



**Cost-effective use of waste heat**

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## Highly efficient use of valuable waste heat from industrial processes

### It has passed the test: waste heat power plants with piston engines have proven themselves in the industry

ORC waste heat power plants by DeVeTec work efficiently even with fluctuating waste heat flows.

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**In many industrial processes, waste heat is produced that often could not be efficiently recovered or even had to be discharged into the environment unused. ORC waste heat power plants convert this valuable waste heat into electricity. DeVeTec's waste heat power plants, which also work particularly efficiently even under partial load conditions, have proven their worth after extensive field tests in various industries and are now available as series-produced products. Not only do they produce electricity, they also deliver useful heat within the meaning of Germany's Combined Heat and Power Act (KWKG), which can be used in other applications.**

Excess process heat is generated in many areas: in the energy-intensive processes of the metal, glass, ceramics, chemical and cement industries, as well as when operating large motors such as in CHP units or ships for example.

Waste heat power plants by DeVeTec operate on the same basic principle as large power plants: they evaporate a liquid, which is then expanded in a piston expansion engine (heat engine) developed by DeVeTec, and thus generate power. The main difference is that - instead of water - an organic fluid (bioethanol) is used, which exhibits an efficient thermodynamic behavior even at low temperatures. This way, waste heat flows can be exploited efficiently and economically starting at 230°C. In large power plants, however, the entire process is solely based on the heat engine installed there. Just as much heat is generated as the heat engine - typically a turbine - requires to achieve optimum efficiency. Any deviations from the optimum operating points lead to significant losses in efficiency. However, when you take a look at industrial waste heat, this process is reversed. Here, the heat engine must depend on the generated heat such as from the production process for example. It thus becomes clear that completely different demands are placed on the machines as a result. This is exactly what the piston expansion engine was developed for.

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Following extensive basic research, DeVeTec has developed a waste heat power plant that is based on the fundamental piston engine principle. It can respond very quickly to changing waste heat conditions and thus exploit an exceptionally high proportion of the valuable waste heat. On top of that, the piston expansion engine in particular is very efficient because it can achieve very high differential pressures due to its design. This results in high temperature differences ( $>150^{\circ}\text{C}$ ) and a large enthalpy difference as well, which results in a high energy yield.

Waste heat power plants by DeVeTec thus generate electricity highly efficiently even under partial load conditions. Moreover, they also provide heat to other users at a temperature level of about  $80^{\circ}\text{C}$ . More than 90% overall efficiency can thus be achieved. The recovered energy can be used to heat plants, dry material or temper processes for example. The waste heat power plants are suitable for all processes where temperatures exceed  $230^{\circ}\text{C}$ . More recently, fluids that already achieve significant efficiency at  $170^{\circ}\text{C}$  are also available.

### **A compelling overall energy balance with high ecological benefit**

The economic results are impressive: DeVeTec's waste heat from power plants reduce the cost of purchasing externally procured fuels and electrical energy. Added to this is the fact that self-produced electricity is partly or even completely free from EEG levies or other charges. The operator can raise additional revenue with the CHP bonus because DeVeTec's waste heat power plants are CHP plants in compliance with Germany's Combined Heat and Power Act (KWKG). Since these operate automatically and do not require on-site monitoring, no costs are incurred for personnel.

Industrial users confirm that the plants pay for themselves in less than four to five years, and in less than three years as well depending on the configuration, while simultaneously generating electricity and utilizing heat.

### **ORC technology - electricity from previously unused waste heat**

DeVeTec's machines use the method known as Organic Rankine Cycle (ORC) named after the Scottish physicist and engineer William Rankine (1820-1872). He is considered one of the founders of thermodynamics.

The DeVeTec ORC method is a traditional steam cycle: the waste heat flow of a process is used to vaporize an organic medium – in this case ethanol – which is then expanded in a steam expansion engine and does its work. The now depressurized vapor is then fed into a condenser to be liquefied there. The liquid ethanol is then fed back to the evaporator with a pump and evaporated again. The process is thus complete and the cycle starts all over again.

Normally, the organic fluid used by DeVeTec is bioethanol, which has proven itself due to its many advantages. It is environmentally friendly because it is neither toxic nor subject

to the F-Gas Regulation stipulated by the EU. Moreover, it does not freeze - which is of particular importance to outdoor plants. Bioethanol is also characterized by its low price. Right from the start of development, DeVeTec designed the plants in cooperation with Germany's TÜV in such a way to avoid any potential hazard, especially regarding the subject of fire and explosion protection.

With the electricity generated on site, operators reduce their purchase of electricity from third parties. They also save on levies like network charges or liability and EEG levies. DeVeTec's ORC technology is suitable for industrial enterprises with energy-intensive production processes and for the energy sector. In CHP units operated with mine gas, landfill gas, sewage gas or natural gas, they improve the energy yield just as they do in biogas, solar and geothermal plants. In conjunction with a combustion engine, a so-called combined cycle power plant is created which is characterized by high efficiencies. Moreover, DeVeTec's thermal power plants improve the energy yield of heavy, mobile machines because they generate electricity and heat for their own use, thus saving significant amounts of fuel.

