Engine Power Plants
Technology & Applications

European
Engine
Power
Plants
Association

EPPA ENGINE

Engine Power Plants Manufacturing: A dynamic EU-based Business Sector

- **10,000 employees**
- **€ 1 billion turnover**
- **3 GW new capacity** installed in the EU

The various engine types available on the market are covering a broad output range, **between 6 kW and 21 MW.**

Engine power plants are a reliable proven technology:

Already more than **30 GW** capacity has been installed in the EU!

- Production
- Research activities
- Production and Research activities

Engine Power Plants –

Contributing to a better Energy Generation!

Engine power plants will play a vital role within the future energy mix. Already today engine power plants are a widely used technology in energy generation, mainly in the field of emergency power and combined heat and power applications.

The integration of more and more intermitting renewable energy into the European electricity grid generate the need for a very flexible and fast back-up solution to ensure the supply in times where no sufficient energy can be generated from sun and wind. This task can easily be performed by engine power plants, running within minutes of start up and can provide the correct electricity needed, thanks to their modularity.

Engine power plant technology is already fully available. Its environmental performance is convincing for several reasons:

- **Only energy that is really needed is generated – no excess capacities and emissions produced**
- **Use of biomass, biofuels, sewage gas, landfill gas etc. as primary energy**
- **Clean engine technologies**
- **Decentralised applications – reduced demand of additional power lines**
- **High efficiency rates – especially in combined heat & power generation**

With this brochure we would like to give you an idea of the different applications and advantages of this technology. You will afterwards understand, why we use the following five adjectives to characterise our technology and to structure this brochure: reliable – fast – efficient – responsive – environmentally sound.

Feel free to contact us in case you need further information.

Kari Hietanen
President of EUGINE

Engine power plants are a well-developed technology to generate electricity and often additional thermal energy. Their main advantages are the very short start-up and ramp-up times, the solid reliable technology and the ability to run on different fuels.

Reliable Technology

Typical engine power plants consist of the following main components:

- Internal combustion engine (ICE)
- Alternator for producing electricity
- Heat exchanger: Used for thermal power

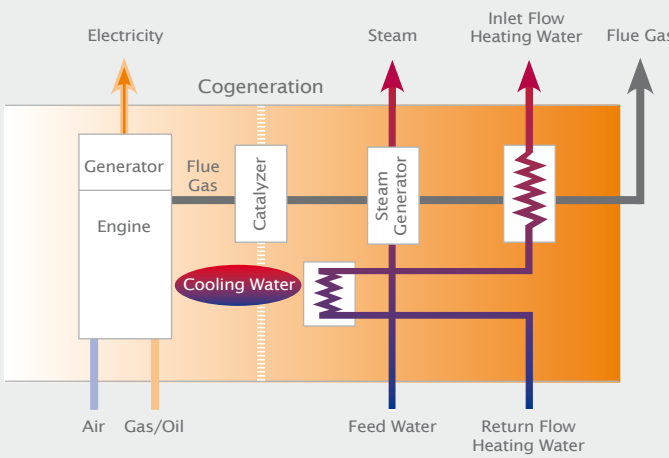
The internal combustion engine can either be a spark ignition engine (e.g. gas engine) or a compression engine (e.g. diesel engine). While in smaller engine power plants often modified engines designed for cars and trucks are used, larger plants above 1 MW often use modified ship engines. Most engines run on natural gas, but the engines can be optimised for many other gaseous or liquid fuels. The technology is proven and optimised for regular load changes.

The alternator transforms the mechanical energy into electrical energy. Via the use of an additional supercharger a larger amount of compressed air can be supplied to the engine and by this the power output can be increased. Depending on the target to deliver electricity to the general electricity grid or operating in island mode the technology differs. In conventional large power plants as well as in engine driven vehicles less than half of the fuel is used for energy generation while the remaining share is unused exhaust or engine heat. In engine power plants this heat is often used for generating additional thermal power – widely known as cogeneration. As heat from exhaust gas is between 350°C and 500°C and the engine cooling water which has a temperature of around 90°C are normally in separate circuits transformed via heat exchangers into heating or cooling purposes or via a steam turbine into additional electricity.

