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## Chapter 5

# Renewable energy integration: A delicate balancing act





## Renewable energy integration: A delicate balancing act

We human beings hold the unique and enormously fragile responsibility of shaping our own destiny, and possibly even the destiny of our planet Earth, through the choices we make.

But if we were on the outside looking in, how would we grade ourselves on the choices we have made so far to secure our critical resources, such as food, water, infrastructure, and energy?

If we were to separate just energy from that list, would we approve of the blueprint we're handing down to future generations? What decisions have we made that will help us sustain our energy needs for hundreds, even thousands, of years?

Our most common and longest-running forms of energy — coal, oil, and gas — have effectively powered industry and civilization for over 100 years, yet they are tragically flawed in two fundamental areas: 1) the unprecedented rate at which they are released from the ground, breaking the delicate balance of our planet's climate, and 2) they are finite.

To address these flaws, industry pioneers are striving to put renewable-energy-powered technologies on equal footing with carbon-emitting fuel sources. More and more, they are succeeding.

Whether we watch from the sidelines or are actively involved in the trenches of innovation, the evolution to a renewable-only world seems all but inevitable. The question is not *if* that shift will take place, but *how* and *when*.

The “how” question is already being addressed: Technologies exist today that capture the energy of our sun, wind, and moving water. The question of “when” is being answered on a daily basis in boardrooms across the globe when key energy stakeholders make decisions and place investments.

However, it will not be an easy progression to general renewable power — quite the opposite in fact. Traditional interests tend to protect an outdated model while new interests often rush in without fully realizing the consequences of their actions.

This chapter analyzes the current state of affairs regarding solar, wind, and hydroelectric power generation, and offers perspectives on how utilities can manage the delicate balancing act that is the transition to an all-renewable world.







## Answering the “how” question: What stands in the way of renewable energy?

### Old-fashioned financial subsidies

If more and more nations, governments, and people are demanding a definitive shift to renewable power, why isn't it happening faster? It is a complicated question that requires an equally complicated answer. But historically, one main barrier has been the price tag.

Renewable energy technologies simply could not compete with fossil fuels due to government subsidies that had been in place long before. However, traditional barriers to renewable adoption, such as cost, are beginning to disappear.

Continuous innovation and economies of scale have driven cost down to the point where it is near parity with other ways of producing electricity. As a result, political incentives to accelerate renewable penetration will no longer be required as the economic business case simply begins to make sense.

In 2013, non-fossil fuel power plants accounted for more than half of net additions to global power capacity. That same year in Europe, renewables gained a 72 percent share of new generating capacity — a significant number, since fossil fuels accounted for an 80 percent share just a decade before.



The challenge for utilities is to quickly learn how to integrate renewables into their networks. In some mature countries, renewables have chipped away at the century-old legacy of fossil fuels, thanks to declining prices and a regulatory environment that pushed for a greater integration of renewables.

Renewable portfolio standards — or regulations that require an increased production of energy from renewable energy sources — have helped build interest in renewables and overcome the capital investments needed to compete against the development of gas-fired plants.

Some of those incentives will remain. However, over the last several years, and especially in those countries still recovering from the economic crisis, the same subsidies and tax credits that were designed to bolster renewable energy investments are either being revised or eliminated. But when, at the same time, subsidies to the mature energies are suppressed, this levels the playing field.

In countries like India, where plentiful land with sunshine exists, access to sites (land and property for solar farms, for example) and the bureaucracy involved in securing permits are other examples of typical barriers.

The reverberations of these changes are impacting the pocketbooks of renewable generation asset owners, as fewer incentives are resulting in higher risk and longer return on investments. At the same time, fossil fuels and nuclear programs are still receiving subsidies despite their eventual decommissioning. In fact, fossil fuel subsidies are still several times higher than those related to renewables.<sup>1</sup>

### The variable nature of renewables

Sun, wind, water — nature's most abundant and precious energy sources are virtually everywhere. But we are currently limited in how much or how often we can extract that energy to supply our energy demand. Moreover, unpredictable factors such as cloud coverage, wind speed, and water flows, have complicated the production of renewable-based electricity for utilities.

### Net metering

Net metering mandates dictate that on-site electric energy generated by a consumer may be used as “credits” to offset electricity costs on a monthly bill. Essentially, it's like selling energy back to the utility. This concept is intended to drive residential and business investment in renewable energy.



### Shifting sands

E.on, Germany's largest utility, announced in November 2014 its decision to spin off its conventional generation, global energy trading and exploration, and production business activities and to only refocus its brand around the renewable business, its distribution networks, and its customer solutions. This move demonstrates the value that major utilities are placing on distributed and renewable energy.



