Smart Power Generation

Smart savings for power transmission systems
Smart savings for power transmission systems

New electricity market studies show that major grid operators and power utilities can achieve huge savings by applying the concept of Smart Power Generation to increase the flexibility of their power generation portfolios.

Upcoming changes in energy markets include the increased use of renewable energy sources, the retirements of ageing fossil fuel-fired power plants, and tougher environmental restrictions. These all mean that energy providers will have to make their networks smarter and more flexible.

Power suppliers describe renewable energy sources such as wind and solar power as “non-dispatchable” because their output potential varies uncontrollably, depending on the weather. In spite of their variability, clean power sources are usually exploited to the maximum, because they result in no fuel costs or emissions.

A complex balancing act
The total electricity supply needed in the grid is determined by fluctuating demand from energy users. This already makes load balancing a challenging task. Adding more non-dispatchable energy sources will make things even harder, as the rapidly varying shortfall needs to be filled by other power sources. The term “net load” is used to describe this energy gap.

Energy markets around the world are planning to use much larger amounts of renewable wind and solar energy. But when adding more renewables to a power system, their fossil-fired power plants will have to increasingly dispatch energy on an intermittent and unpredictable schedule.

To supply this net load at a reasonable price, energy utilities will need dispatchable power sources that are flexible, cost efficient, low maintenance, and can be ramped up and down quickly with minimal costs. The state-of-the-art gas combustion engines applied in Smart Power Generation fit the bill.

Multiple gas engine units with capacities of 10–20 megawatts can be set up in parallel to create total capacities of 600 megawatts or more. Advantages include the high efficiency rates of such facilities at all load levels as well as their low start-up costs.
The impact of Smart Power Generation on the electricity system of the UK

In order to explore how Smart Power Generation could affect energy systems and their costs, Wärtsilä has engaged external consultants to perform detailed electricity market studies. The target for the first study, commissioned through Redpoint Energy and Imperial College London, was the electricity system of the UK.

The UK government is committed to decarbonising their electricity network, as a key step towards decarbonising the wider economy. The UK is legally bound by emissions reduction targets of 34% by 2020 and 80% by 2050. Renewables will play a key role in this decarbonisation: the UK government has targeted that 30% of electricity generation ought to come from renewable sources by 2020, primarily wind turbines.

The study analysed the potential value of system flexibility through detailed modelling of the UK power market and balancing costs. Two underlying capacity scenarios were modelled for 2020 and 2030: a base wind scenario and a high wind scenario. The base wind scenario includes around 10 GW of offshore wind in 2020 and around 15 GW in 2030. The high wind scenario includes around 20 GW in 2020 and close to 40 GW in 2030. In both scenarios, 4.8GW of conventional CCGTs is replaced with 4.8GW of gas-fired Smart Power Generation.

High wind day – reserve provision

![Diagram showing variations in flexibility requirement largely driven by high wind output. Gas and coal providing bulk of flexibility by running at inefficient part load. Flexible Smart Power Generation provides a large share of flexibility requirements when standing. Lesser need for coal and gas plants to provide flexibility by running at inefficient part load.]
The outcome of this study was that flexible – rather than conventional – gas generation could save the UK between GBP 380 million to GBP 550 million by 2020 alone through reduced balancing costs incurred by the British National Grid, rising to between GBP 580 million and GBP 1.54 billion by 2030. As a result, reductions in balancing costs will lead to cheaper electricity prices for the consumers.

### Conclusions from the UK study

- **Our analysis shows that flexibility can have significant value by allowing a more efficient integration of intermittent renewable generation:**
  - £380m to £550m p.a. in 2020
  - £580m to £1540m p.a. in 2030
- Further analysis has shown that the value of flexibility can be even greater when fluctuations at a 10 min. level are considered, 25–35% higher than typical 30 min. modelling
- Current market imperfections result in ‘free’ flexibility as seen by the system operator, however this comes at a net cost to consumers
- These results have formed the basis of Wärtsilä’s response to the Balancing Significant Code Review of the British Office of Gas and Electricity Markets (Ofgem) and further engagement with the British parliament

### The impact of Smart Power Generation on the electricity system of California, USA

A second study on the impact of Smart Power Generation on a large-scale power grid was carried out by DNV Kema, this time looking to California, USA. The energy system chosen for the study is run by the California Independent System Operator (CAISO). It supplies electricity to the homes and workplaces of about 30 million Californians.

