The path towards a 100% renewable energy future

WÄRTSILÄ BUSINESS WHITE PAPER

Executive summary

The global energy market is constantly evolving. Current market trends show the energy landscape is in transition towards more flexible energy systems with a rapidly increasing share of renewable energy, declining inflexible baseload generation and wider applications of storage technology. The declining costs of renewables have begun to reduce new investments into coal and other inflexible baseload technologies; a transition which will eventually cause renewables to become the new baseload. In 2017 itself, 14% of electricity generation worldwide was attributed to wind and solar.

Wärtsilä aims to accelerate this transition towards a 100% renewable energy future. As a leading global energy system integrator offering a broad range of flexible and efficient solutions for the operational lifecycle. Wärtsilä can create optimal paths towards a 100% renewable energy future for its customers by analysing customer requirements and building optimal energy systems with total cost of ownership. This paper describes this transition – the dynamic nature of the energy market, the increasing requirements for the flexible assets in power systems as well as the reliability and flexibility of hybrid solutions such as solar PV combined with engines and storage technology and Wärtsilä's proven track record of successful customer cases.

TABLE OF CONTENTS

The renewable revolution

In recent years, market trends show a steady decline in the price of renewable energy in the global power system. Investments into new inflexible baseload generation are also on the decline and price performance data shows the cost competitiveness of wind and solar is rapidly increasing as compared to traditional thermal generation. In the past 20 years, the cost per kW of wind power plants has decreased by 40% and solar has dropped by 90%. Currently, wind and solar attribute to approximately 1,100 GW of electricity globally which forecasts indicate will rise to 2,000 GW in 2024. Similar trends in global energy storage deployments show an increase from 139 MW in 2012 to 1,173 MW in 2017[1].

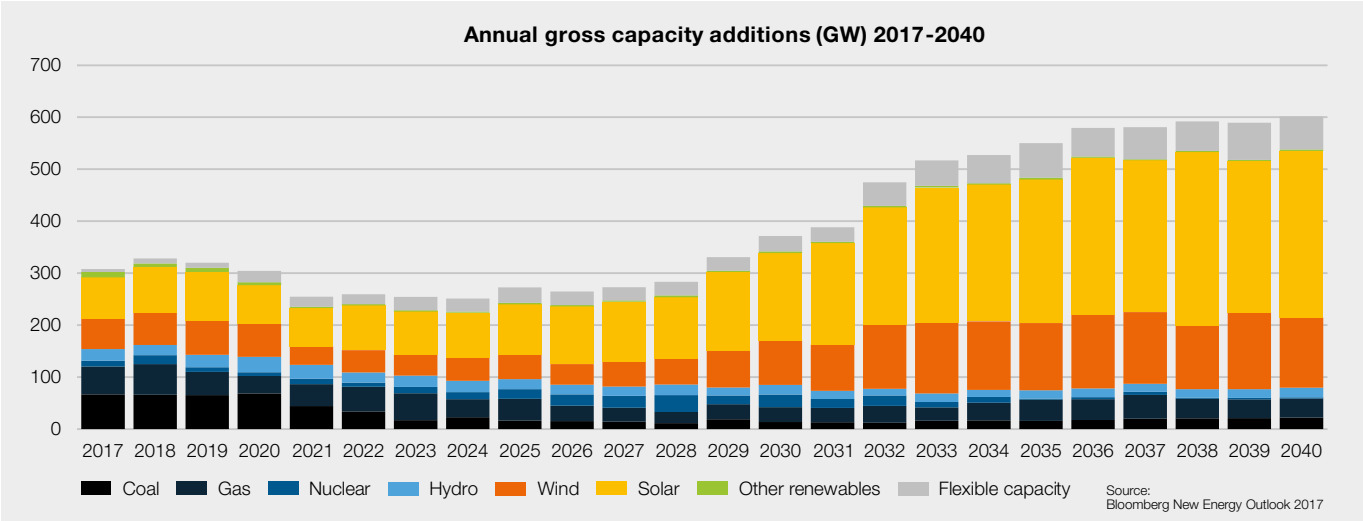


Figure 1 Wind and solar cumulative installed capacity is expected to increase from 14% in 2017 to 48% in 2040, enabled by engines and storage.

Annual global installations of renewable energy capacity are also steadily increasing. In 2017, 175 GW of new renewable energy was installed globally, the highest year on record.

This includes 98 GW of solar PV which is expected to rise to 100 GW in 2018. This industry transformation and global advancement towards renewable generation has made it more difficult for existing inflexible baseload power plants, such as coal and nuclear, to efficiently provide solutions for customers. Since investments define and dictates a company's strategy for the future, the existing business model is shifting from

[1] Bloomberg New Energy Finance, 2017

the era where centralised large units benefited from economies of scale. Moreover, as investments in new intermittent energy technology grow and prices for renewables reach a tipping point, utilities are starting to change their portfolios to involve more renewables and flexible generation. Flexible solutions like engine power plants and energy storage are the key to providing the needed reliability and ensuring the affordable cost of power systems.

Today, large markets such as the US, the UK and specific regions in Central Europe exist for stand-alone energy storage due to high fuel costs and the levelised cost of electricity (LCOE) of renewables set to fall below those of conventional coal and gas by 2040. This will lead to a tipping point, where new build renewables will become cheaper than new build combined cycle gas turbine (CCGT) or coal baseload plants and cause increasing focus on new investments into renewables. This tipping point will arrive at different times in different countries – in China, onshore wind is now beginning to gain a competitive advantage over coal however in the US, the best-in-class on shore wind is already cheaper than the new build CCGT.

A second tipping point will arrive when new build renewables become cheaper than running an existing gas or coal plant, hence the loaded costs of renewables will become cheaper than the marginal costs of thermal generation[2]. This will cause retirements of thermal plants from the system ahead of their economic lifetime and speed up the transition. Eventually, these tipping points will lead to renewables achieving grid parity – where they generate power at an LCOE less than or equal to price of purchasing power from the electricity grid, without subsidies or government support.

