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# Toward a Distributed-Power World

*Renewables and Smart Grids Will Reshape the Energy Sector*

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# Contents


## What Will Disruptive Power Changes Look Like? 2

The Evolution of New Energy Technologies 5

The Impact of Distributed Generation 6

## Enablers for a Distributed-Power World 7

The Hardware Needed 7

The Role of Government 8

New Business Models 10

## Distributed Power: Risks and Opportunities 11

The Risks of Not Taking Action 11

The Potential Opportunities 12

## The Imperative for Action 13

# Toward a Distributed-Power World

*Renewables and Smart Grids Will Reshape the Energy Sector*

Europe's power utilities are entering a period of great uncertainty and change, with seismic shifts transforming the energy landscape. Energy security concerns and related worries about price and political volatility are driving governments across Europe to reexamine the source of energy supplies.

Meanwhile, the climate imperative has moved up the agenda, with European policymakers expressing clear political support for the move to a low-carbon society. European Union targets for 2020 aim at reducing greenhouse gas emissions by at least 20 percent from 1990 levels, applying energy-efficiency approaches to cut usage by 20 percent compared with projected levels, and having 20 percent of EU energy consumption come from renewable sources—collectively known as the 20-20-20 targets.

In the face of these security and environmental concerns, one scenario is a partial continuation of the status quo: carbon reduction targets would be met by expanding the use of both large-scale renewable-energy and conventional technologies such as nuclear power and by developing both large-scale renewable-power generation and carbon capture and storage, which would allow for the continued burning of coal for electricity.

In this paper, however, we focus on another potential development for European power generation: prospects for a distributed-energy system in which decentralized and renewable-power generation eventually displaces conventional power plants, reducing the balancing role of the transmission grid and shifting intelligence to the distribution grid through the creation of local and regional energy systems. This scenario is much more disruptive because it transforms many of the industry's common beliefs. It does create many more opportunities for business model innovation. However, it also presents severe challenges to the leading incumbents.

Meanwhile, the regulatory landscape is also evolving rapidly. With political will gathering behind the ambitious 20-20-20 targets, renewable energy is entering the portfolios of power generators at a rapid pace. Promoted by a wide range of subsidies, renewable energy is claiming increasingly large proportions of the power supply. Solar power and onshore and offshore wind power have emerged as prominent sources of energy, with many—such as solar—coming from distributed-generation plants.

At the same time, the old centralized systems that deliver a one-way supply of electricity to consumers will be increasingly displaced by localized generation, and the future power landscape will include a larger proportion of small-scale sources, such as cogeneration through combined heat and power (CHP) plants. Moreover, some energy will be produced by consumers themselves, through a distributed network of power that incorporates everything from rooftop wind turbines and solar panels to CHP microplants (micro-CHPs) in consumers' cellars.

In the process, conventional power generation will assume a less prominent position in the hierarchy of energy technologies, with centralized power plants facing lower use as the demand for and availability of cleaner sources increase. Meanwhile, power utilities will be required to strengthen their role in balancing increasingly complex ranges of fluctuating energy sources, especially renewables and microgenerated power.

Utilities will also need to develop new business models to maintain the profitability of traditional power generation. These will include increasing the flexibility of their generation fleet, or power plants, to enable them to profit from price fluctuations and, potentially, from fees for providing backup capacity rather than from hours of power sold in the day-ahead market. Utilities must act to bolster revenues as their traditional-generation business model fades with the reduction in annual running hours of power plants. They will also need to invest in smaller decentralized technologies, "smart" flexible power plants, and sophisticated energy-management systems so that they can capitalize on the increasingly diverse range of power sources coming into play.

Some liken these trends to the history of the information technology industry, which moved from the mainframes that dominated computing in the 1970s to client-server and networked computers in the 1980s and 1990s and then to the open systems that exist today. Cloud computing allows users to share software and data over the Internet, without a centralized processing system.

And if the evolution of the energy sector is starting to reflect that of the IT sector, the IT sector is also invading the energy sector's territory, particularly through a further transformation in how power is managed—the implementation of smart grids. Smart grids (which use digital technology to allow greater visibility of energy use and power flows), supported by smart meters, allow bidirectional communication between utilities and customers, facilitating a two-way flow of electricity. Smart grids therefore create the possibility for more flexible pricing mechanisms and the opportunity for both private and corporate consumers to contribute to the power supply as "prosumers," who switch between net production and net consumption of power.[1]

This paper, based on extensive research, interviews with industry experts, and forward-looking analysis conducted by The Boston Consulting Group, examines these disruptive changes and the factors shaping the new decentralized-power landscape. We also discuss the implications for utilities and the risks and opportunities they face as the power sector undergoes its biggest transformation since Thomas Edison's invention of the light bulb.

## What Will Disruptive Power Changes Look Like?

Today, the electricity value chain is structured as a sequential, centrally organized process—from generation to retail. Large power plants are scattered across Europe's major centers of consumption, feeding power through the grid. Business models of utilities have been based on the premise that utilities provide a simple commodity, with operational strategies focused on reliability of supply, one-way flow of power from provider to consumer, and energy sales that use simple "all-you-can-eat" pricing structures for private customers. Under this old model, companies have been able to prosper, achieving high generation margins on the back of rapid economic growth and soaring commodity and energy prices.

This model is no longer sustainable. In order to maintain this current system, utilities would need to invest heavily in the renewal of their aging infrastructure. Studies of the utilities in Germany forecast investments of €40 billion to €50 billion for the renewal of the conventional generation fleet by 2020, and the United Kingdom is expected to see investments of €20 billion to €30 billion during the same time period. However, the political drive toward cleaner energy is creating barriers to the construction of new power plants. These barriers are driven both by resistance to new large-scale plants and the challenges to profitability resulting from fewer expected running hours.

