



Triogen offers simple and reliable solutions for biomass-to-power conversion:

- + **High-quality biomass such as wood chips:**
combustion flue gas can directly be used in the ORC
- + **Lower-grade biomass (chicken litter, manure, waste wood, RDF etc.):**
an intermediate air loop ensures the longevity of the power generation

Together with our partners, we can supply these solutions across Europe.
Our focus is on building safe and reliable power plants that fit our customers' needs.

+ COMPANY + TECHNOLOGY

Since 2001, Triogen has focused on developing and deploying a compact, modular, highly efficient Organic Rankine Cycle (ORC) technology which enables small power plants: the technology is based on the traditional water steam cycle used in conventional power plants for the last 150 years. Thanks to replacing water as working fluid with an organic medium, ORC plants realize a higher efficiency level at small scale than the water steam based cycle, and can operate fully autonomous.

The reliability of Triogen's technology has been proven on 40+ sites, 700,000 operating hours and fleet availability consistently above 97%.

- + **High efficiency, small scale power production:**
up to 170 kW power, 770 kW hot water at 55–80 °C
- + **Unmanned operation:** Certified for unsupervised operation by Lloyds
- + **Reliability:** Serial product with extensive history,
fleet availability above 97%



SOLUTION FOR HIGH-QUALITY FUELS: DIRECT EVAPORATION



Fuel and combustion: Wood chips or other high-grade fuel is fed into a furnace, gasifier/flare ($1.2 - 1.5 \text{ MW}_{\text{th}}$ per ORC) that produces flue hot gases. Depending on the fuel type and characteristics, a range of combustion technologies is available.

Flue gas handling: The flue gas ($900 - 1000 \text{ }^{\circ}\text{C}$) is mixed with colder outside air to bring the temperature to $\sim 520 \text{ }^{\circ}\text{C}$. It then passes through a cyclone to reduce the ash content to below 200 mg/Nm^3 . The flue gas passes through a heat exchanger ("evaporator") where it heats up the ORC working medium. Triogen provides a proprietary cleaning system to manage dust deposits in the evaporator. Instead of injecting cold outside air to reduce the flue gas temperature to $520 \text{ }^{\circ}\text{C}$, the flue gas that has passed the evaporator can be used; this flue gas recirculation reduces the required heat input for the furnace by $\sim 200 \text{ kW}$. When needed, a filter can be installed to meet specific environmental regulations.

Power conversion: In the ORC, a turbine drives the generator producing up to 170 kW power; the ORC also provides heat in the form of cooling water. Multiple ORCs can be operated in parallel.

Inputs	Outputs
Fuel: $3000 - 4000 \text{ t/year}$ assuming 11 MJ/kg	Gross power ORC: up to $170 \text{ kW}_{\text{el}}$ Net power ORC: up to $160 \text{ kW}_{\text{el}}$ Plant own consumption (furnace, extraction fan etc.) typically $\sim 30 - 50 \text{ kW}_{\text{el}}$. Cooling water with $770 \text{ kW}_{\text{th}}$ heat at $55 - 80 \text{ }^{\circ}\text{C}$:

Benefits:

- Enables local scale, decentralized power and heat production
- Energy production close to fuel source and/or heat user
- Highest efficiency solution on the market in this power range
- Compared to steam plants, ORC requires less supervision, no need for water treatment and lower maintenance costs.

SOLUTION FOR LOW-GRADE FUELS: INTERMEDIATE AIR LOOP



Fuel and combustion: Chicken litter, manure, waste wood, RDF or other low-grade fuel is fed into a burner ($\sim 1.3\text{--}1.6\text{ MW}_{\text{th}}$ per ORC) that produces hot flue gases. Depending on the fuel type and characteristics, a range of combustion/gasification technologies is available.

Flue gas handling: The flue gas ($700\text{--}1000\text{ }^{\circ}\text{C}$) passes through an air-air heat exchanger designed to handle aggressive flue gases with high ash-content. It heats up air from 200 to $500\text{ }^{\circ}\text{C}$ which runs in a closed loop to a heat exchanger ("evaporator") where it heats up the ORC working medium. When needed, a filter can be installed to meet specific environmental regulations.

Power conversion: In the ORC, a turbine drives the generator producing up to 170 kW power; the ORC also provides heat in the form of cooling water. Multiple ORCs can be operated in parallel.

Inputs	Outputs
Fuel: $3000\text{--}4000\text{ t/year}$ assuming 11 MJ/kg	Gross power ORC: up to $170\text{ kW}_{\text{el}}$ Net power ORC: up to $160\text{ kW}_{\text{el}}$ Plant own consumption (furnace, extraction fan, air loop etc.) typically $\sim 50\text{--}70\text{ kW}_{\text{el}}$. Cooling water with $770\text{ kW}_{\text{th}}$ heat at $55\text{--}80\text{ }^{\circ}\text{C}$

Benefits:

- Enables local scale, decentralized power and heat production
- Close to fuel source and/or heat user
- Conversion of difficult materials into revenue sources instead of costly disposal
- Highest efficiency solution on the market in this power range
- Compared to steam plants, ORC requires less supervision, no need for water treatment and lower maintenance costs.