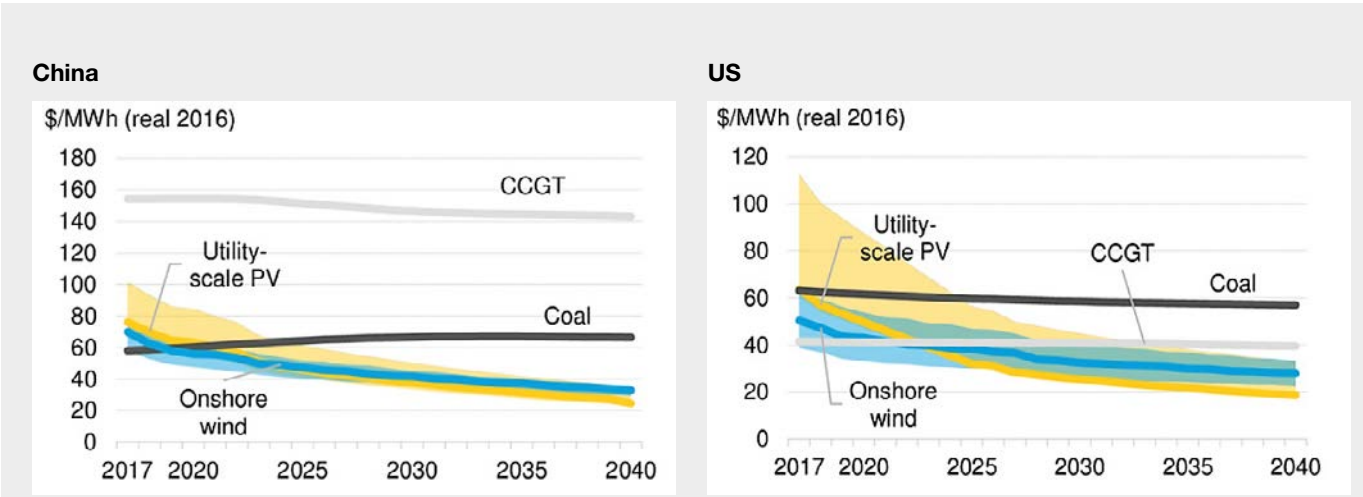


Figure 2 On a levelised cost of energy basis, by 2040, solar will become another 60% cheaper and wind will become another 40% cheaper.

[2] Bloomberg New Energy Finance, 2017

Furthermore, inflexible capacity is being shut down and a prime example of this in Australia, which is in the process of steady decarbonisation. AGL Energy Limited, Australia's leading integrated energy company is planning to replace the 1,000 MW Liddell coal plant with 1,600 MW of renewable energy, an additional 750 MW of flexible gas capacity and an additional 250 MW of energy storage.

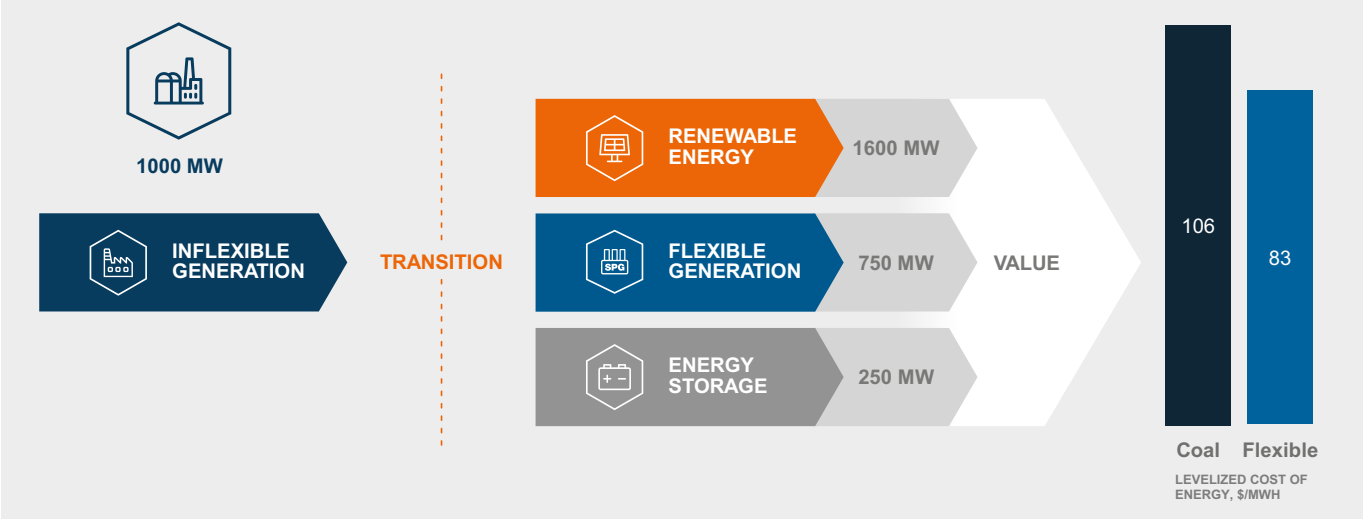


Figure 3 This flexible portfolio with renewables has LCOE costs of about AUS 83/MWh compared to the AUS 106/MWh of a coal plant.

Case

AGL Energy Limited, Australia

Wärtsilä will deliver a 211 MW Smart Power Generation (SPG) power plant to AGL which will provide fast, flexible and highly efficient capacity. This engineering, procurement, and construction (EPC) project represents the first utility-scale internal combustion engine (ICE) power plant in Australia's National Electricity Market (NEM). Comprised of multiple Wärtsilä 50DF dual-fuel engines, it will provide the fast-start capability required to respond rapidly to fluctuations that are inherent to renewable generation and can reach full output within minutes and provide reliability in all conditions.

"The new power plant will improve the reliability and security of supply in South Australia. Wärtsilä's internal combustion engines operate with a lower heat rate than other forms of fast-start plants currently available,"

Doug Jackson,
Executive General Manager, Group Operations, AGL.

Flexibility is rewarded in the National Electricity Market, which drives investment in flexible gas as well as energy storage. The operational flexibility of Wärtsilä power plants is a key enabler for utilities in an electricity market with high share of renewable energy.

Moving towards high renewable energy systems

Global progress towards achieving a 100% renewable energy future is being made at an incredibly rapid pace. Power providers, utilities and governments are changing their perspectives towards inflexible generation and existing thermal capacity is being replaced with renewables. This phased transformation, from the global power system operating at 0-20% renewables to a stage where 80-100% renewable energy systems will exist, requires major changes in infrastructure, investments and innovation in technology.

In the past, due to renewables being expensive as compared to fossil fuels, a large proportion of energy was produced by inflexible plants operating on coal, natural gas and nuclear. Inflexible generation was utilised to provide both baseload power and peaking generation and opportunities for storage to cost effectively address ancillary services were limited due to the lack of development in the technology. Moreover, in this 0% renewables scenario, power systems in countries were based on conventional centralised grids and consumers were passive participants. Currently, the world is at 14% renewables, where flexible thermal capacity has begun to replace inflexible generation to enable more stable grids and renewables are becoming more competitive without subsidies. Now, storage is being more widely used for energy shifting and increasing intermittent load profiles are challenging the existing business model. Soon, grid parity of renewables and energy storage will also be achieved as the feasibility of integrating them increases.