Furthermore, power companies are experiencing a loss in demand as factories cut their output in the face of recession. Despite signs of an upturn, it is likely that through 2020, power demand will remain relatively flat because of a lengthy economic recovery, the risk of additional deindustrialization, and only moderate GDP growth in Europe. Demand is being further constrained by the continued focus of both governments and businesses on increasing gains through energy efficiency. Throughout the European Union, for example, standards promote energy-efficient air-conditioning and other systems as ways of cutting the emissions generated by the built environment. Aggressive measures to reduce these emissions more broadly are also undermining the status quo.

At the same time, an increasing share of renewable and other forms of decentralized energy is entering the power supply. We project major growth in wind power, solar-photovoltaic (PV) power, and CHP

1. The term "prosumers" is used to indicate market participants who are both producers and consumers of power. At some points in time they feed power into the grid, and at others they need additional power.

(especially small-scale plants) in the European Union's 27 member states (the EU-27) by 2020, and that decentralized generation will account for as much as 40 percent of the installed base by that date.

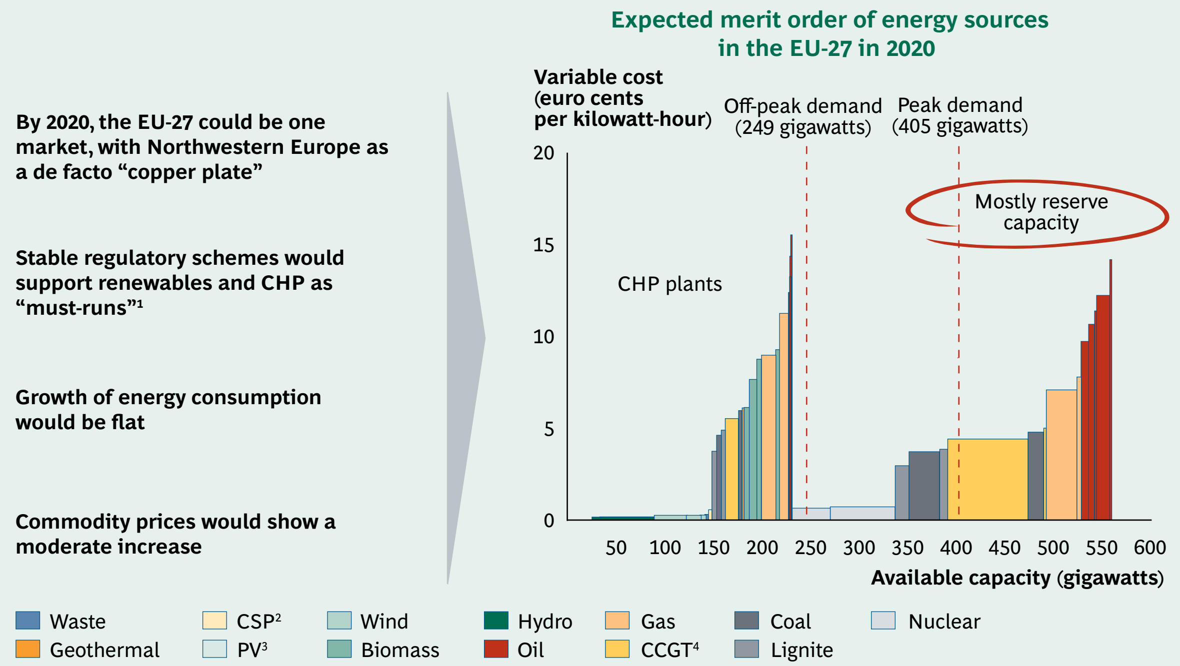
BCG has developed a "distributed-world scenario" to demonstrate the impact on traditional power generation. This scenario illustrates one possible power landscape, as well as the technical advances, business model innovation, and political support required for its realization. The scenario is based on the following four assumptions:

- By 2020, the EU-27 will be increasingly functioning as a single market for power. Northwestern Europe will be acting as a de facto "copper plate" (which assumes an unrestricted power network across Europe), with countries physically linked by high-voltage transmission lines, or interconnectors. The rest of Europe will become more connected, too.
- Renewables and other forms of decentralized generation will be backed by strong regulatory support in the form of feed-in tariffs for CHP and renewables, which, in the current regulatory environment, are systems often categorized as "must-runs" on the left of what is called the merit order curve—which ranks power generation technologies according to their production efficiencies. The associated costs have to be covered by consumers' power bills.
- Flat power demand will be driven by further deindustrialization in Europe and concentrated efforts to increase energy efficiency.
- There will be a moderate rise in commodity prices.

As a result, conventional power generation will move to the right of the merit order curve. (See Exhibit 1.)