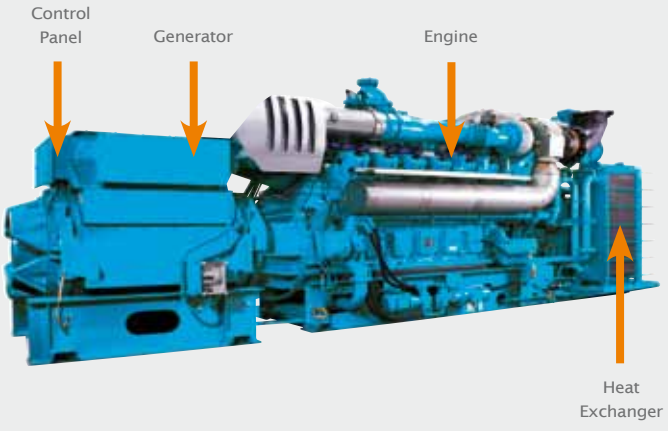
From S to XXL – Available in all Sizes

One of the large advantages of the engine power plant technology is the sizeability. While the smallest cogeneration plants are available from 3 kW electrical power upwards the large electricity-only plants can generate today up to 600 MW. The small units

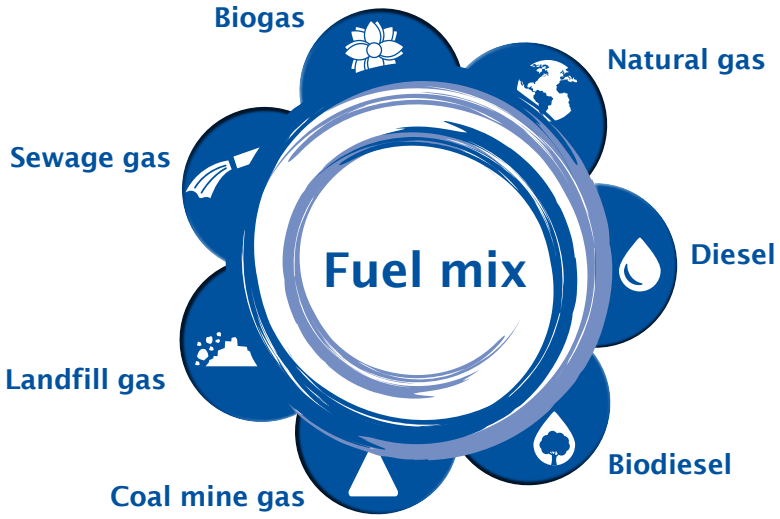
Cogeneration Process



Gas engine power plant basic components



Technology of Engine Power Plants
A Few Facts



are normally built as compact all-in-one units. In the medium range of 0.5 to 2 MW often all components are packaged into a turn-key power module for remote applications, emergency power solutions or mobile applications.
The larger plants are built in a modular approach, combining several engines, that can be started according to demand. The single engines can provide electrical power up to 20 MW per unit and are normally four-stroke engines. Due to the modularity they avoid part-load inefficiencies and ensure availability. They can provide base-load power as well as balancing power and can replace conventional power plants.

Whatever fuel – they take it

The engines used can be optimised for a wide variety of fuels from liquid to gaseous, depending on the availability, purpose and environmental considerations. Among the fossil fuels the most used for engine power plants is natural gas. Natural gas has the lowest CO_2 emissions of the fossil fuels and therefore contributes to further decarbonisation of the energy sector. However, if circumstances require it, e.g. at remote places, diesel or gas can be used to run the engines. Other appropriate fossil fuels are propane or special gases e.g. from coal mines. Engine power plants are not limited to fossil fuels, but can burn renewables such as biogas and biodiesel.

Thanks to their **reliability, safety and robustness**, engine power plants provide **steady power**, around the clock, to meet the continuous electricity demand ('base load') of specific places or regions. Due to their **high cost-efficiency and modularity**, they represent an **optimal solution** to provide steady power at any location: small to medium-size engine power plants may be installed **in the basement** or **on the roof** of buildings or even be **containerised.** Base load engine power plants are also particularly suitable **for challenging conditions**, in remote locations (islands) and in extreme climates (deserts, mountains). The robust technology makes engine power plants also an ideal solution to convert special gases like landfill or coal mine gases into base-load energy. Finally, no need to wait to get them running: some of them may even be installed within two weeks.