In an 80-100% renewables scenario, there will be no role for inflexible generation as renewables become the new baseload and excess renewable energy is used as raw material for other commodities. This increase in the usage of renewables will require highly flexible thermal capacity to maintain system reliability and energy storage will become a key component in the baseload grid to maintain overall grid balance. As the information and knowledge surrounding power generation is demystified, consumers will begin to actively participate in the system management and power-to-gas will be utilised to produce synthetic gas for flexible back up and seasonal load variations in lieu of flexible thermal capacity.

Case

Malicounda power plant, Senegal

The Government of Senegal has prioritised the development of the power sector, making it a central part of its Plan Sénégal Emergent (PSE), in which Senegal aims to become an emerging economy by 2025 and provide access to electricity for the whole country. Senegal has substantial potential to develop solar power, wind power and its offshore natural gas resources; the country is also exploring other crucial technologies including energy storage.

A Wärtsilä Flexicycle™ power plant contracted by Matelec Group, will increase Senegal's energy production and lower the country's energy costs by ensuring high availability, efficiency and reliability of power. On a broader scale, the thermal plant will provide the needed flexibility to enable the integration of intermittent renewable energy into Senegal's grid as well as enable Senegal to achieve its goal of reducing consumer electricity pricing.

The Matelec company, the engineering, procurement and construction (EPC) contractor for the independent power producer (IPP) Melec Power Gen, placed an order for the delivery of an energy efficient 130 MW Flexicycle™ power plant. Wärtsilä will engineer, manufacture and deliver the Malicounda power project to the Mbour region, 85 km south of the country's capital Dakar. The Malicounda power plant will initially operate on seven Wärtsilä 18V50 engines running on heavy fuel oil (HFO). There is, however, an option to convert the engines to gas operation as soon as gas becomes available in Senegal. Matelec will operate the plant to help satisfy baseload needs in Senegal, and a 10-year maintenance agreement with Wärtsilä will guarantee the high availability and reliability of the plant. Wärtsilä Flexicycle™ power plants combine the benefits of a flexible, simple-cycle plant with the outstanding efficiency of a combined cycle plant and thus can operate in a highly-efficient combined cycle mode as well as in a dynamic rapid simple-cycle mode. The Flexicycle™ solution is based on gas, multi-fuel, or liquid fuel power plants combined with a steam turbine. The plant is expected to become operational in 2020.

"We needed a reliable and qualified partner to engineer and provide a flexible and reliable energy system now, and later as our energy infrastructure evolves. With its global and Pan-African experience, Wärtsilä fully meets the project requirements. This is a major energy project that is very important for Senegal."

Sami Soughayar,
CEO, Matelec Group.

Unlocking flexibility is the key

Increasing flexibility in every part of a power system is vital to achieve high renewable integration. Flexibility ensures that power systems can adapt to fluctuations in both demand and supply in a cost effective manner. Conventional power systems were focused on ensuring sufficient generation capacity to meet peak demand however for power systems with a greater share of renewables, it will be more important to have sufficient flexibility. As the usage of renewables increase, variations in supply and demand will be significantly higher due to the intermittency of renewable energy sources, thus arises the need for efficient power regulation.

Flexibility offers power regulation, which is utilised for providing additional power for balancing the system when required and reducing power when demand decreases. In the short term, it will be important to provide the ability to maintain quick response times, where as in longer time frames, energy shifting and offering larger storage content will require more emphasis. Operational planning flexibility will also be required to ensure that sufficient flexibility resources are available to enable safe operation under forecast uncertainty in the supply (loss of generation units)[3].

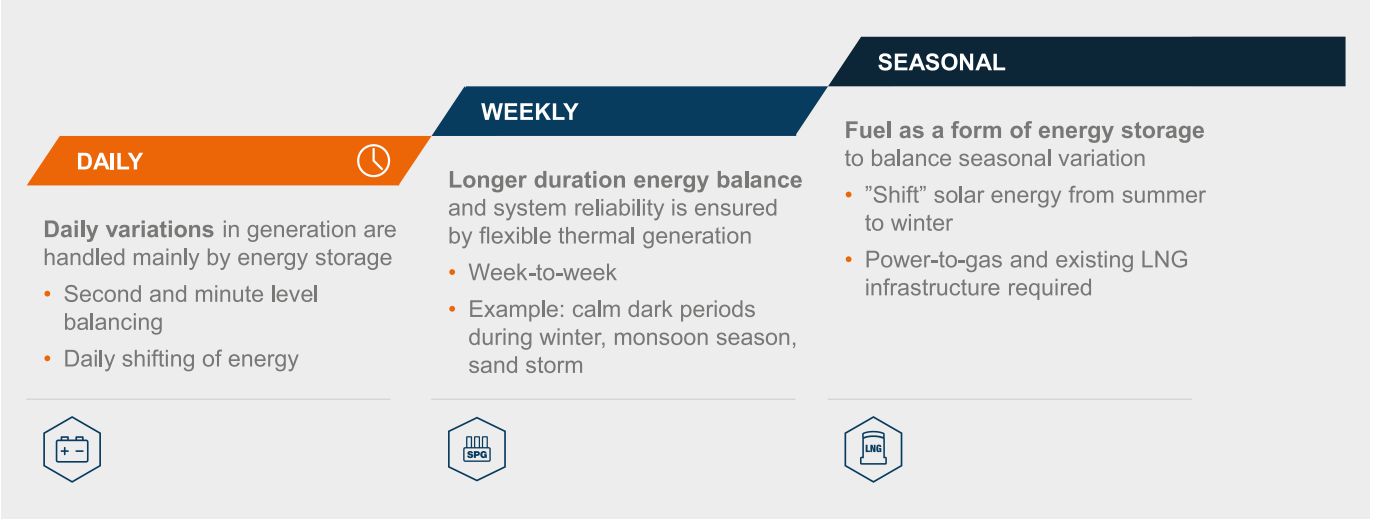


Figure 4 Multiple forms of flexibility are required for a 100% renewable energy system.

The three main types of flexibility required are daily, weekly and seasonal flexibility. The daily variations caused by changes in supply and demand will be covered by energy storage, a key component for overall grid balancing and will provide second and minute level frequency balancing when renewable energy is unavailable. In a 100% renewables scenario, flexible thermal capacity which will incorporate synthetic gas, biogas and synthetic liquid fuels for back up will replace existing baseload capacity and ensure week to week shifting and system reliability. Lastly, seasonal variation caused by significant changes in weather conditions such as monsoons or extended periods of daylight, will greatly affect the output of a high renewables power system. This will be balanced by fuel as a form of energy storage with existing LNG infrastructure and power-to-gas.