By 2020, renewable technologies and CHP units could jointly provide more than 50 percent of all electricity consumed within the EU-27. Nuclear plants would provide most of the remainder, with conventional

**Exhibit 1. Increases in Distributed Generation and Renewables Threaten Conventional Generators' Profitability**



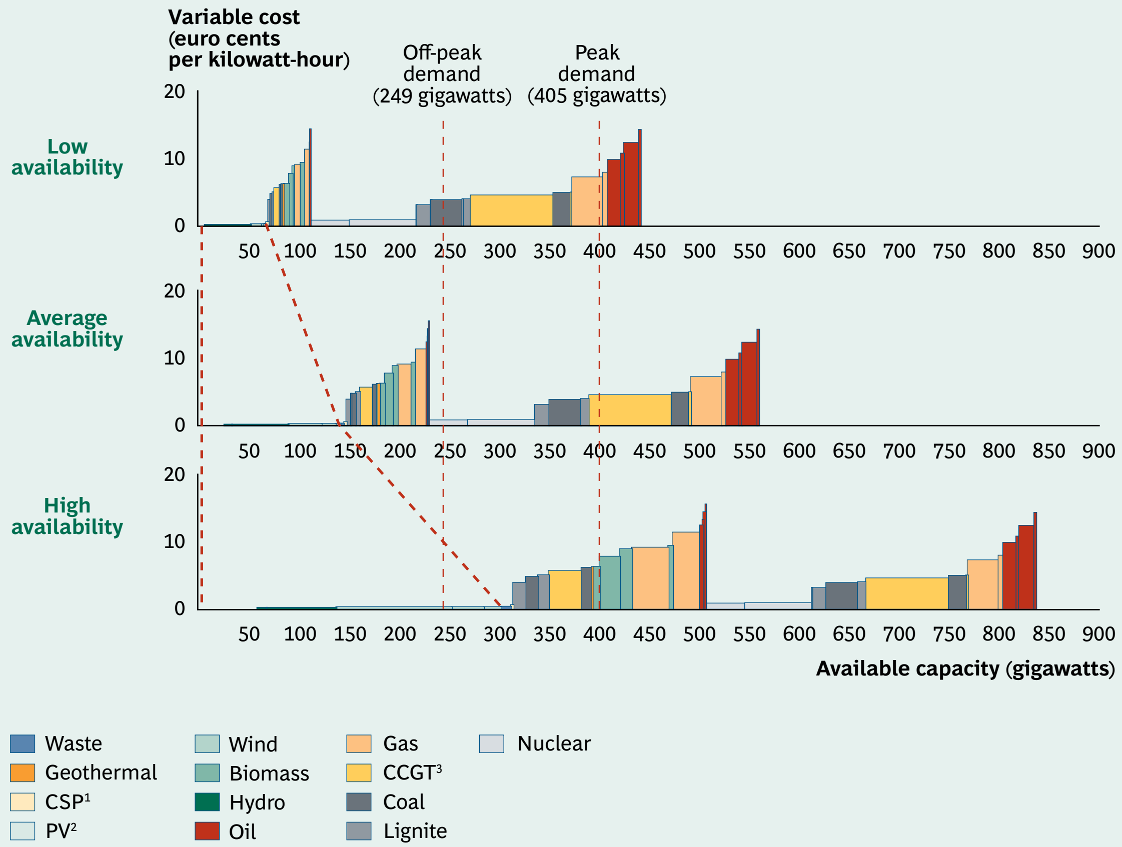

**Sources:** BCG research; BCG analysis.
[1]CHP = combined heat and power. Revenues from heat production have not been deducted from the CHP costs shown.
[2]CSP = concentrated solar power.
[3]PV = photovoltaic.
[4]CCGT = combined-cycle gas turbine.

fossil-fuel plants being replaced in the most valuable part of the supply curve by renewable sources and distributed-generation plants, which benefit from subsidies. This would put utilities' conventional-generation business model under pressure.

What is clear is that business as usual is no longer an option. To sustain the status quo, vibrant growth would need to reemerge swiftly in Europe (something few economists are predicting), and governments would have to renege on their pledges to provide preferential feed-in tariffs to renewable technologies and distributed-generation developers. In most scenarios—even if this is delayed by a few years—the landscape is set to change dramatically, leaving only a very small role for utilities' business models in their present form.

Some of these renewable-energy sources present operational challenges, however. The forces of nature (wind power and solar PV) are intermittent, providing a variable energy supply with both predictable (day-night and seasonal) fluctuations and unpredictable fluctuations driven by medium-term weather conditions and forecast errors. Such intermittency will require complex power-balancing mechanisms that use alternative capacity—including conventional generation and energy storage—to fill supply gaps when production from renewables is low.[2] Both the energy supply and the availability of renewable energy (wind and solar PV) are highly volatile. (See Exhibit 2.) Because the need for conventional power generation is

## Exhibit 2. The Need for Conventional Backup in 2020 Will Be Highly Volatile




**Sources:** BCG research; BCG analysis.
**Note:** Commodity price projections: gas, €6 per gigajoule; hard coal, €70 per ton; lignite, €20 per ton; biomass, €80 per ton; oil, €48 per barrel; and carbon dioxide, €20 per ton. Low-, average-, and high-availability scenarios: onshore wind—6 percent, 20 percent, and 70 percent; offshore wind—6 percent, 35 percent, and 80 percent; solar PV—5 percent, 18 percent, and 40 percent; hydro—43 percent, 60 percent, and 74 percent; combined heat and power—15 percent, 35 percent, and 90 percent.
[1]CSP = concentrated solar power.
[2]PV = photovoltaic.
[3]CCGT = combined-cycle gas turbine.

2. *Electricity Storage: Making Large-Scale Adoption of Wind and Solar Energies a Reality,* BCG White Paper, March 2010.

inconsistent and often unpredictable, a highly flexible generation fleet will be needed until other balancing mechanisms are fully implemented. This will favor gas-fired power plants, which usually have much higher ramp-up and ramp-down speeds compared with, for example, standard coal-fired power plants.