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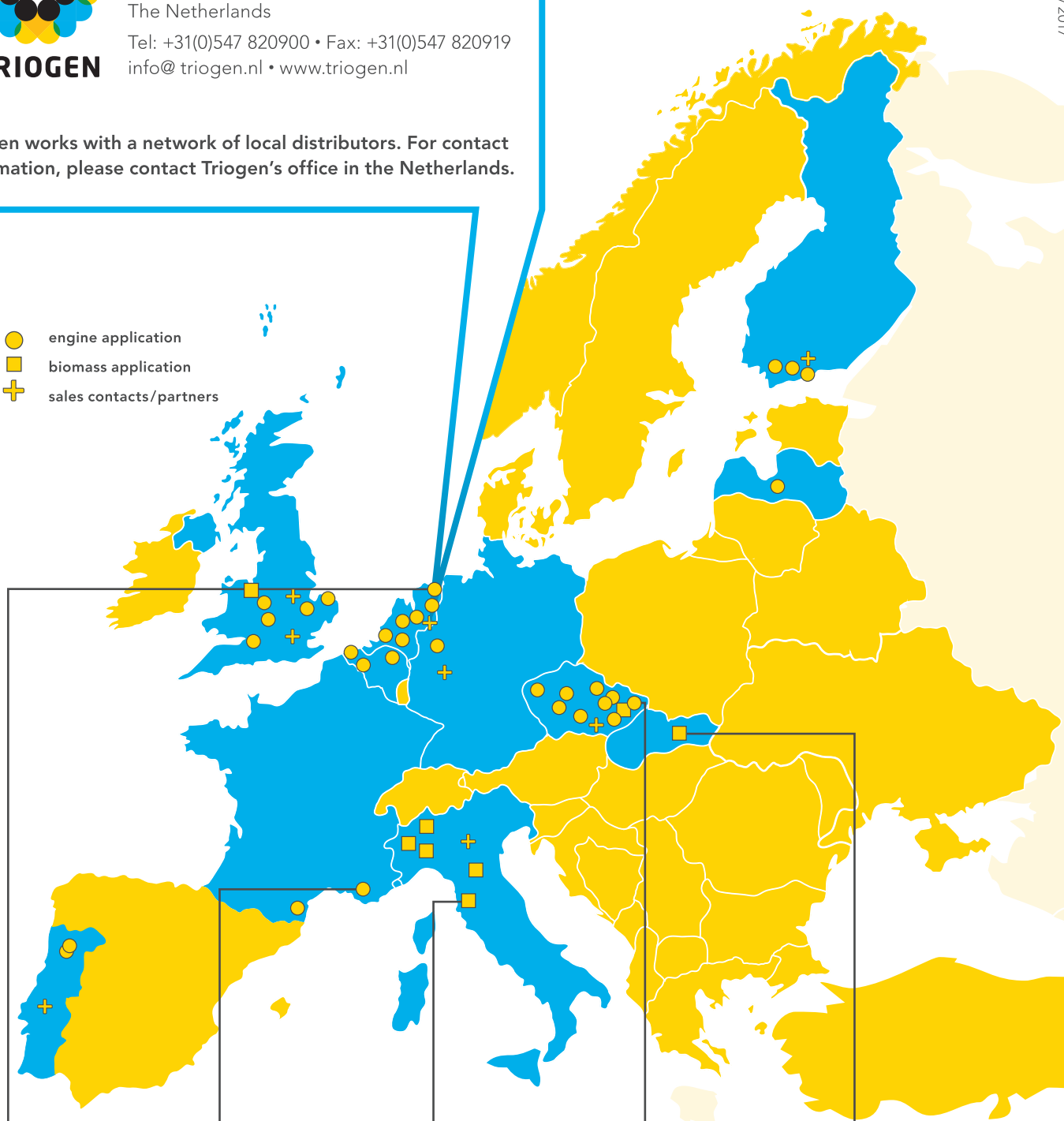
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Triogen works with a network of local distributors. For contact information, please contact Triogen's office in the Netherlands.

-  engine application
-  biomass application
-  sales contacts/partners



SAMPLE SITES



- + 2 Biogas engines (J316)
- + In operation since 2009



- + Landfill gas site commissioned in 2011
- + 2 engines (J320) plus 1 landfill gas flare



- + Wood chip furnace
- + Heating for offices and industry



- + 2 Mine gas engines (Tedom Quanto)
- + Installed 2012



- + Sawdust furnace
- + Sawmill facility using heat for drying kilns