[3] ECOFYS, 2014

In addition to investing in increasing flexibility, the transition to a 100% renewable energy system also requires massive investments in new capacity. As existing baseload capacity will be replaced by flexible thermal capacity, renewables and storage, the intermittent nature of renewables will require a large increase in generation capacity to sufficiently meet peak demand as compared to traditional baseload power plants. In an 80% renewable energy system scenario, assuming peak demand remains constant, four times as much renewable energy capacity is required to meet demand compared to a 0% renewable system. Similarly, a 100% renewable energy system requires five times the amount of renewable energy capacity and four times the amount of energy storage. These investments, however massive, will become the lowest cost options in the future due to the decreasing costs of renewables.

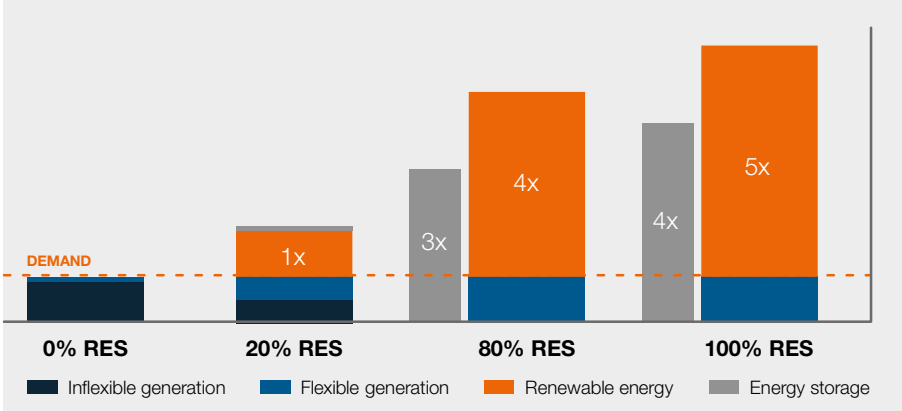


Figure 5 Capacity vs peak demand models for a 100% RES show a massive investment in renewable generation capacity is required.

On a country level, modelling conducted for the Philippines shows that total installed capacity increases from 24,735 MW to 64,271 MW from 20% renewable energy sources (RES) to 100% RES. Additionally, storage increases from 0 MWh to 44,000 MWh. These trends signify the importance of these sustainable technologies in the future and the importance of investing into these to accelerate the growth to a cleaner future.

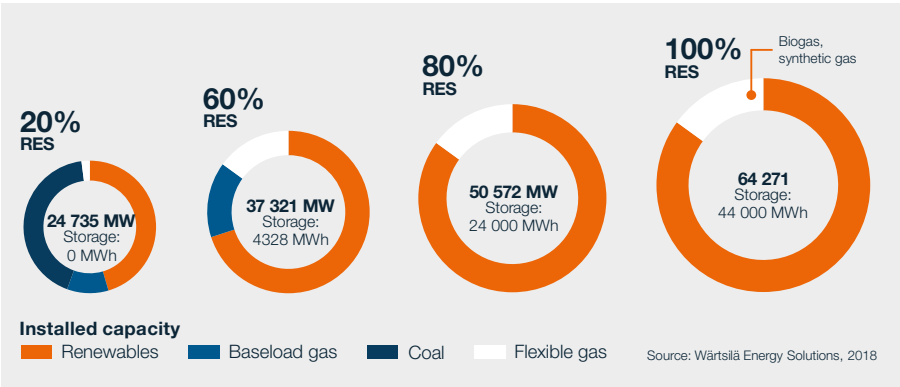


Figure 6 Optimal path towards 100% renewable energy system for Philippines.

Energy system integration

An energy system integrator understands the role of different technologies in customer power systems and combines a customer's assets through software, full EPC offerings and optimal life cycle management to create optimal paths towards 100% renewable energy systems.

Wärtsilä views that energy system integration happens on a power plant level as well as during its lifecycle.

UNDERSTAND

An energy system integrator should understand the evolving energy market and analyse economic and market trends to recognise value-based opportunities for customers in the utility and industrial market. Modern power system modelling, including technology flexibility constraints, high-resolution renewable energy profiles and co-optimisation of energy and reserves, should be conducted to identify the requirements and long-term capacity additional needs for optimal power systems. This provides a holistic view of the type of assets that should be integrated into the system, the system requirements on a customer or country level and the type of technologies needed to minimise costs, and to maximise efficiency and reliability.

DESIGN & BUILD

Based on power system analysis and optimisation, the next step is to design and build the assets required in a system. It requires looking within an individual asset, i.e. the building of a new power plant, which may be a hybrid (integrated solar, engines, storage) or a single technology power plant, to identify the various sub systems that need to be integrated and provide one functioning entity that can operate in a power system in the intended way. This step also requires understanding the values and operational and maintenance profiles for customers depending on the complexity of the power system and the number of energy sources to be integrated to create an optimal power system.

SERVE

Serving seeks to provide a comprehensive understanding of energy systems, including fully integrated assets and advanced software complete with value adding lifecycle services for customers. This step also includes understanding the customers' needs over the lifecycle and how to optimise and maintain the existing asset portfolio of a power market operator.

As an energy system integrator, with the capability to model and define optimal energy systems as well as integrate products and solutions to existing grid assets, Wärtsilä has the knowledge and capabilities to facilitate the path to 100% renewables at the country, community and customer levels. Furthermore, being a leading EPC and lifecycle support provider, Wärtsilä provides support to customers with a combination of engine power

plants, gas-to-power solutions, integrated solar PV, energy storage, integration and lifecycle optimisation. For example, New Mexico in the USA is one of the best locations for a 100% renewable energy system due to abundant wind and solar resources. Results from Wärtsilä's power system modelling for the optimised path from the current 10% renewables energy system to a 100% renewables energy system show a 954 MW increase in flexible gas capacity and a 700 MW increase in energy storage compared to the current portfolio. Furthermore, when comparing two alternative scenarios for New Mexico as shown by Figure 5, continuing to invest in inflexibility produces more undesirable consequences including a CO_2 intensity of 518 g/KWh as compared to almost 0 g/KWh in a flexibility portfolio.