Efficiency through Modularity

Even if this is not their primary task, base load power plants need also - to a certain extent - to adapt to variations of power demand. While other technologies face technical problems or higher costs when adjusting load to the actual demand, engine power plants are a very suitable technology to perform this task. **In engine power plants combining twenty or thirty engines**, each of these units may be started or stopped **within minutes** to **perfectly match power needs, reduce costs and unnecessary emissions** in idle or minimum-load mode. Unlike other units, engine power plants are able to do this without requiring higher maintenance checks.

RELIABLE:
Base Load Power Plants

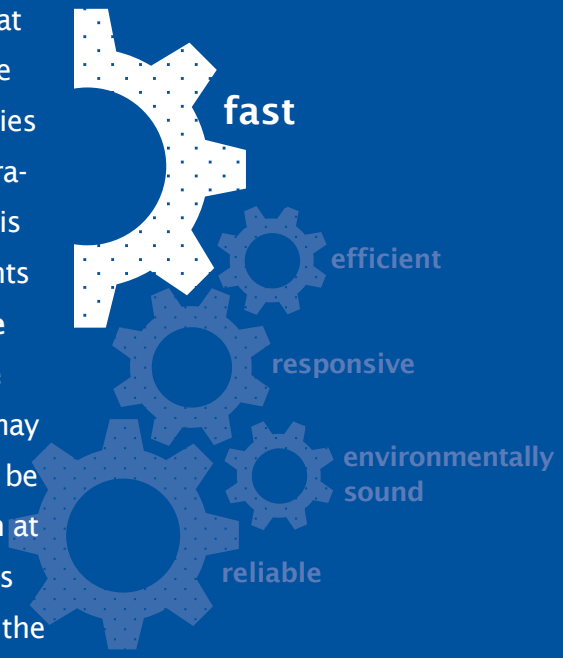
“Containerised” Heat & Power in the Netherlands

An engine power plant **running on gas** was installed in 2014 in a housing complex close to Rotterdam in the Netherlands in order to meet in the most cost-efficient way the energy demand of this area. This **containerised cogeneration unit** provides reliable steady power (500kW) and heat (400kW) to the people living there. Thanks to this engine power plant, **energy costs have been reduced** dramatically and **electricity surplus** is fed into the public power network which means **additional earnings.**

Steady Power for the French Island of Martinique

The electric utility ‘Électricité de France’ invested recently in a base load engine power plant located in Bellefontaine on the island of Martinique. It is composed of **twelve highly efficient engines** generating **220 MW for the grid** and meeting around **60% of the power needs** of this Caribbean island. Since the power plant can cover its requirements using desalinated seawater instead of ground water, water resources are spared. The heat from the engines is used to generate the hot water required at the site. To sum up, this new power plant offers **flawless reliability and high resource**

Benefitting from a **steady power supply** is key for numerous economic activities. This **reliability** must be ensured at any time, including in cases of storms, grid problems and **power failures**. For this, **clinics, data centers, banks or farms** need emergency reserve engine power plants providing energy right away, if needed. Such units are usually running on diesel so that they can react within seconds. In addition to their main task, they may also deliver ancillary services to the public network. What is true at local level is also true at systemic level: electric utilities and transmission system operators as well are investing in this type of emergency power plants to **avoid disturbances on the grid** and their **potential huge related costs.** Such engines may be dual-fuel engines and thus be running on diesel, gas or both at the same time. This represents an optimal solution to ensure the security of supply and adjust to fluctuating fuel prices.



