulated in the public domain by different constituents over the last several decades without much change in overall political and economic positioning on the matter actually taking place in the United States.

These disconnects around the more *values-based* issues, the kind which Pope Francis expounded upon in a sweeping 184 page papal letter on climate change in June 2015, precede even more disconnects in the United States on *how* best to achieve energy system change, which Germany has already found national consistency on as well.



THE ART OF THE POSSIBLE:
GERMANY FOCUSES ON ADDING RENEWABLES AND MAINTAINING GRID STABILITY

The story of Germany's experience over the last five years increasing the amount of renewable sources of energy to the power grids is essentially one about balancing the grid and keeping it stable. Across the nation in every part, regulators, transmission system operators (TSOs), distribution system operators (DSOs), and renewable energy suppliers are working together to ensure that Germany's long-standing record of having one of the most reliable grid systems in the world is not hampered by the intermittency of renewable energy sources like solar and wind. When they started the journey, most if not all of these professionals did not think it was going to be possible. As Clemens Cremer described, "A widespread mentality within the large utilities was that we could not put more than 10% renewables in because it would not work." Of course what traditional grid system operators had failed to anticipate was the creation of information technology tools and resources to help make balance achievable with higher levels of renewables.

A group of economists were among the innovators who did anticipate the need for technologies to assist in integration for the purpose of balancing. They developed a start-up called Next Kraftwerke when they were students at the University of Cologne. Today it is a large-scale virtual power plant (VPP) and a certified power trader on the energy exchange's spot market (EPEX). Next Kraftwerke was a small operation until 2012 when the German Renewable Energy Act was updated to allow VPPs to sell electricity directly into energy markets. Hendrik Saemisch, one of its Founders, said "When we were coming up with the idea of establishing a VPP we thought, what if renewables were able to assume the same level of grid responsibility as conventional power plants? We figured this would boost the amount of renewables in the energy sector. Today, our virtual power plant regularly corrects grid imbalances within minutes and our trading department currently sells more than 5 TWh of renewable energies per year, and we are just getting started."

Indeed, 30 VPPs including Next Kraftwerke are playing an essential role in the rapid increase in renewable energy in Germany, since they connect a wide variety of individual energy producers through sensor technology and sophisticated software tools that help the individual producers, many of them farmers with solar arrays on their fields, to market their electricity in the open energy market. They also serve as a central orchestrating authority to assist with grid reliability. The ability to direct distributed power suppliers to either ramp up production to deliver peak load electricity or shut down production to avoid an over-loaded system has allowed grid system operators in Germany needed flexibility to ensure grid stability as nuclear and coal plants have been taken off-line. The balancing market is also lucrative for Next Kraftwerke. The Founders indicate they made $180M Euro in 2014 and were profitable within the first few years of their existence.

The solar eclipse that took place on March 20, 2015 provided a key test of the VPPs' ability to provide enough flexibility to manage through and keep the grid supplied while roughly 80% of the sun's light across Europe was blocked for about 3 hours. While Saemisch indicates it was a challenge and that prices did surge and drop for a brief time that day, there were no power shortages and he feels the system could have handled even more intermittency without a glitch. Germany's power grid continues to perform as one of the most reliable in the world, with its System Average Interruption Duration Index (SAIDI) actually going down in 2012 and 2013 as the amount of renewables in the system went drastically up. The SAIDI measures the average yearly downtime per customer, and Germany's was 15.32 minutes in 2013, a quarter of the disruption the UK grid sustained and significantly better than the US grid as well. Handling challenges like the eclipse and keeping the grid stable has built confidence across the country that much higher levels of renewables can be successfully added. Saemisch captured the sentiment of many serious energy stakeholders in Germany today when he said, "It seems to be possible to integrate 100% renewables without larger utilities even being a part of it."

"WHEN WE WERE COMING UP WITH THE IDEA OF ESTABLISHING A VPP WE THOUGHT, WHAT IF RENEWABLES WERE ABLE TO ASSUME THE SAME LEVEL OF GRID RESPONSIBILITY AS CONVENTIONAL POWER PLANTS?"