Renewable energy integration: A delicate balancing act

Using wind as an example, we know that hour-to-hour wind generation can vary between 3 and 4 percent of installed capacity. Even a 3 percent day-ahead forecasting error ratio is meaningful and problematic for operating margins.

To remedy the burdens of that energy shortfall, many utilities are calling for precise methods for forecasting weather, generation, and loads with the hopes of bringing uncertainty to manageable levels when it comes to balancing supply and demand.

And that time is coming. Grid operators are just now entering a world where decisions can be made instantly, and where flexible, readily dispatchable loads can adapt to dynamic network behavior.

This is important because some utilities have traditionally based energy forecasts on knee-jerk reactions to weather patterns, historical trends, and other factors. Generation was manually scheduled to meet the anticipated load: a time-intensive routine that required a cumbersome interaction between outdated equipment and multiple program interfaces, and one where big mistakes could be made.

The evolutions in technology are also helping to address concerns with renewable energy overproduction. Overproduction typically occurs when renewable sources unexpectedly produce too much energy as a result of changing weather conditions, especially at times of low demand or in cases where gas-fired peaker plants were already providing energy to the grid. This excess energy can lead to local dangerous overvoltage, grid constraint violations, and additional costs that may or may not be reflected in the price of electricity on energy markets.

In the future, generation forecasts will be based on real-time weather conditions, energy demand, and the status of field equipment, and the supply curve will be met through stored energy and automated demand response systems that will involve less hands-on interaction from grid operators.

This new depth and breadth of situational awareness will allow operators to respond quickly to changing conditions and prevent the harmful effects of forecasting errors.

Renewable power operations and maintenance

A renewable power plant requires superior operations and maintenance practices to achieve optimal profitability.

The moving parts in wind turbines are subject to wear and tear, especially when they are exposed to harsh conditions. Although static, inverters in solar farms need some software and hardware maintenance to avoid any drift in settings that could hinder output.

Warranty periods are another worry for utilities. Over the last 15 years, wind turbines have been erected and connected to grids around the world. The owners and operators of these aging wind turbines are now exiting the warranty periods and are left alone to face issues related to plant maintenance.

As such, the solar and wind farms of today require a more strategic and structured life cycle asset management approach. Renewable energy operators are seeking highly skilled engineers to better manage their operations and maintenance. And in cases where those engineers are reluctant to be relocated so far from urban centers, utilities are building renewable control centers (RCCs) equipped with powerful software to remotely operate and maintain their renewable assets.

Network code requirements

All power plants must be grid code compliant and provide the relevant network services to better manage their output. Failure to comply with the network codes can lead to penalties resulting in financial impact, such as a plant not being authorized to sell its energy delivery or a generation operation being forced to disconnect from the grid.

With rising shares of renewable electricity being injected onto their grid, system operators are now realizing that the usual network codes designed initially for conventional generation do not accommodate for the variable nature of renewables.

For a time, utilities developed and specified power network codes and regulations on a local basis. Those local codes force the utility to work within a specific set of parameters for each wind farm location, causing a logistical nightmare for operators with farms in different geographies. But technical solutions now allow renewable plants not only to comply with the network, but also to provide services and support to the grid.

For example, a dedicated controller can adapt power output, manage equipment, and ensure the plant complies with the code requirements at all times. This makes new general network codes for renewables possible.

Did you know?

Schneider Electric successfully demonstrated in the ENR-Pool European project that errors in prediction could be minimized to close to 1 percent by aggregating renewables with loads at the scale of a country.\* Learn more at [enr-pool.fr/en](https://enr-pool.fr/en).

\* 72 MW of solar and wind generation, balanced with 100 MW of flexible load were firmed into a dispatchable aggregate that had a prediction error of close to 1 percent only.