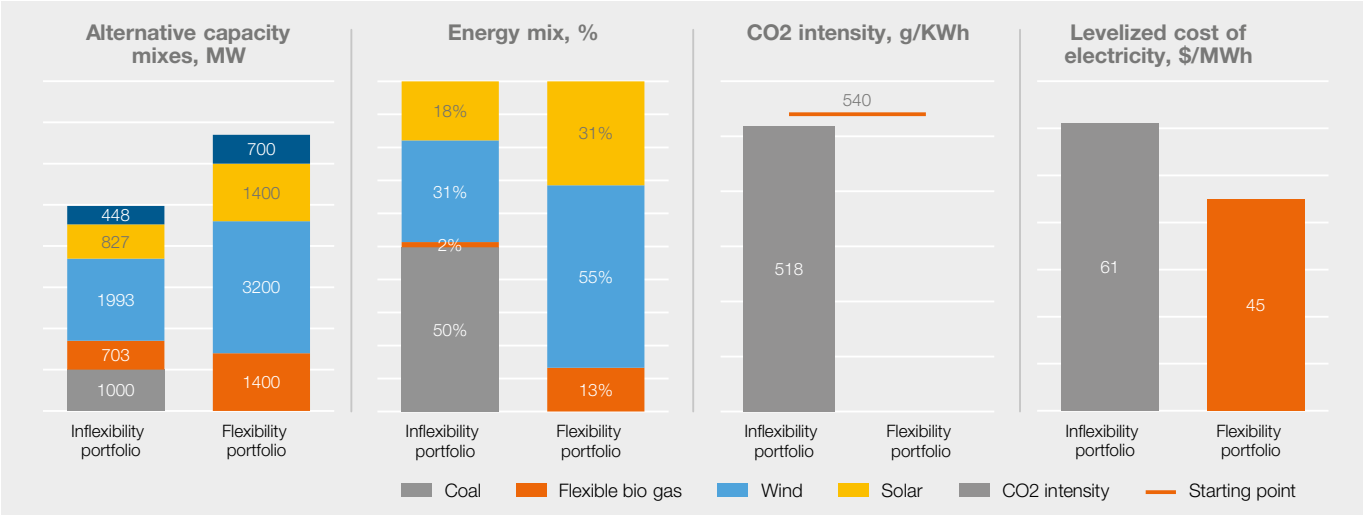


Figure 7 Comparing two alternative scenarios in an energy system with good wind and solar conditions for PNM New Mexico.

Case

Tucson Electric Power, Arizona

In Arizona, Tucson Electric Power (TEP), a subsidiary of Fortis Inc., is building a 200 MW Wärtsilä Smart Power Generation (SPG) plant to provide the needed flexibility to integrate renewables into the power system. Working to deliver at least 30% of its power from renewable energy sources by 2030, TEP selected Wärtsilä since the SPG plant offers fast-start flexibility and is well-equipped to address intermittency and other challenges associated with an expanding renewable energy portfolio. The plant is being built on the site of an existing generating station that currently consists of both natural gas-fired and renewable energy assets.

The Wärtsilä engines will replace two of the existing plant's older steam generators, thereby improving the plant's overall efficiency. This will also reduce the plant's emissions of nitrogen oxides (NO_X) by approximately 60%, equalling about 350 tons per year. Furthermore, the Wärtsilä engines require minimal amounts of water for cooling, which is an important consideration in Arizona's hot, dry climate.

Wärtsilä Solutions for a 100% renewable energy future

Flexibility and hybrid solutions are critical components for leading this transition to a 100% renewable energy future. Smart Power Generation plants provide the best means of support to the power system by offering the highest degree of flexibility, enabling major savings, and creating an optimised response to rapid changes in intermittent generation. To enable the transition for its customers, Wärtsilä also provides utility-scale hybrid solutions of integrated energy storage and energy management systems to achieve system stability and maximises renewable penetration using solar and wind generation. Wärtsilä's existing engine solutions have the capability to operate using various gas and liquid fuels and are flexible to also function on synthetic biofuels and traditional biofuels.

Smart Power Generation

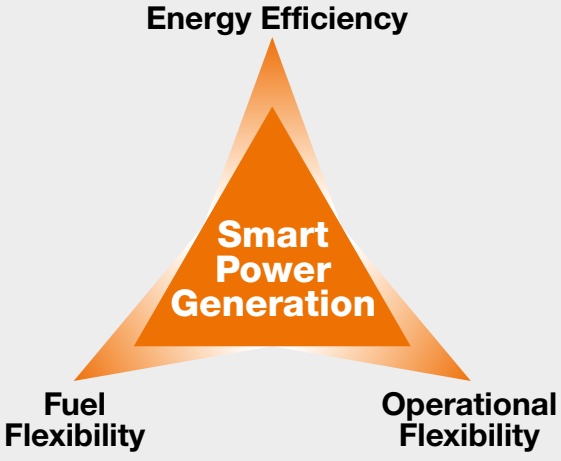
Smart Power Generation (SPG) engine power plants play a key role in providing the operational and fuel flexibility for engine power plants needed to enable the transition to a modern, reliable power system. For today's emerging low carbon systems. it effectively absorbs current and future system load variations and provides dramatic savings.

- SPG technology balances large input fluctuations of wind and solar
- Allows baseload plants to be released from cyclic operation and provides high efficiency base load, peaking, and load following power
- Contributes to grid frequency regulation and system stability
- Improves the total efficiency of power systems

Its main cornerstones are high energy efficiency, outstanding operational flexibility, and multi-fuel operation.

SMART POWER GENERATION OPTIMISES POWER SYSTEM RESERVES

SPG provides super-fast grid reserve capacity on a national power system level and while in standby mode, SPG reserve capacity does not consume any fuel, generate emissions or suffer from wear and has a start-up time of 2 minutes. When large power plants are not needed to provide reserve capacity over and above the capacity needed to meet normal peak demand, the efficiency of the whole power system increases. This enables a more stable operational profile for the large power plants and the additional maintenance costs connected with cyclic operation are reduced.



ENERGY EFFICIENCY

- High baseload efficiency, regardless of ambient conditions
- High plant efficiency over a wide load range due to modular internal combustion engine design

FUEL FLEXIBILITY

- Continuous choice of the most feasible fuel
- Solutions for liquid and gaseous fuels, renewables, multi-fuel plants & fuel conversions

OPERATIONAL FLEXIBILITY

- Fast start to full load in 2 minutes regardless of plant size
- Unlimited starting and stopping with no impact on maintenance

Engine – solar PV hybrids

In 2017, solar represented one third of all power generation capacity increase globally with close to 100 GW added as well as almost 50% of global new investments in clean energy. This proves that it is dominating the renewables market, far surpassing wind, hydro and any form of thermal power generation. Wärtsilä has introduced solar photo-voltaic (PV) solutions, comprising of utility scale solar PV plants, integrated with engine power plants with full EPC delivery capabilities. The solar hybrid option is a combination of Wärtsilä's engine-based SPG power plant and a dedicated solar PV system operated in synchronicity. The engines compensate for day light loss by ramping up the power immediately and automatically, by a sizeable number of megawatts per minute, if needed. These kinds of internal combustion engines represent the only technology capable of such ultra-flexible operations. Wärtsilä offers Lifecycle solutions for engines, solar PV modules, integration, project development and financing.