— HENDRIK SAEMISCH, FOUNDER OF NEXT KRAFTWERKE

The traditional providers point out that it is not that simple. Dr. Martin Wolter, Head of the Division Interconnected Operation and Systems Security for 50Hertz, one of Germany's four transmission system operators (TSOs), points out that more VPPs will be needed, as well as more intelligent grid products such as phase-shifting transformers that can improve overall grid observability and control of power plants. Until then, the TSOs are still playing a significant role in the transformation, providing balance and forging grid connections with other countries to help manage grid congestion. He also points out the economic challenges associated with the energy shift, in particular the fact that overall energy demand is not rising in Germany, prices are still too low and now with the reduced government incentives for solar generation he feels the business case for introducing additional renewables into the system is challenged if not completely destroyed.

that costs were likely to plummet as fast as solar costs did when PV was incentivized for market acceptance in the country. The more significant reason batteries have not been a key focus for Germany's energy transition to date is because existing market players have been touting their own technologies as viable alternatives to battery storage.

Larger utilities point out that their hydropower is an effective alternative to electrical storage since it has the ability to quickly go from zero power to maximum output, while the VPPs note the flexibility they provide is effective, even at higher rates of renewable energy on the grid. More innovation thought and effort in Germany has gone into developing methods to divert and use surplus energy such as Power-to-Heat technologies, which also helps eliminate use of coal for heating in the country. It is clear that

One thing that could help bolster the business case for adding more renewables in Germany is battery storage. Wolter points out, "With the introduction of battery storage, PV generators can sell their energy early in the morning, fill battery storage midday and then sell again when the sun sets." Unfortunately, Germany has not been focused on battery storage technology and innovation, and large-scale batteries in particular are not common there. Some energy constituents in Germany suggested high battery costs pose a barrier to broader adoption, though they also said batteries are a technology laggard in Germany, even though most experts agree that they will need storage in order to successfully move beyond the 50% marker for renewable energy generation in the country. Batteries would also help on the consumer-side of the energy market in Germany, allowing residences to store energy and sell excess back to the grid in the future. Batteries for residential use could also help support an increasing demand for electric vehicles in the country, which most experts anticipate will happen there over the next five years.

THE QUESTION THAT GERMAN ENERGY STAKEHOLDERS HAVE BEEN ASKING AND ANSWERING IS *HOW* THE COUNTRY COULD ADD MORE RENEWABLE ENERGY SOURCES WITHOUT COMPROMISING THE RELIABILITY OF THE GRID.

Felix Dembski, Head of Smart Grids and Energy at the German Association for Information Technology, Telecommunications and New Media (BITKOM), also indicated that consumers there were difficult to reach with smart home automation technologies. According to Dembski, the German government issued a mandate for a smart meter rollout which will cover all households with a yearly electricity consumption of more than 6,000 kWh beginning in 2017. This measure has gotten a lot of pushback from utilities that feel the equipment is too expensive to be useful given the low prices of electricity today and that demand in Germany will be low. While most energy experts agree that German consumers are not clamoring to manage their energy usage today, BITKOM believes the government selected the right level of residential consumers to target with this initiative. They further believe that sending price signals to homes that reflect overall grid stress will create a boom for energy saving technologies like automation systems as customers begin to modify their behavior to take advantage of lower prices and avoid usage at peak times. Dembski explains, "We would be well advised to build that infrastructure, because it is the basis for innovative and consumer-friendly applications. This is how digitization has always worked. Nowadays, a credit card is more than a digital savings account. Smartphones are more than a mobile phone. And the same is possible for energy – as long as we all work together. As it is, there are too many stakeholders who are racking their brains to think of reasons why having this interaction with the energy system might not make sense after all. Too expensive, too complex, no demand – that's exactly what they said about renewables 15 years ago."