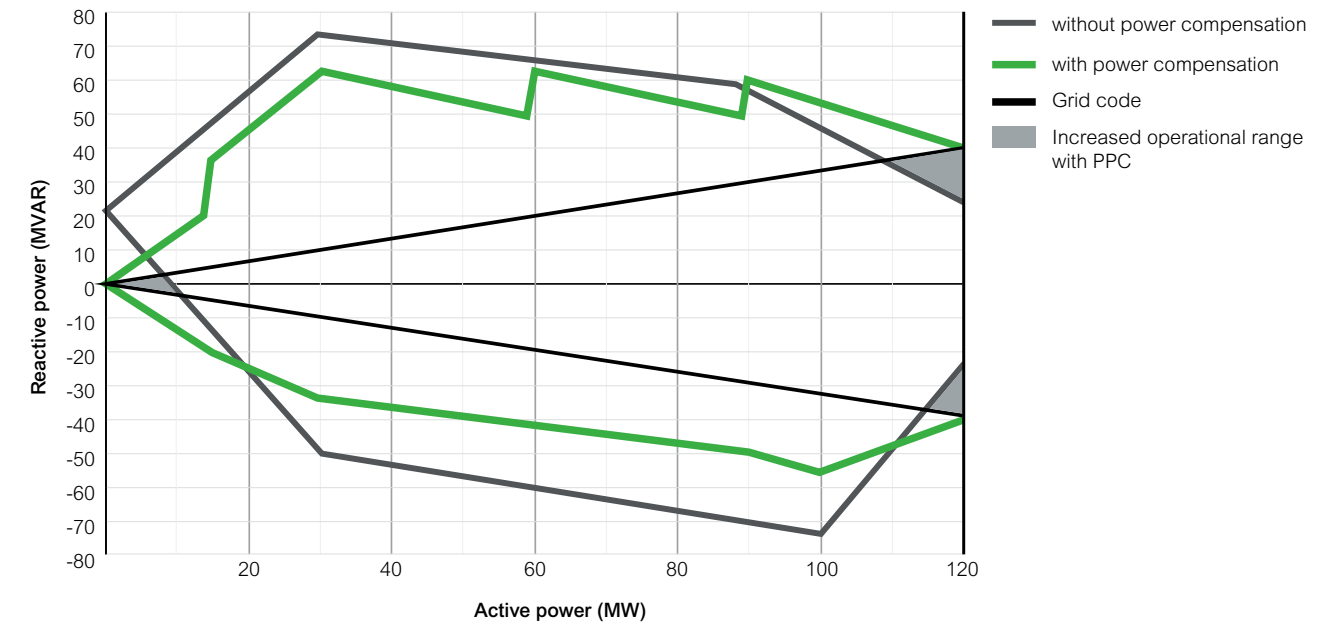






### A power plant controller extends the operating range of a wind farm

PQ chart at grid connection with and without PPC compensation at a typical 120 MW wind park point of common coupling with the grid



### The rise of international network codes

Countrywide network codes for wind power networks are only beginning to emerge, but momentum is building rapidly. In Europe, the European Network of Transmission System Operators for Electricity (ENTSO-E) is defining and developing a common framework.

**At present, the ENTSO-E has set forth three codes for utilities to follow:**

1. The initial codes being enacted define the continuous or transient voltage and frequency operating ranges within which the wind plant can operate.
2. A second set of codes concern active and reactive power control modes. The goal of these particular codes is to avoid rapid power changes that could lead to frequency instability.
3. The third and final set of codes address the issue of plant response during interrupted operating conditions. This requirement places emphasis on response speed. As the level of injected reactive current is proportional to the voltage system deviation, very fast reactive current production or consumption is needed, and only the most advanced wind turbines can embed this functionality as a closed-loop function.

In order to comply with new network codes, additional equipment is often necessary to extend the power plant's reactive power capability and enhance the ability to control the power output.

This new equipment connects to the main substation and is controlled remotely. For the supervision of multiple wind farms, a dedicated wind SCADA system provides utilities with the reporting functions necessary to produce power generation forecasts.

Such systems are especially beneficial for utilities that have wind farms across different locations, and that also source wind turbines from different manufacturers.

### Remote management of wind farms

Wind farm operators require asset management tools with open communication protocols so they can remotely manage equipment from different wind turbine vendors.

Operators are also beginning to see a steep rise in maintenance costs because warranties have run out and the older wind farms are experiencing more frequent breakdowns.

To meet these challenges, utilities are now deploying asset performance management software systems and a dedicated control center capable of supervising an entire fleet of wind farms.

The goal is to optimize the portfolio of wind assets across multiple sites while monitoring specific, detailed individual turbine performance (mechanical and electrical). Such capabilities reduce the overall cost of operation and maintenance of wind assets across the network.





## Ireland

# Managing over 200 wind turbines across the British Isles

**Electricity Supply Board Ireland, better known as ESB, has some 200+ turbines with a 300 MW capacity in 19 windparks scattered across Ireland and U.K.**

Remotely managing such resources is the challenge ESB was facing. Integrating their variable output, subject to weather fluctuations, into the grid with full compliance to the grid codes requirements is another challenge posed by the impacted TSOs and DSOs. Last but not least, ESB wants to maximize the value of the energy of its wind farms when sold on markets.