A critical tool will be the smart grid—a distribution grid that can also actively manage fluctuating supply and demand using grid and IT-infrastructure and optimization software—supported by smart meters, which allow for real-time bidirectional communication between the customer and the power supplier. Distributed generation will rely on upgrading the grid and applying digital technology to it, including monitoring devices to control and regulate voltage, smart switches that regulate production and consumption to avoid major breakdowns, communications and information devices that orchestrate virtual renewable- and nonrenewable-power sources, and, finally, smart meters to better align varying consumption with production volumes.

Applying IT to the system will be essential for managing the two-way flow of power and facilitating demand-side management, which encourages users to modify their own electricity use. Smart grids will also allow for local and regional supply-and-demand optimization and the dispatch of local generation capacity to fill the supply gaps at times when production from renewable sources of energy is low.

Of course, many uncertainties still surround smart-grid development. There are questions about the speed at which technologies will develop, standards will emerge, and new appliances can be deployed. Moreover, smart-grid business models remain unclear, with uncertainty about who will make the investments and reap the benefits, as well as what the risks are for different players.

When it comes to managing new distributed sources of energy, most experts agree that the smart grid will be among the main enablers in a distributed world. However, the value of a smart grid will depend on business model innovations that accompany developments in this area. We believe that strong political backing is needed before smart-grid technology can advance at the pace necessary to support these business model innovations.

## The Evolution of New Energy Technologies

The future energy landscape will be shaped by technologies that are currently in different stages of development. These include onshore and offshore wind power, solar-PV power, small-scale CHP, electricity storage, and concentrated solar power (CSP). Some of these—for example, onshore wind power—have already been implemented, and we anticipate further developments in the industry. Others, such as energy storage, which could play a critical role in managing fluctuating power sources, are in less advanced phases.

When it comes to renewable energy, we see both centralized and decentralized formats prevailing, with centralized offshore wind plants and large solar-PV and CSP installations developing alongside more decentralized versions of these technologies, such as rooftop solar installations and onshore wind farms.

Meanwhile, decentralized technologies are evolving at different rates. Solar-PV rooftop installations are advancing at a rapid pace. By the end of 2009, the installed base in the EU-27 exceeded 10 gigawatts. And by 2020, we expect growth in capacity of more than 90 gigawatts in distributed applications alone.[3] Smaller CHP plants (serving commercial and residential customers) show particular promise and are already starting to be commercialized. In Germany, a number of utilities have pilot programs in place—many with WhisperGen's Stirling engines, which provide home-based heat and power. New contracting business models for commercial and residential customers have been invented: for example, LichtBlick, a "green" energy provider, and automaker Volkswagen are cooperating in building and marketing domestic micro-CHP plants. We believe that if they apply the right business models and tap all revenue sources, utilities will be well positioned to generate power with small-CHP units at costs that can compete with large-scale power plants over the next few years.

On the other hand, micro wind turbines are being implemented only as a niche application. And certain variables could affect the growth of particular energy sources. For example, the drive to insulate homes

3. We expect an overall installed base, including large-scale solar farms, of approximately 150 gigawatts by 2020.

would lower demand for heating and, therefore, soften the market for small-scale CHP plants.

Also on the horizon are new large-scale low-carbon developments that do not follow a distributed-energy model. These include the massive Desertec project, involving a consortium of European companies that, by 2050, aims to supply up to 15 percent of Europe's energy requirements through renewable desert-based solar-energy generation. (Long-term political stability in the Middle East and North Africa is necessary before significant CSP capacity can be realized.)

Through a similarly ambitious scheme, Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden, and the United Kingdom have launched the North Seas Countries' Offshore Grid Initiative to cooperate on the development of high-voltage grid infrastructure in the North Sea and the Irish Sea to capture offshore wind power and use Norwegian hydropower plants as flexible capacity.

### The Impact of Distributed Generation

The introduction of renewables, with their intermittent nature, brings with it the prospect of imbalances in transmission and distribution grids, requiring integration mechanisms. So, in addition to adapting to the shorter run times resulting from increased amounts of renewable- and distributed-power generation in the energy supply, conventional power generators will also be required to change the way they operate in order to meet new flexibility requirements.

Without the introduction of balancing mechanisms to manage the troughs and peaks of supply and demand, the gradual increase in the use of fluctuating renewable-energy sources and distributed generation will reach a limit, threatening the stability of the power supply.

The role of utilities in generating backup capacity to manage the troughs and peaks in a fluctuating supply of renewable energy will increase. However, to compensate for fewer running hours per year, plant operators will need to realize extremely high prices for the power supplied during the times when renewable sources such as wind and solar power are not available.

This will create extreme variations in prices between the times when renewable-energy operators are feeding the system and the times when conventional plants step in. The pricing mechanism for the mid-merit plants could also move toward a flexible-capacity model rather than a production-driven model.[4] Germany, for example, is experiencing such price volatility, with sharp divergences in the daily maximum and minimum prices. (See Exhibit 3.)

The balancing mechanisms needed to stabilize the power supply will include expansion of transmission lines and the introduction of energy storage systems, as well as smart grids that enable sophisticated demand-side management. In addition, conventional power plants—if they can acquire new levels of flexibility—will play a critical role in providing backup capacity.