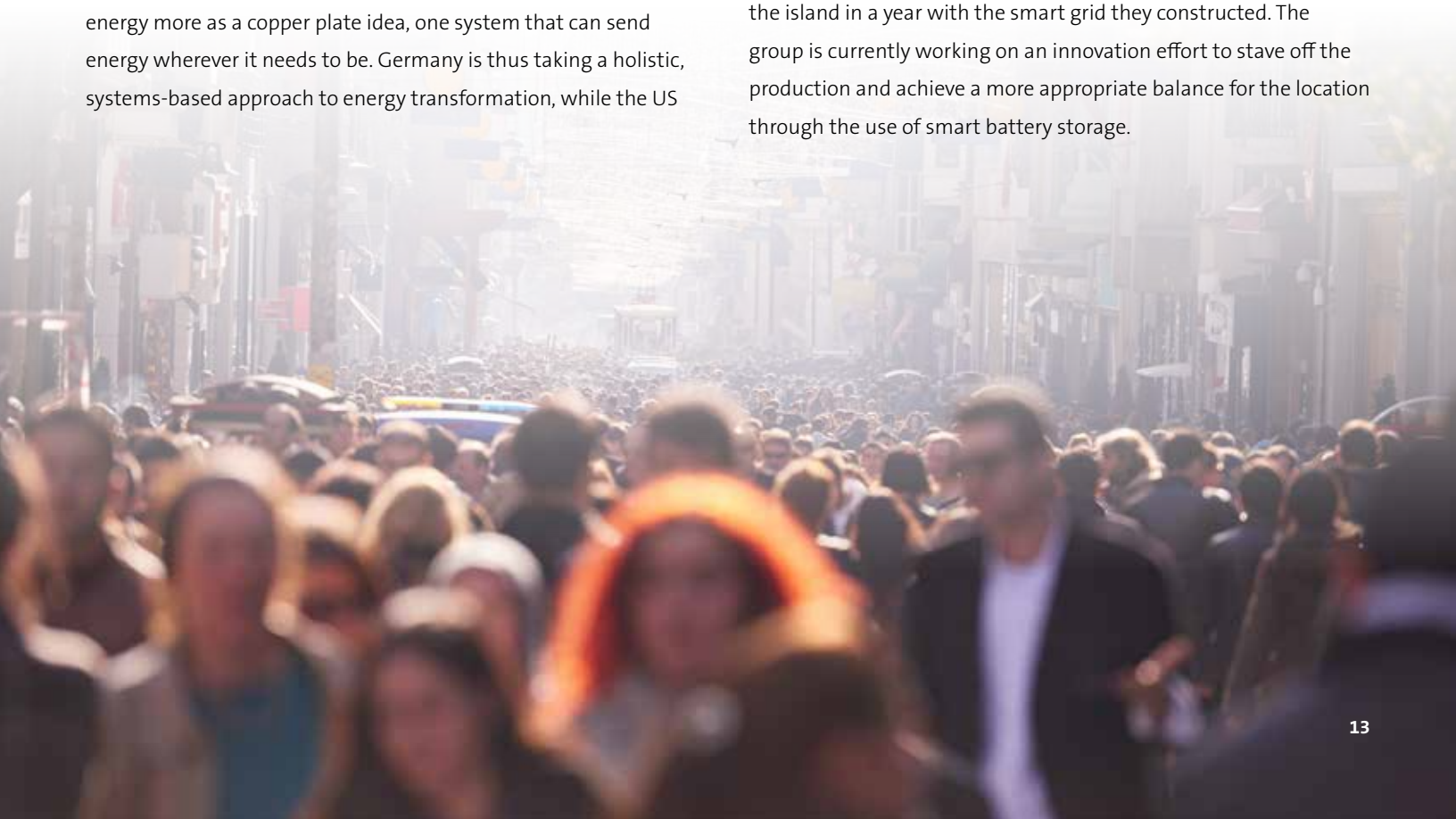
Along with smart meters and automation systems, Dembski points out that Germany is going to need IT security management systems for all grid levels, as well as a variety of grid monitoring and grid diagnostic systems over the next 5-10 years as the energy transformation matures and expands its reach across the country. Jan Luca Plewa, International Representative for the Renewable Energy Hamburg Cluster Agency, a business development association for the renewable industry sector, agrees that the case for smarter grid technology is finally being made in Germany today. He indicated that sensors and storage technology would be needed soon in order to better manage grid congestion. "We need the IBMs and Googles of the world to come to Germany and help us become data business people. We need experts that deal with information rather than electricity to help point the way forward from here because grid communications will be incredibly important to our future."

The energy transformation in Germany to date has largely been engineering focused. The question that German energy stakeholders have been asking and answering is *how* the country could add more renewable energy sources without compromising the reliability of the grid. They have managed to find the right levers from a policy perspective to drive an increase in solar and wind technologies and to get those loaded into the grid while utilizing technology tools to keep the grid stable. As the country's energy leaders become more proficient at this task of balancing, the focus shifts to developing the appropriate business cases to drive the next level of maturity and sophistication to the transformation that is underway. Questions now abound on how to integrate storage technologies, how to connect better and more to different parts of the country and other countries in the European Union, and how to smarten the grid to achieve the ultimate goal of a responsive and resilient grid system. While Germany has been nearly all-consumed with grid stability and management concerns so far, it is remarkable that the United States has been able to develop energy innovations in the exact areas that German constituents are now pointing out are their technology needs in order to reach the next levels (50-60% and beyond) of renewable energy share in the country.