**Schneider Electric RCC** consolidates the data required for monitoring assets' performance (such as turbines' and substations'), enriches it with weather forecasts, displays it in a very intuitive way to the operators, and enables sharing it in real time with the TSO, DSO, and aggregators. All reporting data is also available in full transparency for inspection by governing authorities.

Thanks to this very intuitive tool, the operator is never further away than two or three clicks from all the data he needs. With intra-hour information and forecast of wind farms output, and by having the ability to remotely control possible battery and capacitors, ESB can support the DSO on managing voltage, power congestion, peaks, cable temperature, or energy losses. And the cherry on the cake is that thanks to its openness and ability to connect to third-party applications, ESB knows that RCC is future-proof and will accommodate all its upcoming wind farms.





## Answering the “when” question: The rise of solar, wind, and hydropower

### Renewable power is becoming price competitive

In many locations across the globe, renewable energy has already reached grid parity — or the point from which a kWh produced by a renewable power installation becomes less expensive than a kWh bought from the grid.

This implies that solar and wind, without having to factor in government incentives, can be competitive with traditional fossil energy generation. A decrease of system costs coupled with rising volumes and low interest rates has enabled this dramatic growth in the relevance of renewables.

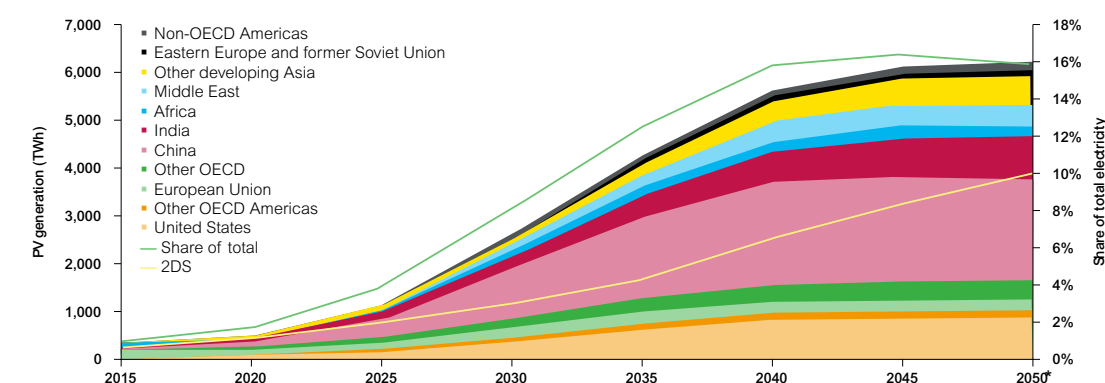
Between 2006 and 2014, the average market price of solar modules has declined from around €4/Watt peak to around €0.50/Watt peak. Prices have decreased by approximately 24 percent each time the installed capacity has doubled.<sup>2</sup>

In 2010, the market price of a power conversion station (PV Box) for solar farms was around €0.20/Watt AC and its typical power rating was 1 MW, per Schneider Electric sources. In 2014, the market price was around €0.09 with a power rating of 2 MW. As with the personal computer revolution, prices drop rapidly and capacity and horsepower grow.

The size of average solar installations is also growing. In 2008, the capacity of the first PV power plant commissioned by Schneider Electric (Vinson/Verdon in France) was 4 MW. In 2014, plants with capacities between 20 and 50 MW have become common. In fact, a recent Schneider Electric project in Europe deployed a site capable of 300 MW. Now 1,000 MW plants are in the planning stages.

What does all this mean for utilities? For some, it will mean greater investment opportunities for wind and solar plant installations. For others, it will mean increased revenue from customers who are willing to pay for more competitive prices.

### Forecasted PV electricity production



\*16 percent of the global electricity production  
Source: International Energy Agency, 2014





## Industry drivers for renewable energy sources.

### Four important trends are altering the renewable energy landscape on a global scale:

1. Distributed renewables are where the humans are. Oil, gas, coal, uranium, large-scale wind, hydro, and tidal spots are often located in sparsely populated areas. Solar, for example, is available everywhere, and is cost effective in a large range (between 55°N and 55°S), where 98 percent of the world's population lives.
2. Renewable generation installation is simple and can be physically placed where the consumption is. This aspect has several significant consequences for utilities:
  - Users aren't forced to buy their electricity from utilities. They can address a share or the totality of their needs on their own.
  - Traditional utilities could see a future of millions of small- and medium-sized competitors trading electricity between themselves, thanks to the IoT and real-time spot markets.
  - Existing networks will have to evolve: They were made to carry electricity from very large power plants to numerous end users; they will need to interconnect multiple producer-consumers (prosumers). This situation begs the question: In the end, who will pay?
3. Renewables are modular. Starting small and extending the capacity with the development of the demand avoids having to generate high upfront costs.
4. Installation and maintenance can be simpler than the maintenance of other power generation sources.

