
**A DeVeTec thermal power plant uses the waste heat of batch-type annealing furnaces at Bilstein GmbH & Co. KG in Hagen-Hohenlimburg (Germany)**

# ORC power plants recover waste heat and help to improve energy efficiency of steel mills

In many processes of steel production, generated waste heat is often not efficiently recovered and hence lost. In contrast, Organic Rankine Cycle – ORC – waste heat power plants convert valuable waste heat into electricity. Waste heat power plants, which also operate highly efficiently under partial load conditions, have proven their reliability in extensive field tests in various industries, also in the steel industry. Such a plant has been implemented at a bell-type annealing plant of a German steel mill. In a fundamentally new approach, the technology extracts all excess energy from coils previously heated to up to 700°C and makes it available to other uses in the mill in the form of electricity or thermal energy.

The centrepiece of each thermal power plant from DeVeTec: the ORC steam expansion engine

Excess process heat is generated during many steps in the energy-intensive production and processing of steel. Two heat power plants of German-based engineering company DeVeTec demonstrate that huge amounts of this energy can be efficiently recovered. One plant is part of a comprehensive energy efficiency scheme of German cold-rolled steel manufacturer Bilstein. In a fundamentally new approach, any excess energy from the coils, heated to up to 700°C, is extracted during the cooling and made available to other consumers in the plant as electricity or thermal energy. This plant is an example of high efficiency with a widely fluctuating heat supply: Once the cooling process starts, the hydrogen used as inert gas is cooled down from 700 to 350°C. The energy extracted then heats thermal oil up to 270°C in a special bypass cooler. This oil is used to evaporate the ethanol that the Organic Rankine Cycle (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 up an emulsion bath. For every annealing heating cycle, the ORC plant generates about 350 kWh of electric power which don´t have to be purchased from external providers.

The waste heat power plant has been part of the annealing line at Bilstein since 2014. As an industrial-scale pilot project that helps to improve resource efficiency it was funded by the German Federal Ministry of Environment as part of its Environmental Innovation Programme.

The other waste heat power plant of DeVeTec has been in operation on the plant grounds of the Badische Stahlwerke in Southern Germany since the beginning of 2014. Badische Stahlwerke uses waste heat from a natural gas-fired pusher furnace to generate electricity. Due to 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. Badische Stahlwerke now plans to take 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 exchanger, the influence of the waste heat power plant on the existing pressure regulation of the pusher furnace could be ruled out.

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## Ecological and economic benefits

DeVeTec's waste heat power plants recover the maximum amount of energy from industrial processes by simultaneously generating electricity and using the remaining energy at different temperature levels. They are also a model example of $CO_2$-neutral and zero emission power generation because a DeVeTec waste heat power plant with a nominal output of 200 kWel can save up to 3,000 t/$CO_2$ per year.

Industrial users confirm that DeVeTec's plants pay for themselves in less than four to five years, and even in less than three years, depending on the configuration, while they simultaneously generate electricity and utilize heat. Using waste heat generation power plants reduces the costs of externally procured fuels and electrical energy. To German companies also applies that, depending on the case, this self-produced electricity is partly or sometimes even completely free from levies or other charges of the Renewable Energy Law. Here, operators can raise additional revenue with the CHP (combined heat and power) bonus, because DeVeTec's waste heat power plants are CHP plants in compliance with Germany's Combined Heat and Power Act. Since these operate automatically and do not require on-site monitoring, no costs are incurred for personnel.