Even Nuclear Power Plants Need Engine Power Plants

Further to the **Fukushima nuclear accident**, the French Nuclear Safety Authority (ASN) has decided that each of the French nuclear reactors should be **made safer** through the **installation of 58 emergency diesel generators.** These engines will be constantly ready to provide electricity in case of power failure to parts of the nuclear power plants which are **key for the overall safety. These new emergency reserve power plants will considerably enhance the safety of the nuclear reactors concerned.**

FAST:
Emergency Reserve Power Plants

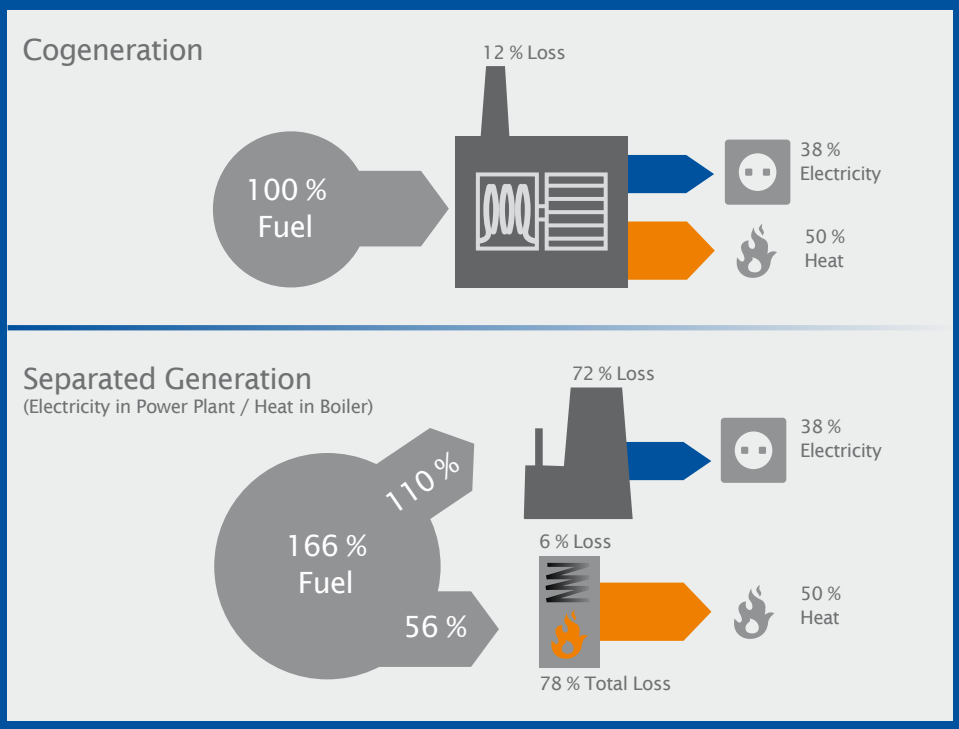
In Porto, Engines Are Always Ready To Save Lives

The Hospital São João of Porto in Portugal benefits from steady power supply and **safe surgery conditions** thanks to two emergency reserve engines installed in an underground room of the hospital. This power plant is able to provide **full power output for all the buildings within 15 seconds.** Except if there are grid power outages, these generators should only operate around 50 hours a year, for the regular controls. However, these engines are extremely useful: they **offer safety to patients and peace of mind to the staff of the hospital**…24 hours a day and 365 days a year.

Electricity Security of Supply for Estonia

The Kiisa emergency reserve power plant was commissioned by the Estonian transmission system operator Elering to cover one sixth of Estonia's maximum electricity consumption in the winter and consequently to provide valuable **electricity security of supply** to this country. The **27 engines** of this power plant are **mainly running on gas** but have also the capability of using light fuel oil as back-up. Together they may provide **250 MW to the grid** in less than 10 minutes.

Energy efficiency has become a **strategic issue** for all energy consumers. For locations using both electricity and thermal energy like in swimming pools, hospitals or shopping centres, combined heat and power (CHP) power plants, also known as **cogeneration power plants, are an optimal solution.** Thanks to the simultaneous production and use of both electricity and heat, an **exceptional energy efficiency of up to 95%** may be achieved, which means **up to 40% energy savings.** Beyond cogeneration, **trigeneration** (combined heat, power and cooling) and **quad-generation** (recovery of carbon dioxide from the exhaust gas) offers very interesting opportunities for today's and tomorrow's users' needs. These cost-efficient and environmental-friendly solutions are also a way to provide **decentralised energy** and to **avoid the costly development of high-voltage power transmission lines.**



Cogeneration: a very efficient solution

In order to generate the same amount of electricity and heat, the separated generation needs in average 66 % more energy input than cogeneration. Power plants with Combined Heat and Power (CHP) ensure a higher energy efficiency which means reduced primary energy consumption, energy import and energy dependency. Therefore cogeneration engine power plants represent a key tool to achieve current EU targets.