### Solar power and grid capacity

The International Energy Agency (IEA), in their 2014 "Energy Technology Perspectives" report, claimed that solar is on pace to become the world's main source of electricity by 2050, at nearly 30 percent of total global electricity production.

However, as this abundant energy source pervades utilities at a rapid pace globally, limitation of the grid capacity will certainly become an issue. Too much sun will create overvoltage and tripped load just when abundant energy is available. Cloudy days will create high fluctuations, deteriorate the power quality, and damage sensitive equipment. Days without sun will lead to power shortage.

Thus our energy economy cannot simply rely on solar. The penetration of solar generation must be carefully coordinated with the rest of the power infrastructure.

In developing countries, the planning of solar power must be closely coordinated with economic development to determine where and when the electric load will be located and what its unique characteristics will be.

In mature countries, the planning of solar power must take into account the existing infrastructure of generation, transmission, and distribution. The goal is to optimize the evolution toward more predominant solar while avoiding unstable and unprofitable operation of existing assets.







As energy demand rises and governments mandate a greater proportion of renewables in the energy portfolio, the importance of generation, demand, and storage coordination will continue to grow.

#### Coordination of generation, demand response, and storage

In the coming years, variable generation sources like solar will call upon demand response and storage systems to help maximize supply and protect grid stability.

One alternative, battery energy storage solutions, is capable of storing energy captured from the sun and injecting that energy back into the grid when it's needed as a means to extend production capacity and gain control over power reserve. Hydropower can also offer a stabilizing influence because of its consistent dispatchability as a power source.

#### Commercial and residential applications

The application of solar power generation will present unique challenges to utilities, including how to compensate for the energy sold back into the grid, how to reclaim the revenue from self-consumption, and how to coordinate participation with business and residences that can help mitigate blackouts and brownouts.

Below is a list of the most popular PV applications:

1. **Grid-tie (also known as on-grid, grid tied, utility interactive, grid inertia, or grid-direct)**  
In a grid-tie scenario, electricity is generated by the PV system and routed to loads, offsetting the utility electrical load of a business or home. In many locations excess energy can be sold back to the utility providing the business or home with a form of revenue. Large systems are typically installed without energy storage, while small systems can include it.
2. **Backup power systems**  
In this scenario energy storage is incorporated, usually in the form of batteries. Batteries are charged through the utility connection, PV, and inverters. When there are utility power fluctuations (brownouts or outages), the inverter provides continuous power to critical loads. Battery power can also provide energy to assist when powering intermittent heavy loads, thereby reducing operating costs.
3. **Self-consumption**  
This approach implies that energy generated by a PV system is consumed by the commercial enterprise or residence. When the price to buy electricity is higher than the price to sell it, the revenue due to self-consumption is higher than the profit of selling electricity to the grid. The objective is to consume 100 percent of the energy produced by the PV system.
4. **Off-grid systems**  
These disconnected systems include a solar array, solar chargers, batteries, and controls. In this configuration, energy is collected and stored to meet all power requirements. The addition of a generator provides additional autonomy, capacity for heavy loads, and battery charging when solar energy is reduced. In a scenario where a generator is providing prime power in an off-grid location, the addition of a PV system can offset the costs of both fuel and generator maintenance.





Value Labs, India

## Prefabricated PV boxes to meet deadlines

**Value Lab LLP is a global IT services company based in India,** providing software product development, as well as remote management and IT process consulting services.

To take advantage of government incentives and to switch its energy resources to renewables for more sustainable operations, Value Lab sought to power its 8 MW plant in Mehboobnagar with solar energy. To do so, however, Value Lab had to complete the installation by a specific date, and all efforts to meet this deadline were vital to the success of the project.

The project's scope included engineering the electrical part of the plant with a SCADA monitoring system, Conext™ Control, which was specifically designed by Schneider Electric for utility-sized solar plants. When significant delays on the client side threatened meeting the original deadline — and potentially getting in the way of those government incentives — the Schneider Electric team was able to propose its specialized prefabricated offers: ready-assembled PV boxes consisting of the inverter, the ring main unit component, the transformer, the LV panel, as well as UPS and batteries, all wired and cabled, to get the project back on schedule.