The environmental benefits of Engine – solar PV hybrids minimise fuel losses and operations and maintenance costs. A grid-connected 150 MW hybrid facility comprising 100 MW of engines and 50 MW of solar modules can save 21% of the oil consumption, compared to a pure engine-based power plant. This represents a reduction of approximately 200,000 barrels of oil per year.

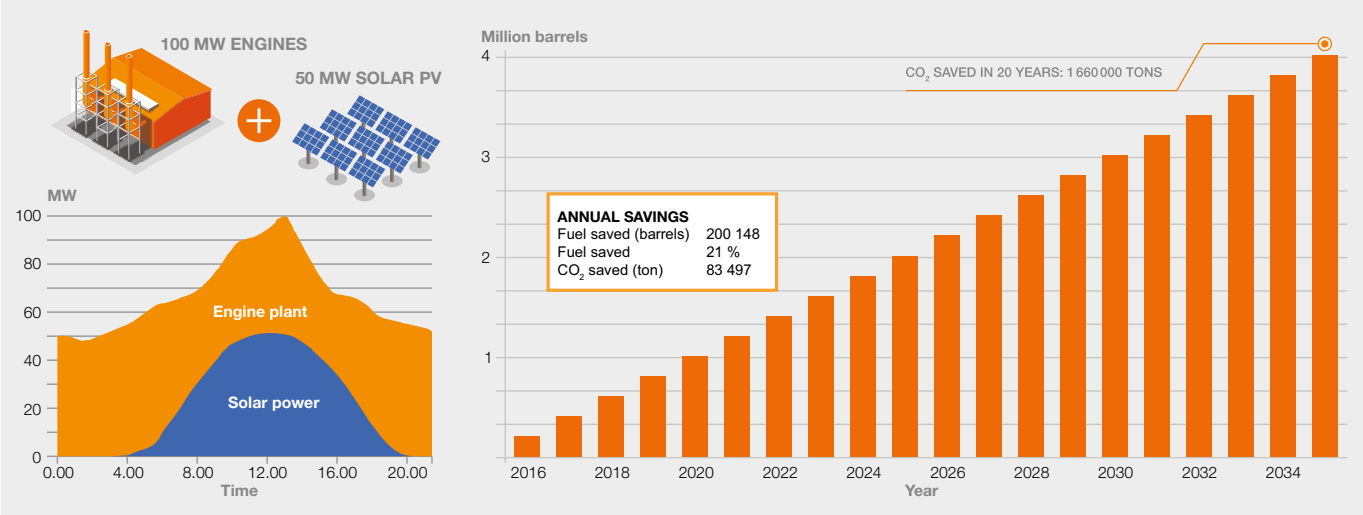


Figure 8 Assuming delivery price of 50 USD/barrel, the fuel cost savings are 10 million USD per year. In carbon emissions, the reduction is equally 21 percent, or approximately 83 000 tonnes per year.

This hypothetical case shown in Figure 8 presumes a utility-owned facility, located in an equatorial region, operating on a typical hot climate residential load profile (with the demand peak at noon due to extensive air conditioning). The Operation and maintenance (O&M) cost per MWh for hybrid PV power plants can be up to 50% lower than for standalone PV. Lastly, the economic logic of an engine-solar PV hybrid plant is to save fuel and thus pay back the additional investment in solar PV modules. A hybrid becomes economically feasible when the value of the displaced fuel exceeds the investment in the PV modules.

Case

Essakane Solar SAS, Burkina Faso

The Essakane gold mine in Burkina Faso receives its needed power from Africa's largest engine-solar PV hybrid power plant delivered by Wärtsilä. This 15 MWp solar PV power plant was delivered to Essakane Solar SAS, the Burkina Faso based subsidiary of French renewable energy IPP Total Eren. The hybridisation of an existing 55 MW Wärtsilä power plant running on heavy fuel oil (HFO) with the new solar PV plant and related hybrid plant controls enhances the plant's performance significantly. The engine power plant provides backup and balance of load, while the solar farm produces energy during the day.

IAMGOLD Essakane SA, an off-grid gold mine, is the largest privately held business in Burkina Faso and is located 330 kilometres northeast of the capital city, Ouagadougou, and 42 kilometres east of the nearest large town. Because of the isolated location of the gold mine, reliable and sustainable around-the-clock energy is vital. Total Eren, an independent power producer which develops, finances, invests in, builds and operates renewable energy power plants globally, and its partner African Energy Management Platform (AEMP) are the owners at respectively 90% and 10% of the project company, Essakane Solar, which signed a 15-year power purchase agreement (PPA) with IAMGOLD Essakane SA. Total Eren and AEMP via Essakane Solar SAS will operate the solar PV plant for the PPA term, and sell the electricity generated to IAMGOLD's Essakane Mine.

This solar PV plant will help save fuel, which results in cost savings and environmental benefits; an estimated 6 million litres annual reduction in fuel consumption and a reduction of annual CO_2 emissions by 18,500 tonnes. The entire scope delivered by Wärtsilä covers engineering, procurement and construction (EPC) of the solar PV power plant, including inverters and switchgear, in addition to almost 130,000 photovoltaic panels. Finally, there is the control system – a crucial component of the hybrid plant – which is also included.

The asset management agreement signed between Wärtsilä and Essakane Solar SAS seamlessly complements the EPC agreement. Wärtsilä optimises the production of the PV plant and makes sure that the thermal plant delivers effective, efficient and stable power with unsurpassed performance. In parallel, the thermal plant, which operates on eleven Wärtsilä 32 engines, retains a sufficient number of engines in stand-by mode to cover potential fluctuations in the PV solar energy production. Maximising the solar PV plant's production means that less heavy fuel oil is needed for the thermal plant, reducing both fuel costs and environmental impacts.

Essakane Solar's engine-solar PV hybrid power plant is one of the largest of its kind in the world. The plant is a breakthrough for industries relying on carbon-intensive diesel power, which until now has been their only reliable energy source. For large isolated industries such as mining companies, which operate around the clock, hybridisation can be the answer, especially as the energy costs typically represent up to 30% of the operating expenses. Connecting a renewable energy source such as solar power to a SPG plant reduces energy costs, improves the carbon as well as the social footprint, and hedges against oil price unpredictability.

"This project represents a major breakthrough in the industry. Hybrid solar PV-engine solutions will allow energy intensive industries to enter an era of more climate-friendly operations, improve business and increase resilience to oil price variations. Total Eren chose Wärtsilä for its outstanding track record in EPC projects in Africa and the company's commitment to design, deliver and support a reliable hybrid solution like this."

