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Benefits of using high temperature ORC-modules for electricity-only applications

by

Hartmut Kiehne, ADORATEC GmbH

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Adoratec GmbH – Milestones and Highlights

2004 – Company Foundation by Peter Eiermann and Hartmut Kiehne

2005 – Development of an ORC-module program 315 to 1.600 kW

2005 – Acquisition of the 4 first orders for plants in Germany

2005 – Maxxtec AG takes over 42% of company Adoratec GmbH

2008 – Maxxtec AG increases its stakes to 98% of Adoratec GmbH

2008 – Introduction of the new ORC-module program 300 to 2.400 kW

2009 – Introduction of the new ORC-turbine AD-A and AD-B

2009 - Siemens Venture Capital aquires 20% of Maxxtec

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Government CHP Promotion Policies

The German government has introduced various incentive schemes to support CHP.
In order of importance, these are:

- The **Kraft-Wärme-Kopplungsgesetz (the 2002 CHP law)**
- Natural gas, as well as heating oil, used for CHP are **exempt from Ökosteuer** (Ecotax), creating an incentive for industry to replace heat-only boilers with CHP systems.
- Biogas CHP receives favourable feed-in tariffs under the **Erneuerbare-Energie-Gesetz** (Renewable Energy Law).
- CHP is recognised as a compensation measure in the **EEWärme-Gesetz** (Renewable Heat Law).
- The **German building code** targets primary (not final) energy consumption and therefore allows for proper reflection of efficiency advantages in energy conversion and delivery.
- Larger CHP plants were carefully considered **Germany´s implementation of the EU ETS** (Emission Trading)

ORC CHP plants are less electric efficient, but with an overall efficiency of 98 % unbeatable!

There are applications where CHP is not possible, i.e. electricity-only applications:

- Industrial waste heat recovery
- Solar thermal applications
- Power production in areas with high ambient temperatures and no heat demand

Even for electricity-only applications it should be carefully analysed whether high or low temperature ORC makes technically and economically sense!

1. Example Low Temperature (LT)

Assumption:
Industrial heat recovery plant with 5.270 kW available heat, ambient temperature 20 °C

Low temperature ORC-module		
Cooling water temperature in/out	25 / 38	°C
Thermal power input	5.270	kW
Gross electric efficiency	20,02	%
Gross electric power	1.055	kW
Auxiliary power ORC	46	kW
Cooling water power	4.170	kW
Cooling water flow	277	m³/h
Cooling water pump drive power	35,9	kW
Radiator cooler fan power	140	kW
Net electric power	**833**	**kW**
Net electric efficiency	**15,81**	**%**

2. Example High Temperature (HT)

Assumption:
Industrial heat recovery plant with 5.270 kW available heat, ambient temperature 20 °C

High temperature ORC-module			
Cooling water temperature in/out	6	60 / 80	°C
Thermal power input		5.270	kW
Gross electric efficiency	2	18,98	%
Gross electric power		1.000	kW
Auxiliary power ORC		55	kW
Cooling water power		4.225	kW
Cooling water flow		186	m³/h
Cooling water pump drive power		24,4	kW
Radiator cooler fan power		40	kW
Net electric power		**881**	**kW**
Net electric efficiency		**17,71**	**%**

Comparison low temperature (LT) and high temperature (HT) version

- same heat input and ambient temperature on both versions,
- higher gross electric efficiency and output on LT due to lower cooling water temperature (20,02 vers. 18,98 %),
- less auxiliary power on LT (46 vers. 55 kW)
- less cooling water power due to higher electric efficiency on LT (4.170 vers. 4.225 kW)
- higher cooling water flow on LT (277 vers. 186 m^3/h)
- higher cooling water pump drive power on LT due to higher water flow (35,9 vers. 24,4 kW)
- higher radiator cooler fan power due to smaller temperature difference between ambient and cooling water temperature (140 vers. 40 kW)
- lower electric net output on LT due to less power demand for cooling system (833 vers. 881 kW)
- lower electric net efficiency on LT (15,81 vers. 17,71 %)

Benefit: 48 kW (5,8 %) more export power on HT, more than 360.000 kWh/a

3. Example Low Temperature (LT) high-efficiency

Assumption:
Biomass power plant with 5.270 kW available heat, ambient temperature 35 °C

Low temperature ORC-module		
Cooling water temperature in/out	45 / 55	°C
Thermal power input	5.270	kW
Gross electric efficiency	21	%
Gross electric power	1.110	kW
Auxiliary power ORC	46	kW
Cooling water power	4.077	kW
Cooling water flow	355	m³/h
Cooling water pump drive power	65	kW
Radiator cooler fan power	160	kW
Net electric power	**839**	**kW**
Net electric efficiency	**15,92**	**%**

4. Example High Temperature (HT)

Assumption:
Biomass power plant with 5.270 kW available heat,
ambient temperature 35 °C

High temperature ORC-module			
Cooling water temperature in/out	6	60 / 80	°C
Thermal power input		5.270	kW
Gross electric efficiency	2	18,98	%
Gross electric power		1.000	kW
Auxiliary power ORC		55	kW
Cooling water power		4.225	kW
Cooling water flow		186	m³/h
Cooling water pump drive power		24,4	kW
Radiator cooler fan power		60	kW
Net electric power		**861**	**kW**
Net electric efficiency		**16,34**	**%**

Comparison example low temperature (LT) high-efficieny and high temperature (HT) version

- same heat input and ambient temperature on both versions,
- higher gross electric efficiency and output on LT due to lower cooling water temperature (21 vers. 18,98 %),
- less auxiliary power on LT (46 vers. 55 kW)
- less cooling water power due to higher electric efficiency on LT (4.077 vers. 4.225 kW)
- higher cooling water flow on LT (355 vers. 186 m^3/h)
- higher cooling water pump drive power on LT due to higher water flow (65 vers. 24,4 kW)
- higher radiator cooler fan power due to smaller temperature difference between ambient and cooling water temperature (160 vers. 60 kW)
- lower electric net output on LT due to more power demand for cooling system (839 vers. 861 kW)
- lower electric net efficiency on LT (15,92 vers. 16,34 %)

Benefit: 22 kW (2,6 %) more export power on HT, more than 160.000 kWh/a

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Summary

ORC CHP should always be the first choice.

There are applications for high and low temperature ORC-modules, but the gross electric efficiency allone should never be the only decission criterion.

Thank you very much for attention!

ADORATEC GmbH
Breite Seite 1
D-74889 Sinsheim / Germany
www.adoratec.com

Sales:
Adoratec GmbH Kiel Office
Schultwiete 2
D-24248 Mönkeberg / Germany
Tel.: +49 (0) 431 5708924
E-Mail: hartmut.kiehne@adoratec.com

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