This technology and these specialized engineering capabilities allowed Value Lab to meet its deadline and claim the tax benefit it desired. Additionally, it continues to benefit from green energy certificates as well as seeing its own energy costs reduced as it sells back some of its own generated power.





# Wind and solar energy in 2050

Below is a list of trends that will change the way utilities integrate wind and solar power into their networks:

**Standardization:** All aspects of wind and solar installations will be held to specific and unified certifications.

**Efficiency:** Modules and inverters won't just be larger and more efficient, they'll also have a longer life.

**Scope:** The size of power blocks, converters, and other components will continue to grow. The coming generation of solar will be 5 – 8 MW, which may break the LV/MV barrier (1000 VAC, 1500 VDC). Some experts believe the rotor diameter of wind turbines will reach 250 meters.

**Codes:** Grid codes will converge to unified requirements based on the work currently made in the U.S. and Europe. These requirements will take into account the specificities of variable renewable energies.

**Traditional generators:** Traditional generators will remain, powered for a part by gases produced by wind and solar (power-to-gas), and will have to become extremely flexible.

**Micro and nanogrids:** Communities, even remote ones, will be more self-sufficient. Hybrid PV-diesel power plants or PV-diesel-storage power plants will be widely used.

**Services:** A large share of services will be made remotely (remote troubleshooting, remote firmware upgrade, etc.), thanks to the wide use of electronics and power electronics for power conversion in solar systems.

**Real-time insights:** Automated grids will self-adapt to weather conditions.

**Cyber security:** The sheer number of power plants and the communication needed between them will give rise to information vulnerabilities.

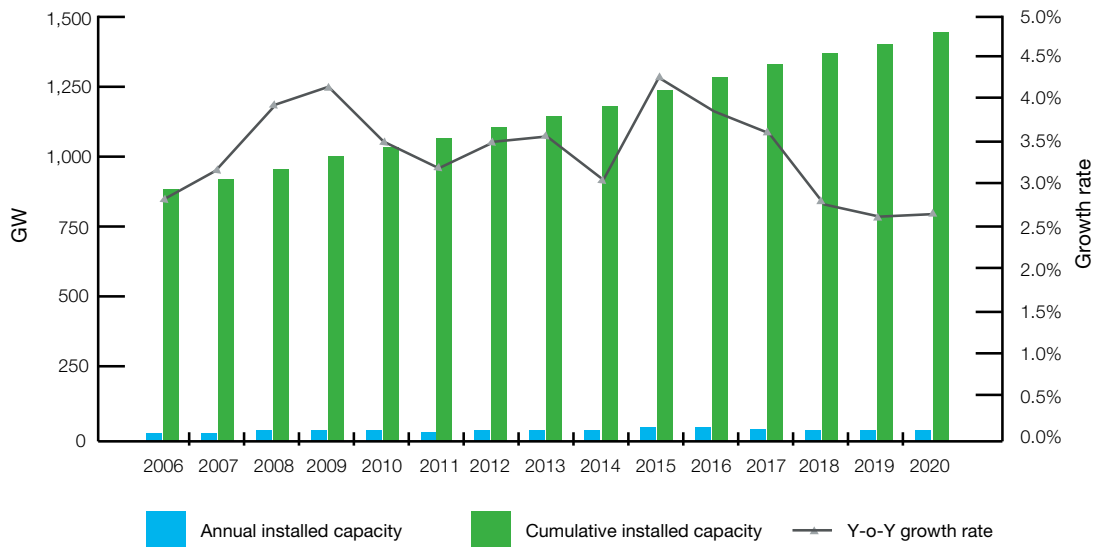
**Lower costs:** The specific cost of silicon-based solar modules and wind turbines will continue to decrease, making them competitive with almost any other source of energy (including nuclear and possibly hydro). The Levelized Cost of Energy (LCOE) of solar could reach €0.025/KWh.

**Combined systems:** Systems like hydro, wind, solar, and batteries will be interdependent. Power-to-gas (CH4, H2, NH3) systems will become common.

**Trade:** Neighboring systems, at all scales, will exchange power when it benefits both parties. Participants to the energy trading will be millions if not billions.

**Capacity:** Installed energy capacity will increase to optimum levels for a higher efficiency network.

## Hydro market evolution



Source: GlobalData, Alternative Energy eTrack [Accessed Date: June 7, 2012]

## Hydro: Optimizing performance of a clean and abundant energy resource

More than 25 countries depend on hydropower for 90 percent or more of their electricity supply (99.3 percent in Norway), of which 12 countries have 100 percent hydro-based systems.<sup>3</sup>

In 2013, the global amount of hydropower generation was estimated at 3,750 TWh. China leads the world with the most installed capacity (29 GW). Brazil, Turkey, India, and Russia have also made major investments in hydropower.