EFFICIENT:
Cogeneration Power Plants

Cogeneration and Athletic Performance going Hand in Hand

The **municipal sport centre** Rundforbi of Rudersdal municipality **in Denmark** has invested in **three cogeneration units running on natural gas,** each of them having 40 kW heat capacity and 20 kW electrical capacity. These high-efficiency engine-powered **micro-cogeneration units** are extremely responsive with **practically no time needed for stop/start/ramp up.** They provide an optimised solution for acute electrical load-following operation through fully automated, "learning" load-sharing and modulation of individual units. The customer is benefiting from **vastly reduced energy costs.**

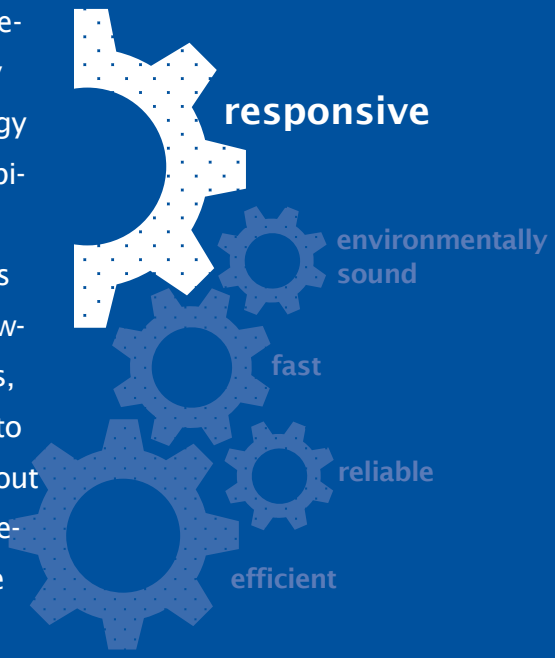
Heat & Power for Cost-Efficient Ice-Cream Production

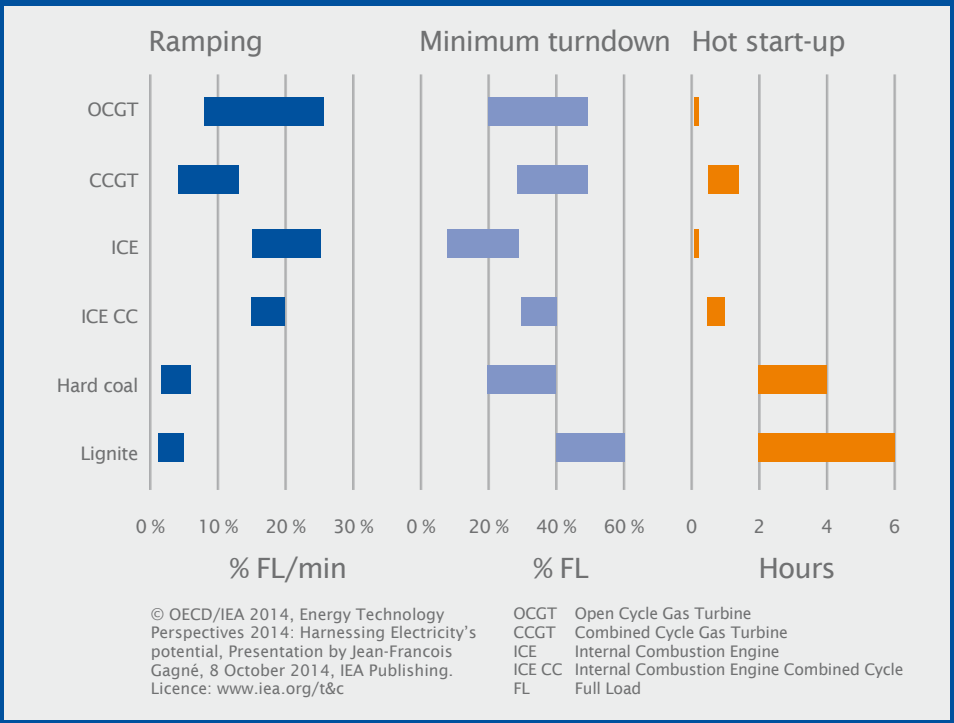
Cogeneration may also be very cost-efficient for **industrial production processes using both electricity and heat.** Germany's largest ice cream producer installed in its plant of Heppenheim a heat-controlled cogeneration unit with a **natural gas engine generating 1.7 MW of thermal power.** The heat is used to turn the basic ingredients milk sugar, fat, chocolate, fruit preparations, aromas, water and air into rich ice cream but also for the cleaning and heating circuits as well as for the supply of hot water. Engine power plants can perfectly **adapt to variable production needs.**