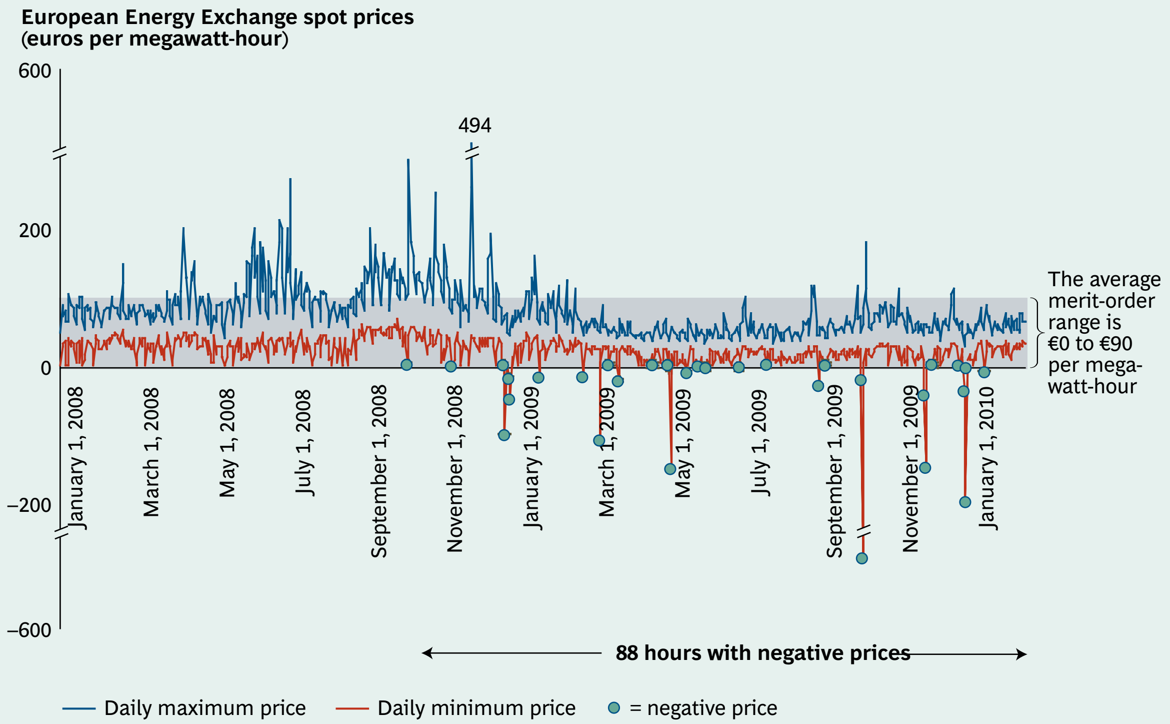
However, if pricing mechanisms do not change to reflect the role of utilities as backup suppliers, their profitability will come into question. Moreover, without realizing high prices for backup-power generation, companies will be unable to make the necessary investments in conventional plants, which will still be needed to supply backup capacity until other balancing mechanisms, such as energy storage and demand-side management, have matured.

When it comes to balancing fluctuating renewables and managing local power generation, new market roles are likely to emerge for transmission system operators and distribution system operators. In a distributed-energy landscape, most power will be generated locally, reducing the need for the expansion of transmission grid capacity. Distribution grids could take over a larger share of the responsibility for balancing the power supply and resort to balancing themselves only through the transmission grid.

Meanwhile, the possibility for two-way power flows and the rising share of distributed-energy sources will push value creation downstream and create the opportunity for new business models. Armed with rooftop

4. Mid-merit plants supply power during periods of medium or high demand. Such plants are not run during periods of off-peak demand.

**Exhibit 3. In Germany, Energy Systems Are Already Showing the First Signs of Stress**




**Sources:** European Energy Exchange; BCG analysis.

and other local power-generation equipment, even consumers will play a role in generation, becoming prosumers. With generous feed-in tariffs supporting its development, microgeneration includes a variety of devices that supply individuals or groups of consumers with energy.

## Enablers for a Distributed-Power World

In addition to renewable and distributed-power sources, three enablers for the new energy landscape will be needed to meet 20-20-20 targets: new IT-facilitated infrastructure, increased government support, and new business models. On the infrastructure, or "hardware," side, we foresee a need for a targeted extension of transmission lines, an upgrade of the distribution grid to make it "smarter," the introduction of more flexible power generation, and increased use of energy storage technologies, as well as communications systems and optimization software for decentralized energy systems.

Meanwhile, government will play a critical role not only in supporting the development of individual technologies and systems but also in shaping the overall energy landscape. Government should also offer incentives to stabilize the energy system to facilitate a low-carbon world at reasonable costs.

Finally, the market will respond to the first two drivers with new business models—developed by utilities, start-ups, and players from outside the energy sector—emerging to meet demand.

### The Hardware Needed

At one time, discussions about the infrastructure supporting the delivery of energy to its users were confined to large physical assets, such as transmission lines. Today, however, new and different forms of technology, such as energy storage devices, are part of the picture. At the same time, IT is making its entrance into the energy sector—a trend that is likely to radically alter the way power management is conducted.

In a world of wireless technology and cloud computing, transmission lines might look like old-world infrastructure. Yet they remain essential to energy delivery. On the one hand, the need for transmission grid capacity will be reduced as more and more energy is generated locally. On the other, huge generation assets such as those in the North Sea make sense only if the respective transmission capacity is available to transport the energy to the centers of consumption. This will require surrounding countries to make large investments in high-voltage transmission grids.

IT, which is one of the most significant forms of infrastructure supporting a low-carbon world, has not traditionally been associated with the power generation sector. Smart grids carrying data and communications serve three main functions:

- Smart distribution grids are able to manage the increasing share of reverse-flow power resulting from a high proportion of electricity generated on a decentralized basis
- Armed with wireless digital technology, the humble electricity meter becomes a powerful tool in energy management, facilitating real-time monitoring of consumption and allowing utilities to use pricing signals to influence that consumption
- By dispatching and optimizing distributed generation and consumption, smart grids can compensate for imbalances in the distribution grid

Smart grids are also necessary to provide the enabling technology that ensures bidirectional data flow and the integration of prosumers, who also generate power from decentralized heat-and-electricity production units such as rooftop installations, local micro wind turbines, and micro-CHP units.