In comparison with other renewable energy sources, hydropower generation offers the lowest operating cost and the lowest cost of energy storage.

Maintenance cost is also low. In some cases hydro plant equipment can run up to 40 years with minimum upgrades.

The integration of hydro offers high-energy supply predictability and availability to the smart grid, which will, in turn, drive hydro growth over the coming decades. In addition to providing energy storage capabilities, hydro is very quick to ramp up, which is attractive in environments with highly fluctuating demand or variable renewable generation.

And since humans can directly manage the raw resource of hydro (by controlling water flows) it has some advantages over wind or solar, where humans are at the mercy of unpredictable weather patterns.

Worldwide, the number of small hydropower plants is booming. Even if the investment cost is higher than large plants, the environmental impact is lower. Also the management of small plants contributes to grid flexibility by allowing the facility to operate very quickly and by offering the capability to manage reactive power.

In the future of renewable energy, hydropower will play an integral role in providing a reliable power source for both backup storage and power generation.

## The three pillars of hydropower: What it means for utilities

- 1. Large hydro dams and run-of-river systems can serve in a standard power generation mode, replacing more traditional, less environmentally friendly means of power.
- 2. Hydropower can also be configured to address peak load demand, because it is readily stopped and started on demand.
- 3. Hydropower can also act in an energy storage capacity. The concept is known as “pumped storage.” Water is pumped to a higher altitude during a time period when the cost of electricity is low (charging) and flows downstream into generators when electricity prices are high (discharge).

Despite these advantages, only about 30 percent of global hydropower resources have been developed. This represents an immense opportunity for energy resources in expanding markets.



Corsica, France

## Remotely controlling a 54 MW hydro plant

**EDF is the main French electric utility** and one of the largest in the world currently producing 610 TWh for 38 million customers across the globe. EDF's generation projects vary from large-scale nuclear plants to a wide variety of renewable operations. In Corsica, a Mediterranean island off the French Riviera, EDF needed to build a new hydropower plant to provide electricity to the southern half of the island during peak hours. This peak power plant should be able to start up easily and generate quickly in “one click” at any moment to avoid capacity-related outages.

The Rizzanese Hydropower plant would be the backup supply for a town of 60,000 inhabitants and increase the share of the island's hydro output by 40 percent. The highest standards of safety and reliability were a key prerequisite.

Schneider Electric supplied the complete electrical distribution and grid connection equipment, i.e., MV cubicles, transformers, LV switchboards, protection relays, and full process control systems based on modbus TCP/IP architectures.

This automated system enables the utility to have 100 percent remote control and monitoring of the plant, increasing the operational efficiency of the actual site and the related grid management. As always, Schneider Electric worked hand-in-hand with the partnering contractors, in this case the hydro turbine supplier. Schneider Electric also provided EDF's specialists the technical knowledge and training to take full ownership of the installed systems.

For an island like Corsica, the installation of efficient hydropower systems enables the producing utility to reduce diesel consumption for power generation by 20,000 tons per year, which not only makes for cost-effective operations but also reduces CO<sub>2</sub> emissions by more than 60,000 tons per year. Islands, like Corsica, which have powerful natural resources, can increase the share of hydropower installations, making the most of existing natural resources, reducing their diesel imports, and creating sustainable energy operations complying to renewable regulations.





## Renewable original equipment manufacturers

The future and relevancy of renewable energy depends largely on the efforts of original equipment manufacturers (OEMs) in power generation, such as wind turbine manufacturers. These manufacturers are responsible for designing and creating cost-competitive solutions and supply chains so their products can compete with traditional fossil fuel generation equipment. Without these advances, green energy would remain only a theoretical concept.

Innovation, the cost of materials, the streamlining of the supply chains, and the standardization of parts lie at the heart of this endeavor. For renewable manufacturers, bringing a product to market can be a delicate equation where efficiency and cost per unit can make or break the future of a design or even the vision of a company.

Following the same path as the car industry a few decades ago, OEMs in wind, hydro, and solar have begun to regain their focus on core competencies by outsourcing to suppliers to make specific, standardized parts, subassemblies, and products for economies of scale. These outsourced parts, which often entail preassembled subequipment, give manufacturers the right product, at the right time, at the right place in their value chain, keeping them competitive to match the requirements of ever-lower LCOE.