Peak load power plants, also called ‘peaking’ or ‘grid stability’ power plants, feed energy to the grid **every time there is a peak in power demand** to be met instantaneously.

Thanks to their **responsiveness**, very fast **starting and ramping capabilities,** engine power plants are **highly flexible**. They are perfectly well-suited to react as quickly as required by an unexpected increase of power demand or changes in weather conditions leading to a decrease of the power supplied by **intermittent renewable** energy sources (intermittency & flexibility challenges).

Unlike traditional power plants including nuclear and coal power plants but also gas turbines, engine power plants are able to adjust power production without causing higher costs of maintenance: they are made to make up for variations.





OCGT Open Cycle Gas Turbine
CCGT Combined Cycle Gas Turbine
ICE Internal Combustion Engine
ICE CC Internal Combustion Engine Combined Cycle
FL Full Load

Engine Power Plants: a Highly Responsive Technology

As shown by this graph from the International Energy (IEA), “Internal Combustion Engines” and “Internal Combustion Engines operated with a Combined steam Cycle” are highly responsive and perform particularly well in comparison with other technologies available. Engine Power Plants are able to start-up and ramp-up very quickly as well as to work efficiently with both high and low loads. Therefore they represent an optimal technology to complete the electricity provided by growing shares of intermittent renewables.

RESPONSIVE:
Peak Load Power Plants

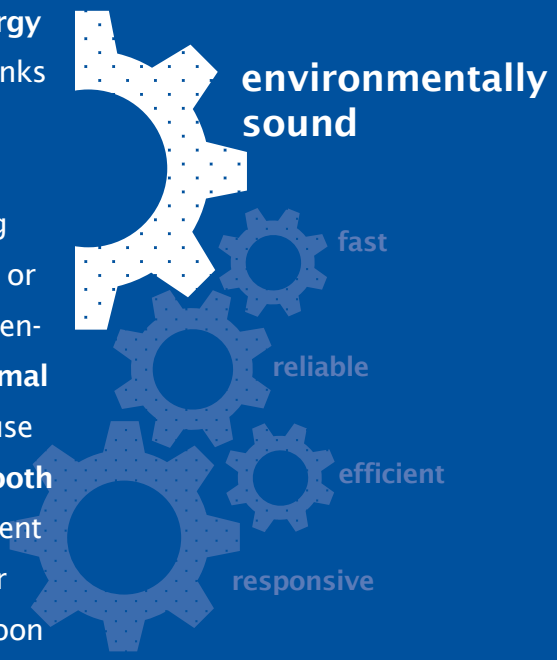
Renewables + Engine Power Plants = Tomorrow's Power Generation