UNITED STATES' INNOVATION SUCCESSES CAN FILL GERMANY'S ENERGY BLIND SPOTS

One of the most interesting dichotomies between Germany and the United States when it comes to energy sector transition and modernization is that while grid balance and maintenance issues are paramount in Germany, they tend not to hold the attention of most American energy experts and innovators. While German engineers have embraced the weighty challenges associated with maintaining grid integrity in the renewable age, the topic simply has not proven to be enticing enough on this side of the Atlantic. In the United States, the topic du jour has been all things "smart," from buildings, to grids, to technologies and cities, American innovators and entrepreneurs in the energy space are often more inspired by the idea of "the network," which is purposely fragmented and highly conceptual. In Germany, they think about energy more as a copper plate idea, one system that can send energy wherever it needs to be. Germany is thus taking a holistic, systems-based approach to energy transformation, while the US is embarking on more of a piecemeal effort at this point, fueled mostly by innovative companies and entrepreneurs rather than regulators and utilities.

It is not that Germany is uninterested in a smarter energy system; rather the country has tended to focus on it in the context of demonstration projects, such as the island micro-grid in Pellworm. There, energy experts and engineers are loading the grid with smart meters and batteries and working to gain grid visibility and management control to keep the system balanced with the introduction of increasing levels renewables. Dieter Haack, representative for the SmartRegion project on Pellworm Island, indicates they produced three-times what they needed to power the island in a year with the smart grid they constructed. The group is currently working on an innovation effort to stave off the production and achieve a more appropriate balance for the location through the use of smart battery storage.



While research and experiments are happening in remote locations like these in Germany, the United States has started the mainstream commercialization process for battery technologies, automation systems, grid interconnects and a variety of information technology tools that can manage grid activity. While the US lacks a clear transformation vision and intent across the country and also a centralized focus and the discipline to connect and balance the grid systems across the nation, adding distributed battery resources where needed, US-based entrepreneurs have made independent business cases to develop and bring to market a variety of technologies that Germany will ultimately need to support its own transformation.

Elon Musk's recent announcement that his company Tesla Motors, known for its high-end electric cars, will start selling batteries to power homes, businesses, and utilities was a game changer for the battery technology industry as well as the renewable energy industry. The products, which will cost approximately $3500 for Powerwall home systems and about $25,000 for Powerpack business systems, are expected to begin shipping to customers later this year. The home system will store 10 kilowatt hours, enough to power the average American home for about eight hours. The Powerpack industrial unit is a cabinet-and-rack system which can theoretically be expanded by filling the racks with additional 100 kilowatt capacity units for up to 500 kilowatt hours. Multiple units can be connected to create a capacity for 10 megawatt hours. Most analysts believe the price point puts the storage technology within reach of wealthy individuals and certainly cutting-edge businesses, particularly in areas of the United States where electricity costs are higher than the national average. Their size alone allows them to absorb and amortize these higher costs for newer technology. While the payoff periods for Powerwall technology combined with solar panels may still be out of reach for average consumers and businesses in the United States, it is clear that the market will converge to improve on Tesla's technology and can bring costs down in the same way that happened to solar panels. The company's Founders kept its patents on the technology open to help ensure this would happen.

Tesla announced publicly that, to date, 90% of the customers reserving the Powerpacks are utilities. Indeed, there is a growing group of utilities in the United States that are seriously considering using battery storage to maintain grid balance and stability as more renewable sources are added to grid systems. This is an obvious possibility now for German Transmission System Operators as well, to add stability measures as new levels of renewables are added. Tesla expects the price of batteries to drop quickly. Producing out of the Gigafactory in Nevada alone is expected to shave 1/3 off of the existing price. One of the Founders, JB Straubel, believes the batteries will experience an 8-13% improvement in power density and cost reduction year-over-year moving forward. Some analysts, recalling the rapid commercialization of solar panels fueled by China's industrial machine, believe the price will drop as much as 50 percent over the next three years, putting them well within in range of mainstream market constituents.