Christophe Fleurence, Vice President, Business Development for Africa, Total Eren

Energy storage hybrid solutions

Energy storage technologies are a critical part of the power system in a 100% renewable energy world. Both capacities and output of storage are expected to increase hundredfold with more than a quarter of all electricity in the system going through storage and the 1.3 TWh of storage energy capacity present today is expected to rise to 1,050 TWh[4]. Wärtsilä energy storage solutions are significantly improving efficiency by increasing back up capacity and creating new opportunities in electricity markets.

Through the acquisition of Greensmith Energy, a leading provider of energy management system (EMS) software, Wärtsilä offers grid scale hybrid energy storage, as well as hybrid systems, pairing engines or renewables with energy storage systems or a combination of all the latter. Specialising in energy storage systems optimisation and integration, Greensmith has delivered more than 70 installations around the world to some of the largest power companies. The Greensmith Energy Management System (GEMS) platform is the most widely-deployed energy storage software solution that enables the most-advanced and proven energy storage systems in the world. With GEMS, hybrid power plants run optimally, always ensuring the ideal utilisation of all the power generation assets.

Wärtsilä offers a unique combination of hybrid energy solutions that are based on engine power plants, renewable energy and energy storage systems, all integrated, managed and optimised by GEMS. The hybrid solar solutions allow the utilisation of all the available solar energy that is otherwise partly curtailed due to the shifting of the energy to a later time in the day.

MAIN FEATURES

- Frequency support & reserves
- Peak demand management
- Demand charge reduction commercial and industrial (C&I)
- Energy shifting

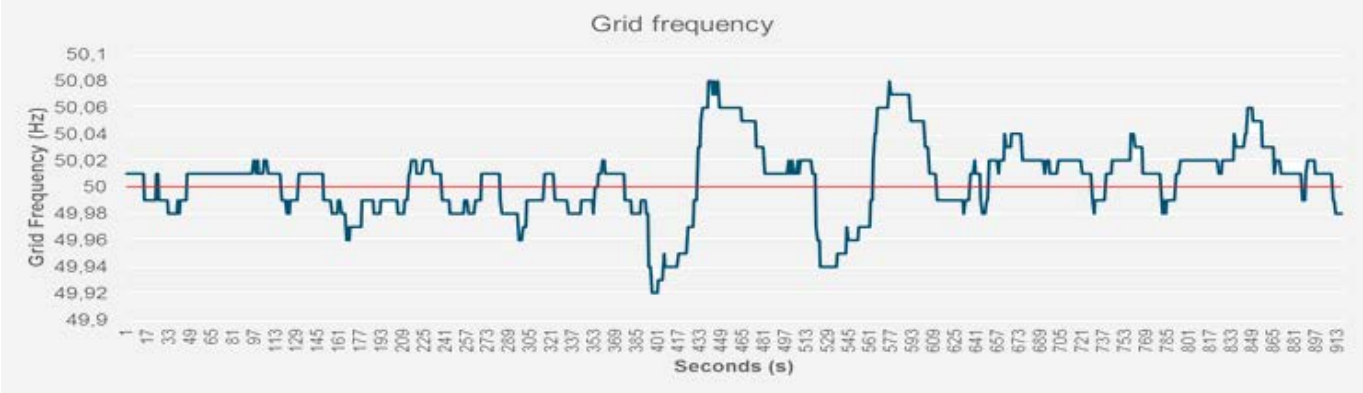


Figure 9 Grid Frequency Control with Energy Storage.

[4] Wärtsilä Energy Solutions, 2018

SOLUTION ADVANTAGES

- Income maximisation by firm, high quality, on-demand renewable energy delivery
- Revenue stacking by stacking energy selling with ancillary services
- Energy saving by recapturing clipped and curtailed PV power
- Higher energy efficiency and lower equipment cost with direct current coupled technologies
- Expertise in renewable power generation, grid market, control and computing technologies
- Future proof by adapting to weather conditions, market conditions and competitions
- Energy Time Shifting – Time-shifts energy output from day-time, peak irradiance hours to high demand hours, even in the evening
- Power Ramp Rate Control – Confines the ramp rate of plant power output within utility-defined limits regardless how changing weather conditions affect PV output
- Frequency Regulation – Dispatches real power on AGC signals or in response to grid frequency change within one second

Case

Energy storage system test bed, Singapore

The CW Group, a leading speciality advisory, research and business intelligence company has chosen Wärtsilä for the provision of a 2.4 MW/2.4MWh energy storage system (ESS) test bed for Singapore's Energy Market Authority (EMA), a statutory board under the Ministry of Trade and Industry of Singapore and SP Group, a leading energy utility company in Asia Pacific. CW Group has been contracted by the EMA and SP Group to implement this project. The Wärtsilä solution will incorporate GEMS software and this test bed will be Singapore's first utility-scale energy storage system. Singapore aims to have 1 GW of its electricity from solar power by 2020, thereby significantly reducing the country's environmental foot print. The first major energy storage deployment in Asia, this project represents a clear endorsement of Wärtsilä's advanced technology and software, along with EPC capabilities.

Energy storage capacity will support Singapore's use of solar power by providing energy reserves and reducing peak demand. It will also assist the EMA and SP Group to evaluate the performance of energy storage system technologies in the country's hot and humid climate, its impact on the electricity grid, and to establish future guidelines for energy storage system deployments.

"Insights from this test bed will be useful for Singapore to learn how storage could enhance the stability of the grid, provide quick response capacity, and improve operational flexibility. We are also exploring how to couple energy storage with solar forecasting capabilities to enable greater deployment of solar in Singapore."

Mr. Ng Wai Choong,
CEO of EMA

Gas-to-power

In recent years, there has been a global shift towards cleaner fuels. This has led to an increasing abundance of liquefied natural gas (LNG) available from markets and increased opportunity to transport LNG in smaller quantities to smaller users. Levelised costs of electricity in the US especially show that gas can compete closely with coal on a cost of generation basis and the role of gas in power generation is increasing as it is being more widely utilised to run engine power plants that are integrated with intermittent wind and solar systems.

Gas power plants are advantageous as compared to other thermal dispatchable plants as they can be constructed rapidly at a reasonable cost and produce lower emissions. As the share of wind and solar capacity increases and the net load to thermal plants decreases, gas power plants can also provide peaking to system balancing. Liquified natural gas is a low emission fuel that is becoming increasingly relevant for industrial facilities, shipping industries, and energy providers. Wärtsilä is a leading provider of gas-to-power solutions and a recognised leader in gas engine technology. Wärtsilä offers solutions and services throughout the entire LNG distribution chain with a focus on developing smaller scale capabilities, including the technology for both liquefaction and re-gasification. More than one third of the world's re-gasification units for floating storage have been delivered by Wärtsilä. Additionally, Wärtsilä's Tank Control Systems are used in many of the world's leading LNG facilities.