### **Unique: the ORC steam expansion engine**

The centerpiece of each highly efficient thermal power plant from DeVeTec is the expander. Various basic research conducted within the context of R&D activities concluded that the piston machine is the system with the highest efficiency.

Piston expansion engines achieve a very high pressure differential in a single stage so that the enthalpy gradient increases significantly to thus generate much more electricity than is possible using related technologies. Another significant advantage of the piston expansion engine is its real partial-load capacity. Depending on the amount of waste heat available, the V8 engine operates in the 0-130 kW range, the V12 engine in the 0-200 kW range, or the V16 engine in the 0-266 kW range at nearly constant efficiency. Should other heat sources with lower temperatures be exploited, then the same engine can also be operated with other organic fluids without having to be modified.

Following an intense developmental and testing period with industrial application partners over five years, DeVeTec's waste heat power plants are now available in a single product family with three performance classes. This allows unused waste heat flows between 800 kW and 2 MW to generate electricity highly efficiently at a temperature level above 230°C. The waste heat from power plants can be adjusted to the exact needs of the customer.

DeVeTec delivers the waste heat power plants as mobile container units together with the expander generator unit, the pump unit and the control unit. This way, it is possible to simply retrofit these in existing plants. If desired, DeVeTec can also implement the entire heat transfer technology. If higher outputs are required, multiple plants can be connected in parallel.

The plants work fully automatically and are monitored remotely. The specially developed Noise & Vibration Guard monitors signs of wear, protects the engine from potential damage and, in the context of preventive maintenance, minimizes the risk of faults.

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### Example: the glass industry

At the end of 2013, DeVeTec a waste heat power plant was commissioned in the gas-fired glass foundry of Noelle + von Campe Glashütte GmbH in Boffzen, located in Germany's Weserbergland region. The waste heat source of this reference plant provides a constant thermal level year-round and thus offers optimal conditions for generating high levels of electric power and useful heat. With a V12 steam expansion engine, which was used for the first time here, the waste heat power unit produces 200 kW<sub>el</sub> of power.

The condenser's remaining cooling water that is still available at 70°C after the process is used by the company to heat the halls of its factory premises and thus significantly reduce its consumption of the fossil fuels used to heat the plant in winter.



### Example: chemical plant

Another waste heat power plant was commissioned by Evonik Industries in early 2013 at the Worms site. The waste heat source used here is the cooling air from an acid cracking plant that processes sulfuric acid. This waste heat is available at 350°C.



A special feature of this plant is that the hot air flow is subject to strong fluctuations. The plant thus runs very frequently in partial-load operation and has many phases. The plant is integrated in a complex industrial production process and must meet stringent safety requirements. Nevertheless, DeVeTec installed the plant in less than four months, immediately after which it was technically accepted.

Since the heat from the ORC condenser can no longer be used in a heating circuit, an ethanol air-condenser will be used for the first time. Even during summertime operation with 42°C outside temperatures, this permits a reliable liquefaction of bioethanol without severely reducing the electrical net power output of the ORC plant.



### **Example: pusher furnace in the steel industry**

Another waste heat power plant from DeVeTec has been in operation since the start of 2014 on the plant grounds of the Badische Stahlwerke in Kehl which uses the waste heat from a natural gas-fired pusher furnace to generate electricity. Due to the limited space, the waste heat power plant was erected at a height of 8 m and distance of 80 m to the ORC heat exchanger.

There are deliberations about using the waste heat from the ORC process to operate an absorption chiller. By using an induced draft blower in the flue gas line of the ORC heat

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exchanger, the influence of the waste heat power plant on the existing pressure regulation of the pusher furnace could be ruled out.



### **Example: batch-type annealing furnace in the steel industry**

A DeVeTec plant has been part of the comprehensive energy efficiency scheme of BILSTEIN GmbH & Co. KG in Hagen-Hohenlimburg since 2014: its annealing plant is not seen in isolation here but the entire plant is involved. The fundamentally new approach is to extract any excess energy from the coils, which have been heated up to 700°C, during cooling and make it available to other consumers in the plant in the form of electricity and thermal energy.

When the cooling process starts, the hydrogen that is used as inert gas is cooled from 700 down to 350°C. The thus extracted energy heats thermal oil up to 270°C in a special bypass cooler. This oil is used to evaporate the ethanol that the ORC module uses to generate electricity with its steam expansion engine. The heat derived from the condensation of ethanol is used for hall heating and for heating an emulsion bath. This