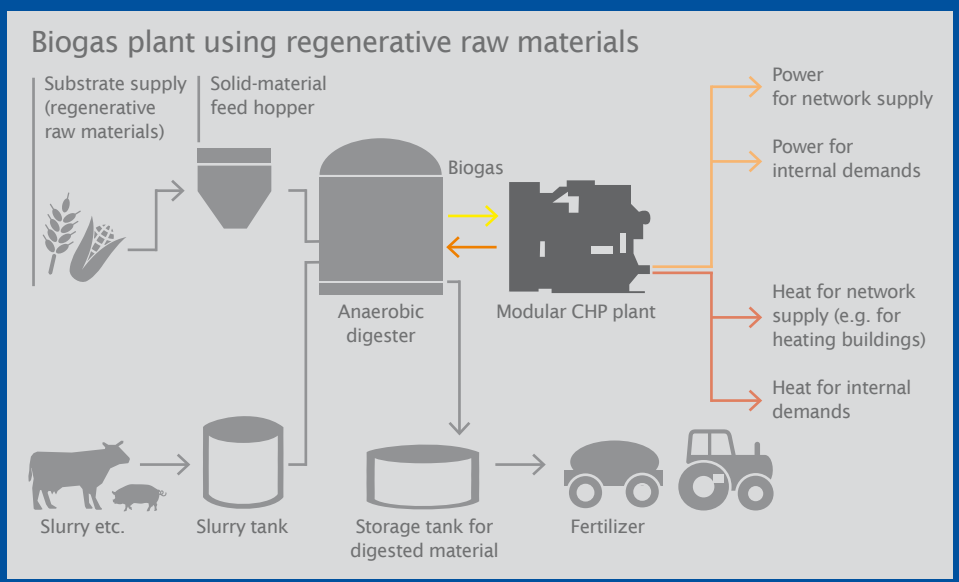
According to the American Wind Energy Association, the state of Kansas produced 21.7 % of its electricity from wind power in 2014. In order **to offset the growing variations** generated by the **rising share of wind power,** the 'Mid Kansas Electric Company LLC' built in 2014 the 'Rubart' engine power plant made of **twelve highly flexible engines.** This power plant is feeding **up to 110 MW to the grid** every time the wind dies down, **instantaneously** providing the flexible power needed to meet the demand.

More and More Engines to Manage the Energy Turnaround

The municipal utility of the German city of Rosenheim is taking part in the energy transition. It developed an **'energy concept'** and invested in **five highly flexible gas engines** generating about **40 % of the electricity** and **20 % of the heat consumed** in the city of Rosenheim. These engines are used as an essential complement to variable renewable energy sources. Since the energy transition is an **ongoing process**, more and more renewable energy is going to be provided to the grid and the Rosenheim municipal utility is therefore planning to **install further gas engines** to meet the growing variations.

To achieve the **2030 EU target of a 40 percent reduction of greenhouse gas emissions** in comparison to 1990, carbon-intensive energy sources like coal must be replaced by environmentally sound energy sources emitting much less carbon dioxide. These include renewable energy sources like wind, sun or biomass - but also gas. Engine power plants run on the full range of fuel types, **from different biofuels to all types of gases, from natural to sewage and biogas.** They are therefore a very useful technology to **help decarbonising Europe's energy production.** Furthermore, thanks to their very fast availability, engine power plants **only run when really needed,** avoiding unnecessary emissions in idle or minimum-load mode. Finally, engine power plants are an **optimal partner to renewables** because their flexibility allows the **smooth integration** of these intermittent energy sources into the power grid by completing them as soon as the wind or sun intensity is declining and a responsive and environmentally sound power source is needed.