Case

Tornio Manga, Finland

Manga Terminal Oy is building an LNG import terminal in Tornio, Finland. This terminal will be the largest such facility in the entire Nordic region. An efficient logistics chain is being developed around the terminal, which will create a diversified fuel market, benefiting both Northern Finland and Sweden. Furthermore, LNG is a low emission fuel which can be utilised for shipping, industrial application and power generation. Compared to alternative fossil fuels, substantial reductions can be obtained in carbon dioxide, nitrogen oxide and particulate matters emissions.

Wärtsilä was contracted to provide a full EPC solution for the terminal including complete unloading, storage, pipeline distribution, and regasification facilities. The storage tank has a 50,000 m^3 capacity. The Tornio Manga LNG receiving terminal will play an extremely significant role in reducing the carbon footprint of the region's industrial operations. It is, therefore, an important environmental milestone for the Baltic Sea area, and especially for Northern Finland and Sweden. The project also showcases Wärtsilä's expertise in this field.

"The Tornio Manga LNG terminal is a long-term infrastructure investment programme. The beneficiaries include shipping and road transportation companies, power and heat utilities, as well as other industrial and mining companies in northern Europe. We appreciate Wärtsilä's participation as a valuable partner in the project with special value-adding capabilities in this field."

Pekka Erkkilä,
Chairman of the Board, Manga LNG Oy

Wärtsilä Lifecycle solutions

In conjunction with offering energy solutions, Wärtsilä offers lifecycle solutions that optimise customer operations through guaranteed asset performance and operation and maintenance solutions. Throughout the lifecycle, these services aim to maximise the productive lifetime of installations and ensure reliable system performance.

Guaranteed asset performance is a solution where Wärtsilä guarantees the reliability or availability of a power plant with fixed costs. As standard, an availability or reliability guarantee is offered to ensure that required capacity is available when there is a demand to ramp up. Furthermore, by contracting maintenance to the original equipment manufacturer (OEM), customers can reduce their fixed costs by having a leaner operation and maintenance organisation. This solution also offers onsite customer support engineers to ensure the power plant reaches the agreed upon performance targets and who provide an immediate response to ensure the safe operation of the power plant. Through online data, such as plant operating parameters, Wärtsilä can support customers' operating personnel remotely from expertise centres. Condition monitoring and inspections combined with expert analysis also enable flexibility of the maintenance intervals.

During the lifecycle of the partnership, there are proactive modernisation and upgrade solutions available to optimise the use of the assets. Wärtsilä collects power plant operating data that helps to predict the engine condition that forms the basis for the maintenance plan and conducts power plant condition monitoring that helps to identify faults before they lead to unscheduled outages. Multi-engine power plants run according to the power demand and staggered operation of engines enables optimised power generation capacity, thus minimising lost revenue and profits.

Another form of life cycle maintenance offered by Wärtsilä includes fuel conversions. A fuel conversion can help reduce operating costs and extend asset lifetime remarkably. Converting existing engines provides similar benefits to installing new ones. Additionally, all aspects, from safety to the reliability of operations are considered, so that the conversion concept follows the same principles as a new build made by Wärtsilä according to the latest design and engineering. After converting to a new fuel or fuels, a tailored lifecycle solution can help secure a smooth restart and maximise the return on the fuel conversion investment. Operating on cleaner fuel like gas also leads to higher availability due to longer maintenance intervals and most importantly, is an effective way to reduce the carbon footprint of a power plant.

Case

Delimara power plant 3, Malta

Shanghai Electric Power Limited (SEP) is one of the major listed companies of China Power Investment Corporation, and one of the major electric energy companies in Shanghai. The Delimara power plant (D3) is an important part of Malta's energy portfolio and currently serves as the only local power plant providing power to Malta and its neighbouring islands, together with an interconnector from Sicily. D3 originally had eight Wärtsilä 18V46 engines running on HFO with a gross output capacity of 149.8 MW. The plant underwent a gas conversion, which led these engines to be converted to four Wärtsilä 50DF and four Wärtsilä SG engines. In the first phase, the conversion to dual-fuel engines took place: The LFO commissioning finished in September 2016 and the natural gas commissioning finished in February 2017. The second phase with the SG engines is estimated to be completed in August 2017. Wärtsilä's delivery consisted of engineering, procurement and construction (EPC) for a specified scope of supply: gas conversion of the engines including the new UNIC C3 engine control system, construction of a 500 metre natural gas pipeline, including a pipe bridge, valves and instrumentation. In addition, new auxiliary modules such as a compact gas ramp (CGR), purge air fan modules, rupture discs on exhaust gas ducts, and a nitrogen inertisation system were installed.

When the power plant starts to run on natural gas, the emissions produced by the plant will be reduced, ensuring compliance with the emission regulations set by the EU. With four Wärtsilä 50DF dual-fuel engines, the engines have a high efficiency running on natural gas but are also capable of operating on LFO as back-up fuel, in case of interruption in the gas supply.

"We are very happy to be working with Wärtsilä on this gas conversion project. This project is Shanghai Electric Power's first step into Europe, and we look forward to a long and fruitful co-operation with Wärtsilä,"

Mr. Tan Qing,
Project Manager, Shanghai Electric Power Limited.

Conclusions

The transition to a 100% renewable energy future is well underway, with increasing renewable integration, decreasing cost competitiveness of inflexible power generation and remarkable changes in the energy markets across the globe. To work towards a cleaner, more sustainable and energy efficient future, it is imperative for energy providers to adapt their strategies. As an energy systems integrator, Wärtsilä understands, designs, builds and serves optimal power systems that provide the flexibility, reliability and efficiency required to lead the path for future generations.

WÄRTSILÄ ENERGY SOLUTIONS
IN BRIEF

Wärtsilä Energy Solutions is leading the transition towards a 100% renewable energy future. As an Energy System Integrator, we understand, design, build and serve optimal power systems for future generations. Our offering includes ultra-flexible internal combustion engine-based power plants, hybridised solar power plants, energy storage & integration solutions, as well as gas to power systems. Wärtsilä's solutions provide the needed flexibility to integrate renewables and secure power system reliability. Wärtsilä has 68 GW of installed power plant capacity in 177 countries around the world.

10.2018 / Bock's Office

www.wartsila.com/energy

WÄRTSILÄ