Without the abilities of the smart grid, it will be impossible to expand distributed-generation capacity to include these microsources. As with renewables, distributed generation is accompanied by unpredictable short-term variations in the supply-demand balance of the distribution grid. Experience indicates that if the share of fluctuating power generation rises higher than approximately 20 to 25 percent of produced power, there could be problems for the stability of the grid. To operate a large-scale demand-side management business, therefore, requires that information about consumption be closely integrated with data about the grid status.

Despite its central role in facilitating demand-side management, the smart grid has its limitations when it comes to balancing fluctuating power sources. Pricing incentives can persuade consumers to shift some of their demand to off-peak periods, but most loads cannot be deferred for long periods of time. Moreover, demand-side management, which involves greater visibility of consumption patterns, raises issues of privacy and questions about what utilities should be allowed to do with the data they collect. Should the information be treated as proprietary, for example, or can it be sold to third parties? Finally, the success of demand-side management relies on human behavior and changes in consumption patterns, which depend on whether pricing incentives are sufficient to encourage consumers to use power at less convenient times of the day or night.

For this reason, another technology—electricity storage—will be needed to assist in balancing intermittent power sources. At present, few credible forms of the technology have emerged, largely because the financial incentives for aggressive investments are absent.

However, the role of energy storage as a mechanism that can compensate for power source fluctuations is becoming clear. In some parts of Europe, for example, feed-in from renewables already outstrips off-peak demand for electricity, creating high volatility in energy prices and, in some instances, negative power prices. As the share of electricity from fluctuating renewables rises, the pressure to develop better energy-storage technology will increase.

### The Role of Government

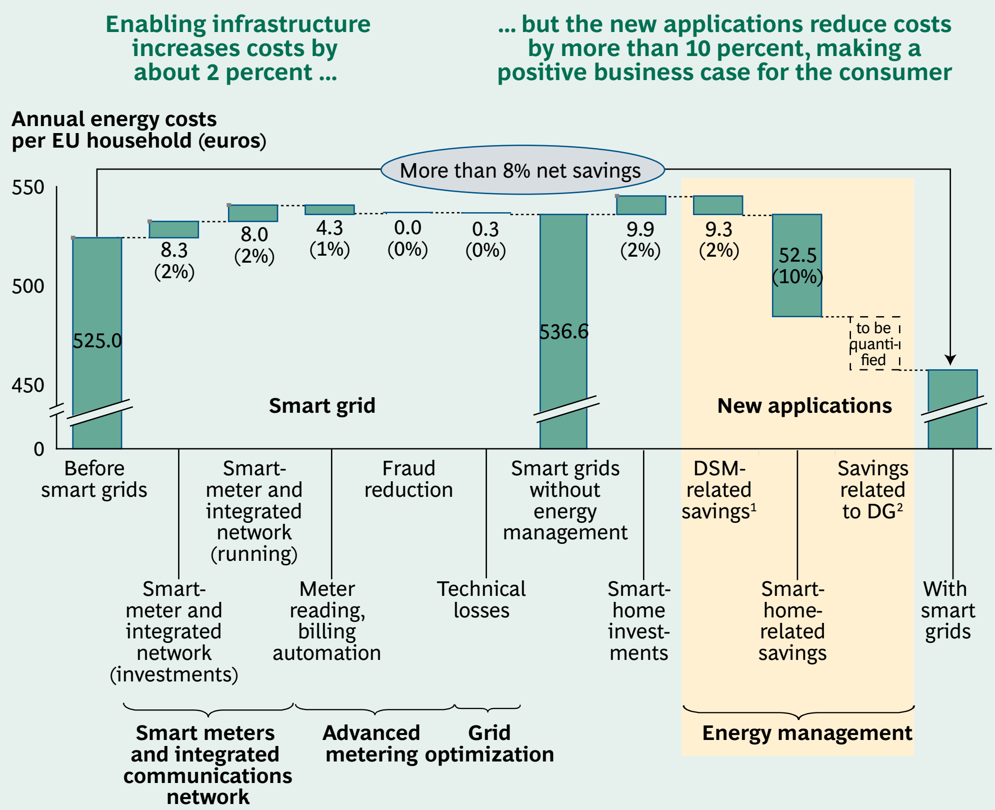
A key obstacle to the transformation of the energy landscape is that although the innovations and technologies now emerging will deliver advantages for the overall economy, they won't pay for themselves. There is still a need to support different renewable sources and technologies—such as energy storage—that can stabilize the energy system and help achieve a low-carbon atmosphere in Europe in the next few decades.

This need for investment holds particularly true when it comes to smart meters and smart grids. The value of advanced demand-side management, smart-home solutions, and small-scale distributed generation clearly outweighs the initial infrastructure costs for the consumer. (See Exhibit 4.) But there is a second "so what?" to consider. If utilities are unable to generate business through advanced energy management—that is, if they cannot profit by helping the client save energy or by expanding and stabilizing the customer base with energy-solution business models—they face shrinking profits resulting from lower sales of commodities. So with the 20-20-20 targets underpinning policy, subsidy regimes will be critical drivers behind the construction of the infrastructure needed to support a distributed-energy landscape.

In some countries, consistent and strong regulatory support has been such that eventually subsidies may no longer be required. In the United Kingdom, for example, offshore wind has developed into a competitive industry. The levelized cost of energy (LCOE) is currently between €0.06 and €0.09 per kilowatt-hour. Grid parity—that is, LCOE equal to the retail power price—for rooftop PV power is expected in Spain and Italy between 2013 and 2015 and in many other countries during the following five to ten years. The exact timing depends on retail-price development, the speed of PV cost reduction driven by low-cost manufacturers in China, and sufficient supplies of silicon to avoid price hikes.