In terms of sensing technologies and data-driven solutions for managing grid systems, both IBM and Cisco are making significant contributions to the enhancement of grid visibility, control systems and security. To date, IBM has targeted utilities as their desired customer of the future as well, promising to help them gain visibility and a central point of command and orchestration for a new distributed grid system that maximizes efficiencies, allows for higher amounts of renewables based on market demand, and leverages a variety of technologies, including large-scale batteries, for flexibility and stability. Just as the cloud is revolutionizing business practices, IBM proposes using cloud technologies to better manage the grid and its associated data, leading to reduced costs and optimization unlike anything that exists today.

Organizations like UL and the International Electrotechnical Commission (IEC) provide meaningful venues for international exchanges and joint-work on requirements for intelligent products and grid systems, driving forward engineering and commercial progress in the sector. One particularly bright spot for German-American collaboration on technical matters related to distributed power and the creation of smart grids today is through membership and participation in the IEEE (Institute of Electrical and Electronics Engineers). The organization serves as a hub for experts from around the globe who want to share best practices and information, and also develop and harmonize a range of needed product and systems standards for the industry. Inverters are one important product category where Germany has provided significant technical knowledge and expertise to standards development that American and other global experts have contributed to and honed. Patrick Ryan, Executive Director of the IEEE Power and Energy Society, says that the organization is focused on bringing engineers together, breaking down barriers and making connections for them that advance the overall thinking about energy innovation. “Smart grid terminology itself is something that scares a lot of traditional engineers because of its unfamiliarity. We often encourage the engineers and technologists to not kill the goose for that reason. After all, the terminology is familiar to the general public and offers us the opportunity to modernize the grid from a distribution, transmission and utilization standpoint. In the end, the terminology actually ends up allowing for a lot of new communications and sharing to happen in the sector.”

CONCLUSION: MANY IN THE DEVELOPING WORLD WILL LEAPFROG TO A SMART AND DISTRIBUTED ENERGY SYSTEM

Research conducted by UL's Chief Economist indicates the United States and Germany are not collaborating enough today on finding potential energy solutions or adopting each other's technology developments to a large enough extent. The time has arrived for the two leaders to start sharing information more broadly about balancing and managing renewable energies at scale on the grid, in Germany's case. The United States must increasingly share its technology knowhow at a product level for batteries, interconnects, and intelligent automation devices of all kinds, not to mention US-based data management and analytical capabilities. It is easy to get bogged down in what is different between the two countries and systems, but this kind of intelligence is internationally relevant and able to be harmonized and leveraged by the different energy ecosystems. Contribution and collaboration on standards development in these areas is also needed. While Germany contemplates the fact that a 100% renewable energy future is now within its technical grasp, the United States continues to add meaningful contributions through a wide range of technologies, including digital ones, that German engineers now realize are needed to actualize the transformation. The impact of innovations such as end-to-end data analytics and flexible long-duration storage technologies being worked on by a number of US-based companies are just a couple of the technologies that are capable of enabling some dramatic shifts in the energy value chain over the next five years.

THE COMBINATION OF KNOW-HOW...AS WELL AS DESIGN AND IMPLEMENTATION... WILL ALLOW FOR A MORE RAPID DEVELOPMENT AND IMPLEMENTATION OF SMARTER GRID SYSTEMS IN MANY DEVELOPING NATIONS, WHERE MORE THAN A BILLION PEOPLE LACK BASIC ACCESS TO ELECTRICITY.

As the German constituents UL engaged for this study pointed out, the United States has a number of challenges to overcome as it transitions its grid system to one that is cleaner, more efficient, distributed and resilient. For one thing, significant efforts need to be made just to rehabilitate the grid in certain parts of the country as a result of neglect and aging of the equipment and systems. In that way, Germany started from an advantaged position, having a more reliable and well-maintained grid system to begin with. Most of Germany's transmission and distribution systems were destroyed and replaced after World War II, whereas the US has much older and less reliable and resilient grids in large parts of the country.

Transformation is even more uncertain when decisions are largely in the hands of large utilities that, in some cases, lack either the profit incentives or the regulatory authority to make major investments to the existing grid system. That said, the growing energy markets in Europe, Greater Asia, and Africa are now poised to contribute to the rapid commercialization of a range of associated products, bringing down prices for needed equipment like batteries, smart utility-grade and consumer-based sensing equipment and automation technologies of all kinds, which will make investments in these enhanced systems more economically attractive for US-based utilities and other energy constituents. It is clear the United States is a power-house of entrepreneurial activity and technical prowess in the energy sector, so it will only continue to contribute significantly to the commercialization and rapid deployment of these technologies to a great extent in its own territory, but perhaps to an even greater extent in other parts of the world.