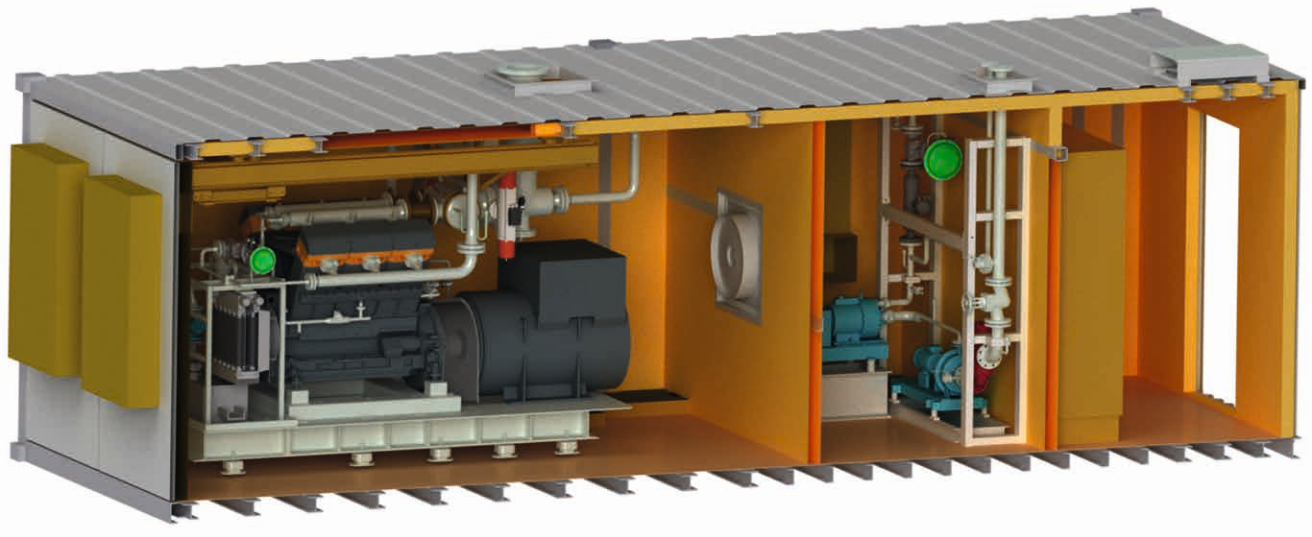
## A piston engine as basic principle

Waste heat power plants by DeVeTec operate on the same basic principle as large power plants do: they evaporate a liquid, which is then expanded in a piston expansion engine (heat engine) developed by DeVeTec, and thus gener-

ate power. Instead of water, an organic fluid (bioethanol) is used here, which exhibits efficient thermodynamic behaviour even at low temperatures. Waste heat flows can be exploited efficiently and economically starting at 230°C.

However, when you take a look at industrial waste heat, the heat engine must depend on the generated heat such as from the production process for example. This is what the piston expansion engine was developed for. It is the basis of the DeVeTec waste heat power plant. Here, it can respond very quickly to changing waste heat conditions and thus exploit an exceptionally high proportion of the valuable waste heat. The piston expansion engine itself is highly efficient; these 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. This high pressure differential results in high temperature differences (> 150°C) and a large enthalpy difference and thus in a high energy yield.

Waste heat power plants by DeVeTec generate electricity efficiently even under partial load conditions. Depending on the amount of waste heat available, one can choose between three versions of the steam expansion engine: the V8 engine operates in the 0 – 130 kW range, the V12 engine in the 0 – 200 kW range, and 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. The engines also provide heat to other users at a temperature level of about 80°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°C. More recently, fluids that already achieve significant efficiency at 170°C are also available.



The thermal power plant is installed in a container

## Electricity from previously unused waste heat

DeVeTec's machines use a method known as organic rankine cycle (ORC). The 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. The depressurized vapour is 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. For example, it is not toxic and therefore relatively environmentally friendly. Moreover, it does not freeze – an important argument for outdoor plants. Bioethanol is also distinguished by its low price.

Right from the beginning of the development, DeVeTec designed the plants in cooperation with German TÜV (Technischer Überwachungsverein/Technical Supervisory Association) in order to avoid any potential hazard. Special emphasis was drawn to the subject of fire and explosion protection.

## Classification of plants

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 efficiently generate electricity at a temperature level above 230°C. It is possible to retrofit the waste heat power plants as DeVeTec delivers them as mobile container units together with the expander generator unit, the pump unit and the control unit. The entire heat transfer technology can also be implemented. 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. ■