Throughout Europe, coordination and joint subsidization schemes will be essential for creating incentives for utilities to make their investments in very large projects that have a long payback period. The most important question for regulators is whether or not they are ready to move from supporting individual energy technologies to providing incentives for the development of systemwide solutions that support the balancing of diverse power sources. And although national subsidies for the development of local

## Exhibit 4. The Enabling Costs of Smart Grids Are Justified by Advanced Energy-Management Capabilities




**Source:** BCG analysis is based on the experience and benchmarks of pilot projects in the United States and a study in Denmark. The drivers were applied to a Western Europe consumption pattern.
**Note:** This exhibit assumes annual household consumption of 3.5 megawatt-hours of power, priced at €0.15 per kilowatt-hour. Taxes are not included.
[1]DSM = demand-side management.
[2]DG = distributed generation. Customers can realize savings by switching from a commodity power-supply contract to a DG unit.

infrastructure are in place across Europe, the international agreements needed for very large projects are only just beginning to evolve.

There are a few signs that policymakers are starting to focus attention on the bigger picture. For example, in the United Kingdom, the Office of the Gas and Electricity Markets (the regulatory agency known as Ofgem) is currently examining the possible incentives and mechanisms required to guarantee sufficient backup capacity for balancing the energy system even when the provision of such backup capacity may not be profitable for utilities. One extreme solution might be for the agency to make long-term commitments to buy power. Incentives to secure peak-load or flexible-backup capacity will, therefore, add a third price element to the system that utilities must master in the future.

In general, however, little guidance has thus far emerged from politicians or regulators indicating what regulatory measures will be taken to support a systemwide architecture. Greater incentives will be necessary, for example, to ensure that sufficient energy storage—which is not yet competitive—is online in time to meet governments' green-energy targets. Meanwhile, no frameworks currently exist for professional demand-side management, another development that will require government support. If utilities are to be able to invest and Europe is to move to a low-carbon environment, systemwide thinking and regulatory clarity on the form that this architecture will take are urgently needed.

## New Business Models

As the traditional-generation business model fades and power plants' run time decreases, utilities need to identify and design new business models that can deliver additional revenue. It is not yet clear what kind of business opportunities such developments as the smart grid present for utilities. Nevertheless, these companies must consider how they can participate in the new systems, because in the meantime, a new set of players is ready to enter the energy sector, capture value, and eat into market share. Coalitions of companies are emerging. In Italy, IBM and Echelon have supported the buildup of Enel's smart-meter architecture—connecting 30 million households with the utility's IT system.

The automotive sector will play a role as well, through partnerships such as that of Volkswagen and LichtBlick in Germany to build micro-CHP units for home use. This business model provides incentives through a contracting solution for residential customers. The value creation is driven by optimizing generation against the spot, intraday, or even balancing market. The business case is already strong, and we expect it to strengthen with further scale and learning-curve effects.

Plug-in electric vehicles are bringing the automotive sector into the power management sector as well. These vehicles could feed power back into the grid by charging at night and storing power in their batteries, which then could feed that power into the grid (vehicle-to-grid charging) during daytime peak hours. This second option will not prove viable, however, until battery storage improves and car owners have sufficiently appealing financial incentives to offset the shortening of a car battery's life.[5]

New entrants to the power sector include players in the IT sector, with smart-grid and other energy start-ups joining established companies in the rush to capitalize on changes in the power landscape. These companies are focused on systems that provide the "intelligence" needed to facilitate smart-grid behavior, including power routing, flow optimization, and pricing for feed-in and consumption. Some of the new players are also managing power distribution between centralized and decentralized producers, enabling quick responses to load changes. The smart-grid playing field is different from that of a traditional grid, making the entry of new players very likely. (See Exhibit 5.)

In the United States, many start-ups are successfully entering the energy arena, including smart-grid companies such as Silver Spring Networks, whose smart-meter networking solutions are designed to boost utilities' efficiency and allow for two-way real-time communication between utilities and consumers. GridPoint, another smart-grid company, is focused on the management of power flows and storage. Meanwhile, start-up companies are also providing outsourced demand-side management services such as

5. *The Comeback of the Electric Car? How Real, How Soon, and What Must Happen Next,* BCG Focus, January 2009, and *Batteries for Electric Cars: Challenges, Opportunities, and the Outlook to 2020,* BCG Focus, January 2010.

**Exhibit 5. The Smart Grid Challenges the Role of Incumbents in Every Layer of Technology and Infrastructure**

| | Traditional grid | Smart grid |
|---|---|---|
| Communication and control infrastructure | ◇ **Technology:** Data transmission along the power grid (for example, unidirectional control of demand)<br>◇ **Purpose:** Remote (fault) sensing and substation switching<br>◇ **Metering:** Mainly manual meters | ◇ **Technology:** Multidirectional broadband-communications network<br>◇ **Purpose:** Enabling smart features such as remote performance analysis and automatic remediation, and demand-generation matching<br>◇ **Metering:** Digital smart meters (active remote-control and remote-readout devices) |
| Grid and energy-management-software solutions | ◇ **Systems support the operation of manual control centers (from network control stations)**<br>• Monitoring and remote-sensing systems<br>• Manual remote controls and switches | ◇ **Systems provide "intelligence" that facilitates smart-grid behavior**<br>• Power routing and flow optimization<br>• Pricing for feed-in and consumption |
| Energy infrastructure | ◇ **Power is distributed to customers from central sources and power hubs**<br>• Tree-shaped structure<br>• Slow response to changes | ◇ **Power is distributed between central and decentralized elements, sometimes switching the roles of source and consumer**<br>• Mesh-and-ring structure<br>• Fast response to changes |
| | Run by grid operators | Competition from new players |

**Source:** BCG analysis.

those provided by Comverge and EnerNOC, each of which manages demand-response capacities exceeding 3 gigawatts.