CAISO was chosen because Californian law requires that 33 percent of the state’s energy should come from renewable sources by 2020. California also has an ambitious environmental plan, which may require existing thermal fossil-fuelled power plants to be replaced over the next few years. These total up to 16 gigawatts. California’s fuel of choice is natural gas. Plans already exist for the installation of new gas turbine power plants with a capacity of at least 5.5 gigawatts.

DNV Kema looked at what would happen if, instead of these gas turbine based power plants, Smart Power Generation capacity would be installed – in this case sets of Wärtsilä’s 9.3-megawatt 20V34SG engines or 18.8-megawatt 18V50SG engines in Flexicycle™ power plant combinations.

The study's scenarios assume that California will enjoy a robust economic recovery and achieve its present targets for the use of renewable energy. The comparisons looked at carbon dioxide emissions and water consumption rates as well as power generation costs.

The study showed that adding highly efficient Wärtsilä gas engines to the system, instead of traditional, high-start-cost, inflexible gas turbines, will save CAISO up to 12% of their annual system costs by 2020.

The savings vary according to how CAISO would additionally deal with an energy shortfall. They could impose costly curtailments, but it is more likely that they would call into service older, less efficient plants that are not usually active. Starting them up might take many hours.

In any case the savings for the California system in cash terms would amount to hundreds of millions of dollars a year.
Wärtsilä’s gas engines would achieve these impressive savings by rapidly ramping up and down the output needed to compensate for fluctuating solar and wind output. We can do this at much lower cost than gas turbines.

Adding Smart Power Generation to the system means that when gas turbines and other power generation facilities are needed to help meet total demand, they can be run steadily at their optimum efficiency. This leads to further savings.

The study also looked at conditions modelled for specific days in the year 2020 with a five-minute timescale, using different scenarios to assess how energy could be produced. The results showed that on days with either high levels of demand, or highly variable wind and solar power production, Smart Power Generation could reduce the total cost of energy production by 30–40%.

The Smart Power Generation scenario would also create significant reductions in water consumption and carbon dioxide emissions from power generation in California. It would allow California to make much faster progress towards its environmental targets on greenhouse gas emissions and water conservation. The state’s water resources are under serious pressure.

DNV Kema’s study of California’s future energy options modelled energy generation and consumption conditions for specific days in 2020. The graph below for a single day illustrates why power system operators need to have a flexible source of energy available to fill the rapidly fluctuating gap (net load) between the renewable energy that can be generated and the total demand from consumers.

The total load needed in the grid depends on demand from electricity users. Daily variations in total demand are fairly predictable, but weather conditions cause fluctuations in power output.

Grid operators want to make the most of any green energy available from renewable sources. But the amounts of wind power available can vary quite unpredictably over any single day. Solar power generation conditions vary naturally with a predictable pattern as the sun rises and sets, but variations in cloud cover add a degree of uncertainty.

Smart solutions like demand response management tools can help to even out demand by encouraging consumers to change their daily electricity use patterns. But there will still be a great need for flexible power sources ready to be ramped up or down at times when demand rises or falls steeply.

A varying daily energy gap

![Graph showing energy production and demand](image)
Smart Power Generation pluses for California

The California study has shown how the Smart Power Generation concept utilising multiple gas combustion engine units have many advantages for power system operators.

- Using flexible gas combustion engines instead of gas turbines, which are costly to ramp up and down, could save the system operator CAISO up to 12% of total annual system costs by 2020.
- Adding gas combustion engines means that other power generation facilities connected to grids can more often be run steadily at their optimum efficiency.
- Carbon dioxide emissions are also reduced when fuels are used more efficiently. Emission targets are becoming ever more important for players in power markets.
- Gas combustion engines can reduce the total water consumption of power supply systems, since their engines can be air-cooled. In the California case, they will enable the decommissioning of outdated power plants with once-through water cooling systems.

Widely applicable findings

These results can easily be applied on a wider scale. The studies demonstrate the value that Smart Power Generation can bring to any large, complex power system seeking to utilise renewable energy. Such systems include entire national grids in countries like Spain.

The Smart Power Generation concept is already a reality. Most modern grid systems using increasing amounts of renewables are already well aware of the growing need for flexibility, though they may not use the term Smart Power Generation.

Though Smart Power Generation is a broad concept that can also cover other technologies, at Wärtsilä we believe our gas engines have the best mix of attributes. We have been sharing the findings of these studies with utilities and other independent system operators, who greatly appreciate that somebody has gone beyond talking and backed it up with analysis and data.
Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.