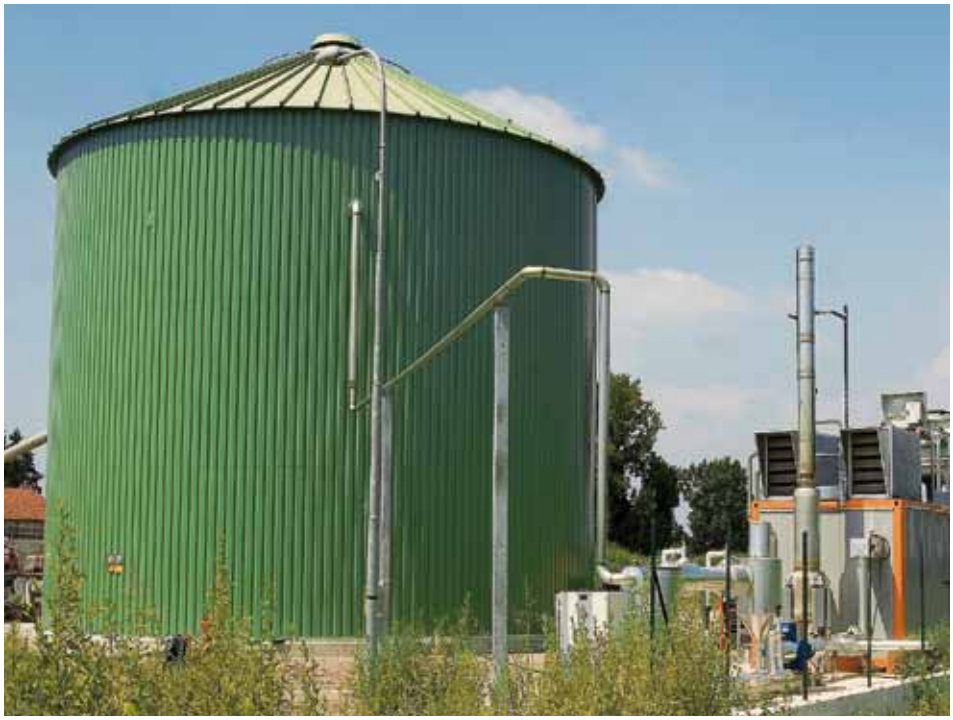




Energy from Biogas

Biogas is produced through **anaerobic fermentation of organic materials like liquid manure, solid dung or corn silage.** Thanks to cogeneration engine power plants, this **carbon neutral** and **renewable energy** can be **converted into electricity and heat.** This replaces consumption of fossil fuels and reduces greenhouse gas emissions. Finally, the energy produced by biogas engine power plants provides an additional source of revenues for farmers.

ENVIRONMENTALLY SOUND: Engines of Decarbonisation



Biogas: From Parma Pigs' Manure to Green Electricity

Like many countries, Italy has set an ambitious goal to foster production of renewable energy from biogas. To benefit from this forward-looking policy, a pig farmer from the region of Parma has invested in **two biogas engine power plants:** the **liquid manure** produced by his pigs ferments **with corn** in a big green tank to produce biogas which powers the **containerised cogeneration engine power plants.** While the electricity generated is fed into the public grid, the heat produced is used to keep the pigsties warm in winter.

ORC: from Waste Heat to Useful Electricity in Italy

With 'Organic Rankine Cycle' (ORC), a turbine coupled to an electrical generator transforms waste heat from gas engine exhaust into additional useful electricity. This smart principle has been implemented at a biogas power plant located in Carpaneto Piacentino in Italy. Not only methane gas has been transformed into electricity (instead of merely flaring to the atmosphere - where its environmental impact is up to 20 times worse than carbon dioxide) but also waste heat has been converted into additional 65 kW of electricity. This means energy efficiency and a better environmental footprint.

EUGINE is the centre of knowledge for engine power plant technology and electricity market design. Its members are the leading European manufacturers of engine power plants and their key components. They provide forward looking solutions for flexible electricity generation.

EUGINE works with EU and national institutions in order to help the European electricity system meet the challenges of today and tomorrow.

efficient

Best form: The efficiency of engine power plants is up to 95 per cent in cogeneration applications.

responsive

Ready, Steady, Go: The energy supplied by engine power plants corresponds dynamically with actual energy demand.

fast

Flash into action: Engine power plants provide energy right away at any time even in emergency situations.

reliable

Green light: Engine power plants guarantee a safe and stable power supply everywhere: from vibrant cities to remote locations.

environmentally sound

Flower power: Engine power plants operate with very low emission levels and are CO_2-neutral with biofuels.

Contact

Brussels Office
Diamant Building - Boulevard Reyers 80
1030 Brussels - Belgium
Phone: +32 (0)2 706 8297
E-mail: info@eugine.eu

Head Office
Lyoner Strasse 18
60528 Frankfurt am Main - Germany
Phone: +49 (0)69 6603 1936
E-mail: info@eugine.eu

Visit www.eugine.eu for more information

European Engine Power Plants Association

EUGINE