At the same time, established companies from the IT sector—such as IBM, SAP, and Cisco Systems—are focusing on energy in order to participate in distributed-power markets. Google, the search engine giant, is also offering a power-meter software product to track energy efficiency and has applied for an energy-trading license in the United States.

The question is whether utilities can build on their strengths and take a slice of this market. The abilities required to do so are not yet among the core competencies of utilities, so it remains to be seen how great a share of the value-added part of the power sector the utilities can capture. Meanwhile, particularly as value creation flows downstream, the next few years are likely to see nontraditional energy companies making further inroads into the power sector, putting pressure on incumbents that lack the flexibility needed to introduce new business models.

## Distributed Power: Risks and Opportunities

The emergence of a distributed-energy landscape will have important implications for all parties, from utilities, gas companies, and technology providers to transmission system operators and distribution system operators. They face risks in not taking action, but there are opportunities for those that move forward.

### The Risks of Not Taking Action

One of the biggest risks is that, because of the lack of political vision, technology and infrastructure enablers such as the smart grid will not receive support sufficient to underpin their development. The resulting pressure on the energy system could be severe, with blackouts and brownouts that not only affect utilities' business models but also have a negative impact on citizens as well as businesses in all sectors.

Meanwhile, the rapidly shifting power landscape presents many risks for traditional utilities. Their current business models and technologies do not equip them to create substantial value in the emerging energy markets. At the same time, new players, such as IT companies, are already making headway into their territory, currently as partners but potentially with other ambitions. We believe that the biggest risks facing power utilities include the following:

- Tenuous profitability as conventional power plants become crowded out of the market by new power sources such as renewables and microgeneration that are benefiting from government subsidies
- The critical need to realize high prices for running conventional power plants to deliver backup capacity (through capacity pricing or high prices in the spot or balancing market) as renewables and distributed-power generators make up an increasing share of the supply
- Microgeneration value creation being left in the hands of manufacturers of the units; service companies or new entrants leaving utilities with diminished roles as commodity suppliers of power and gas
- "Reseller structures" that allow new players to offer bundled power-and-gas supplies, as well as energy consulting-and-efficiency services around microgeneration—for example, solar and micro-CHP
- Loss of market share to new players that can capitalize on distributed-energy business models more easily than incumbents with legacy systems can
- Competition from new players, such as IT companies, that are already entering the markets with full force to take a dominant position in the provision of new smart applications such as demand-side management

### The Potential Opportunities

The new energy landscape will present an opportunity for utilities to rethink their businesses and transform themselves from commodity suppliers to energy solutions providers. We believe that the biggest opportunities for utilities include the following:

- Establishing virtual power plants (VPPs), networks of connected small-scale generation devices that act as one large plant in a "rent-a-roof" model. A utility would pay homeowners to site solar-PV or micro-CHP equipment on their property. In this model, the utility takes on the role of operator, dispatching the devices according to energy demand.
- Expanding their offers to customers to include not only sales of conventional power-and-gas contracts but also sales of distributed-generation devices, potentially including equipment service and maintenance contracts.
- Providing distributed generation and related energy services such as smart-home solutions. Utilities could evolve from simple commodity suppliers to comprehensive energy-solutions providers for commercial and residential customers.
- Locking in the customer base by offering comprehensive energy solutions that allow utilities to compete on more than commodity price alone.
- Developing new flexible power plants to strengthen the role of utilities in balancing supplies of conventional and renewable power to stabilize overall supply.
- Operating different forms of energy storage—both centralized and decentralized.
- Creating new revenue streams by using smart pricing mechanisms.
- Providing demand-side management strategies to shape consumption patterns.

We believe that, given utilities' presence along the value chain and their trading and optimization capabilities, supplementing conventional plants with the VPP model offers utilities a great value proposition.

To summarize, it is critical that utilities move from commodity-sales business models toward providing energy solutions and decentralized optimization businesses. These approaches include seeking revenue through the provision and connection of small-scale-generation units, storing energy, and offering active demand-side management with utilities operating as VPPs.

## The Imperative for Action

Although large-scale low-carbon initiatives are likely to continue to win support, we believe that potentially disruptive changes are moving the industry toward a more decentralized energy landscape. As utilities look ahead, they need to ask how they can adapt their business models and technologies to capitalize on this new landscape. Our recommendations include the following:

- The development of strategic and competitive scenarios that capitalize on new regulatory and market conditions
- The preparation of a clear strategy regarding the smart grid—and the opportunities it gives utilities to create new business models that manage the increasing volatility of energy sources—as well as the formulation of strategies for dealing with regulators
- The creation of new pricing models, new energy sources, new partners, new relationships with customers, and new downstream business models based on distributed generation
- The assessment of the value proposition of new market entrants—both as competitors and as potential partners
- The preparation of contingency plans based on a variety of scenarios

If utilities do not want to be crowded out of the power generation market and marginalized as mere downstream commodity suppliers, they need to act now. The evolution of a decentralized power landscape will not only change the relationship of the different energy-sector players to the electricity value chain, it will also change the very structure of that value chain.

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6/10