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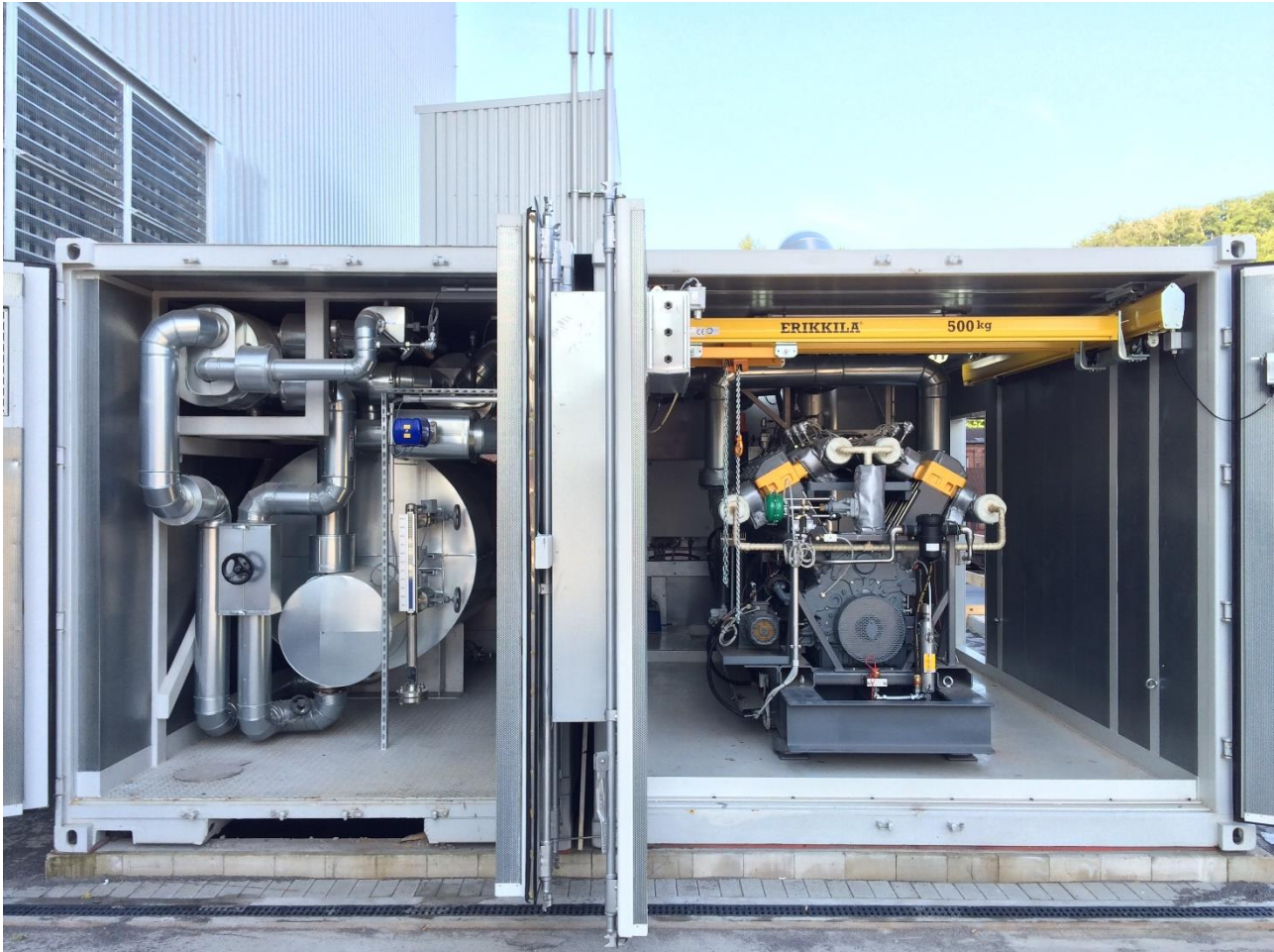
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plant is an example of high efficiency with a widely fluctuating heat supply. For every annealing heating cycle, the ORC plant generates about 350 kWh<sub>el.</sub> of electric current that does not have to be purchased from the utility company.

The plant was funded by the Federal Ministry of Environment as part of its Environmental Innovation Program ([www.umweltinnovationsprogramm.de/englisch](http://www.umweltinnovationsprogramm.de/englisch)).



## Summary

DeVeTec's waste heat power plants recover the maximum energy from industrial processes by simultaneously generating electricity and then using the remaining energy on different temperature levels. This way, they make an important contribution in increasing energy efficiency. They are also a model example of CO<sub>2</sub>-neutral and zero emission power generation because a DeVeTec waste heat power plant with a nominal output of 200 kW<sub>el</sub> can save up to 3,000 t/CO<sub>2</sub> per year.

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## About DeVeTec

Michael Schmidt founded DeVeTec GmbH in 2000 with the idea of recovering unused waste heat in industrial processes as optimally as possible. The starting point was the development of compact modules for the heat recovery in vehicles. The focus shifts quickly to high output plants used in energy-intensive industries and in the field of renewable energy.

Based on several of their own patents, DeVeTec made the waste heat power plants with piston engines ready for series production. Today, several plants with capacities up to 270 kW<sub>el</sub> are proving themselves in daily routine operations in a variety of applications.

DeVeTec designs, manufactures and assembles the plants and commissions them at the customer's premises. All parts relating to the engine are manufactured in-house by the company.

With the involvement of Chinese company Degao in June 2015, DeVeTec has laid the groundwork for the next growth step in the future development and commercialization of ORC technology, particularly in Europe and in Asia. In addition, both partners formed a joint venture - Guangdong De Weigao High Technology Energy Co., Ltd. in Jieyang, China's Sino-German Metal Eco City. This way, DeVeTec has direct access to customers in Asia.

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