For example, a company that creates wind turbines might outsource a certified gearbox from another company to keep costs down. They involve trusted subcontractors in the supply chain to optimize cost and be able to offer competitive prices. Because these best-in-class parts are standardized and rigorously tested across multiple applications, the result leads to an enhanced value of their assembled product. Schneider Electric delivers subassemblies for the power chain of platforms of wind turbine manufacturers, right in their factories at the right time in the manufacturing process to maximize efficiency of their supply chain.

### What's driving outsourcing in renewable equipment manufacturing?

1. The need for policy compliance (e.g., local content rules)
2. The cost of labor and logistics
3. Proximity of service
4. Digitization that enables extended value chains beyond the OEM to its suppliers
5. Standard components







## And now ... smart generation

If smart equals flexible, then the nature of flexible generation needs to be well understood.

The term “smart generation” is beginning to infiltrate more and more utility boardroom discussions. In a smart generation scenario, a new element that is added to the standard utility generation formula of availability, reliability, efficiency, low emissions, safety, and affordability is that of *flexibility*.

The driver in this case is the rapid influx of renewable energy coming online. The implication is that pricing and dispatch patterns will now be heavily influenced by the variable nature of wind and solar.

Flexible generation is driven by the behavior of the load, by ramping up or down as demand fluctuates or by quickly changing “state” from cold (inactive) to hot (active) or vice versa. The goal, at all times, is to fill the remaining demand gap for electricity.

The time needed to launch and synchronize a plant with the grid (startup time) is not crucial in a system where net demand is fairly

predictable. However, when operating with a large share of wind and solar in the mix, weather variations can rapidly change the need for power.

From cold start to maximum output, a steam-boiler-based power plant might need up to 12 hours. It therefore cannot match the minute-by-minute variations of a wind farm.

In addition to operational challenges, introducing flexibility into the generation model drives up costs by running plants less efficiently, below their optimal load factor, and by placing more strain on physical equipment due to frequent up and down power output requests. In fact, the U.S. National Renewables Research Laboratory estimates an increase in operations and maintenance costs of 2 to 5 percent for a typical fuel-fired plant that is transitioning from a stable to a more flexible mode.”

There are ways to grow generation flexibility while minimizing cost increases. Below are some recommended approaches:

- **Manage** generation at a fleet level. Wide area control of generation assets allows for optimization of economic dispatch and scheduling. The integration of external information allows the flexible generation approach to work efficiently.
- **Improve** the level of forecasting of demand patterns by gathering and processing high-precision weather data. This allows for optimization of reserve and standby plants.
- **Change** the ratio of baseload plants (i.e., those plants designed to operate around the clock and not flexible when it comes to dynamic output) to flexible power plants (i.e., those that are designed for part-time operation) in favor of the more flexible plants.
- **Modify** existing baseload plants into plants that can meet peak demands and that are capable of cycling on and off several times a day. (According to IEA, reservoir hydro and certain gas power plants are among the cheapest options to obtain flexibility with additional cost ranging from €0.88/MWh to €4.40/MWh).
- **Alter** operational maintenance practices so that equipment is minimally impacted by the side effects of frequent cycling. This will include the monitoring and managing of temperature ramp rates; proactive inspection to improve equipment reliability; and retraining to reinforce the skills needed for “flexible operation”-based monitoring and inspection.
- **Develop** CHP strategy in order to leverage two forms of outputs, playing on the thresholds to maximize the efficiency of either the electricity or heat production.
- **Re-evaluate** generation plants within the portfolio to determine if their roles can be modified to accommodate reserve power resource functions. Determine whether each plant can achieve fast ramp up or down of output, and how their level of reliability compares with the others in the network.







## Summary

As the climate debate continues to heat up, solar, wind, hydropower, and other clean energies see their costs plummeting and are being deployed at breakneck speed. Traditional utilities are poised to embrace and benefit from these power sources — even if some learning needs to take place before the transition.

The challenges of high penetration of renewables on the grid are balanced by the opportunity for clean power, lowered costs, and universal access to these renewable fuels. Thus renewables are popular. Onshore and offshore wind farms are getting more efficient. Solar is predicted to be one of the main sources of energy by 2050 due to its cost-competitiveness. Hydro plants continue to assert their viability as a dependable backup power source for other renewables.

Flexibility will be a key goal in grid operation. Utilities that wish to participate in the large-scale adoption of renewable energy sources will invest in smart generation and the smart grid to implement a new model of operation, one where the load follows the available generation.

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Photo: Europe biggest PV plant, 300MW, near Cestas, France



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