The combination of know-how regarding grid balance and stability, as well as design and implementation of distributed energy products will allow for a more rapid development and implementation of smarter grid systems in many developing nations, where more than a billion people lack basic access to electricity. Very similar to the way nations of South East Asia, Latin America and Africa are leap-frogging traditional telecommunications technologies in favor of moving directly to a wireless world, these countries and others can also consider the merits of leap-frogging energy systems to be more distributed and efficient from their inception.

The contributions these countries make in terms of driving focus and demand for distributed power technologies will ensure increased innovation, as well as a corresponding overall price reduction of the equipment over time. These countries also have more latitude to design an effective range of business models (e.g. community sharing, independent, or utility-supported) for their energy sectors, which the United States struggles with in the face of its vast and complex energy network. The utility industry in the United States, like most industries, works in its own economic self-interest and, in many parts of the country, is impeding innovation in the sector in order to force the sharing of related cost burdens with a broader set of constituents. One of the problems with this situation is that utilities are dealing in public necessity goods, not mere commodities, which means their commercial stances inevitably raise important values questions for society to grapple with.

Private energy and technology entrepreneurs across the nation are increasingly making utilities pay for adverse positions to innovation by developing the required products to achieve independence from the grid in advance of utilities being involved in the process. From microgrids increasingly used on university and medical campuses to Fortune 500 companies willing to invest in enough renewable power and battery technology to produce and store energy for their own company usage, these groups are taking money off the table for utilities and making them re-think their stances in terms of owning and financing systems and equipment.

The more utilities and other constituencies within the energy sector in the United States begin to realize and accept the fact that energy transformation is both feasible and desirable for the country, in order to achieve a more environmentally responsible, resilient, and smarter energy system that catalyzes the creation of several new industries, the more the country will also see that the pricing of related distributed equipment will start to become more of a tool and less of an obstacle to the overall change process. What Germany realized through manipulating pricing matters for certain pieces of the distributed system, by offering heavy subsidies for a time to solar and wind generators for example, is that they could put pressure on pricing where they wanted to generate a corresponding behavior change, and adapted the level of pressure in flexible ways as the overall transformation process occurred.

When German regulators recognized that they were making solar too cheap and the system was getting overwhelmed with it at the expense of the needs for grid balance, its regulators reduced those incentives and focused on demand reduction incentives instead. It is likely the United States, some regions perhaps sooner than others, will find itself in a similar situation to Germany, with the need to consider raising electricity prices in order to catalyze the energy efficiency market in the commercial and residential building market, for instance. The ability to combine new market-based pricing with signals to customers through building automation products that can give insight into grid stress in real-time is one of the major milestones to normalizing pricing in a distributed power market. There are many milestones to be achieved in advance of this one, which Germany is already well along the way to achieving. The United States, to the extent it can muster a change in overall mindset and philosophy in the energy sector, could evolve its intentions to achieving a national transformation as well.

It is important for the various stakeholders in the US energy sector to recognize that the pricing of individual elements of a distributed system (e.g. PV panels, wind turbines, inverters, batteries, etc.) can continue to be held up as barriers to adoption of smarter and renewable grid systems overall. However, an energy transformation requires systems thinking, which in turn requires coordination. While Germany's energy system is different from the United States, the country has proven that it is possible to achieve a level of coordination between the various constituents in the energy sector to drive significant change to the grids in a relatively short amount of time. If the United States can figure out a way to harness the engineering know-how that Germany has developed in grid stability with renewable energy at scale, and combine that with its technology prowess with sensors, IT control systems and products, and data analytics, most of the battle will be won. If the US can also work together with Germany and other global stakeholders to commercialize battery storage and bring prices down there, all of the most important pieces of a distributed power system will be in place.

In the end, UL's Chief Economist predicts a much more decentralized, resilient and smarter energy future globally will take hold over the next decade because global market movers in the world are already recognizing that that distributed power makes a major contribution to environmental challenges, is technically feasible with today's mechanical and electrical engineering and information technology resources, and allows for the creation and development of a broad range of new commercial industries for related equipment, standards, systems, and information resources. Some will continue to cling to the past and wrestle with antiquated thinking and systems while the countries and industrial players that stand the most to gain from an economic standpoint will all be working and contributing to the world's brighter and stronger energy future.

*This study was completed with the assistance of Lismore Advisors, combining outside-in perspectives with inside-out understanding to accelerate business value (**www.lismoreintl.com**).*