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Application of ORC-process for landfill gas CHP-efficiency optimisation

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Framework – where are we?

- Price of energy (electricity) has increased drastically
- Energy efficiency is identified as Europe's biggest energy resource
- CHP production instead of power production is strongly subvented (in Finland), making investments on new technologies more viable
- Utilisation of low temperature waste heat using ORC process can offer competitive payback times within energy intensive fields of industry
- Mechanical waste management is also relatively energy intensive and produce valuable fuel for energy production (LFG, biogas, syngas…) where the CHP efficiency traditionally remains relatively low

Aim of the research

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- Identify energy linkages within traditional* waste management based on energy sinks and sources
- Formulate general tool to support decision making concerning investments on energy recovery within waste management
- Promote environmental footprint consideration when comparing different energy production/consumption scenarios
- Provide policy makers and operators information about possibilities to earn extra revenue from energy efficiency and renewable energy

*** Waste incineration not included to the scope of the research**

Case study

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- Low temperature waste heat recovery potential from LFG fired power plant was studied
- Studied power plant is situated in Ämmässuo waste treatment centre in Espoo, Finland

Pa			ew section
Est	Gas type	Landfil gas	
Landf	Gas amount	~ 7,000 nm^3/h	2007
Total w	Methane content	~ 50 %	500-600
	Fuel power	35 MW	2
Electricit	Engine type[1]	MWM 2032	up to 50
Heat con	Engine power[1]	3.76 MW	
Installed LF	Installed electrical power	15.04 MW	
LFG mar	Electrical efficiency[2]	40.4 %	65
LFG bo	Thermal efficiency[1]	40.8 %	3
LFG ge	Total efficiency[1]	81.2	1
			000 (2014)

Energy conversion (before HR)

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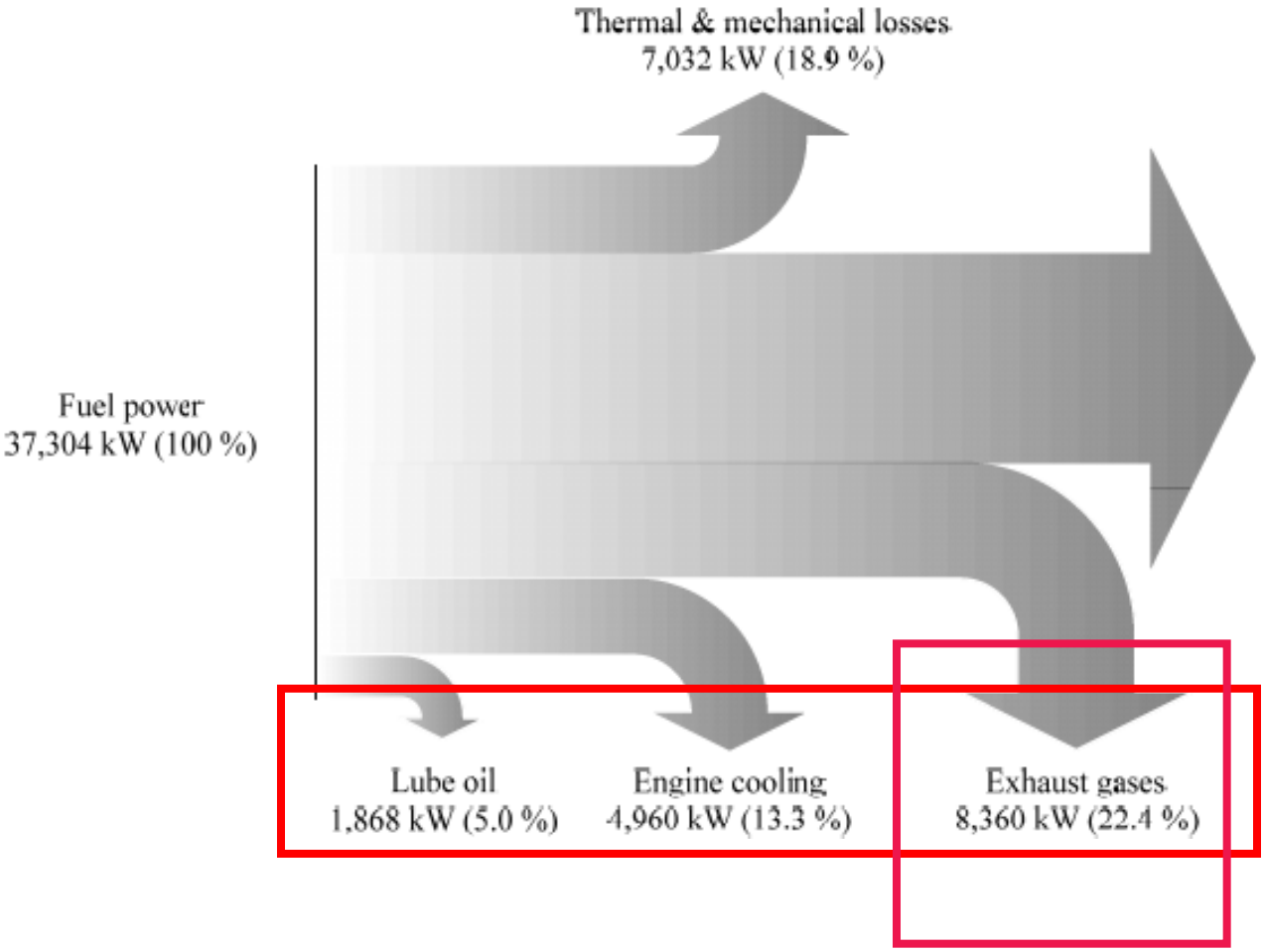

CHP efficiency 40.4 %

Suitable for recovery using ORC

Waste heat recovery using ORC

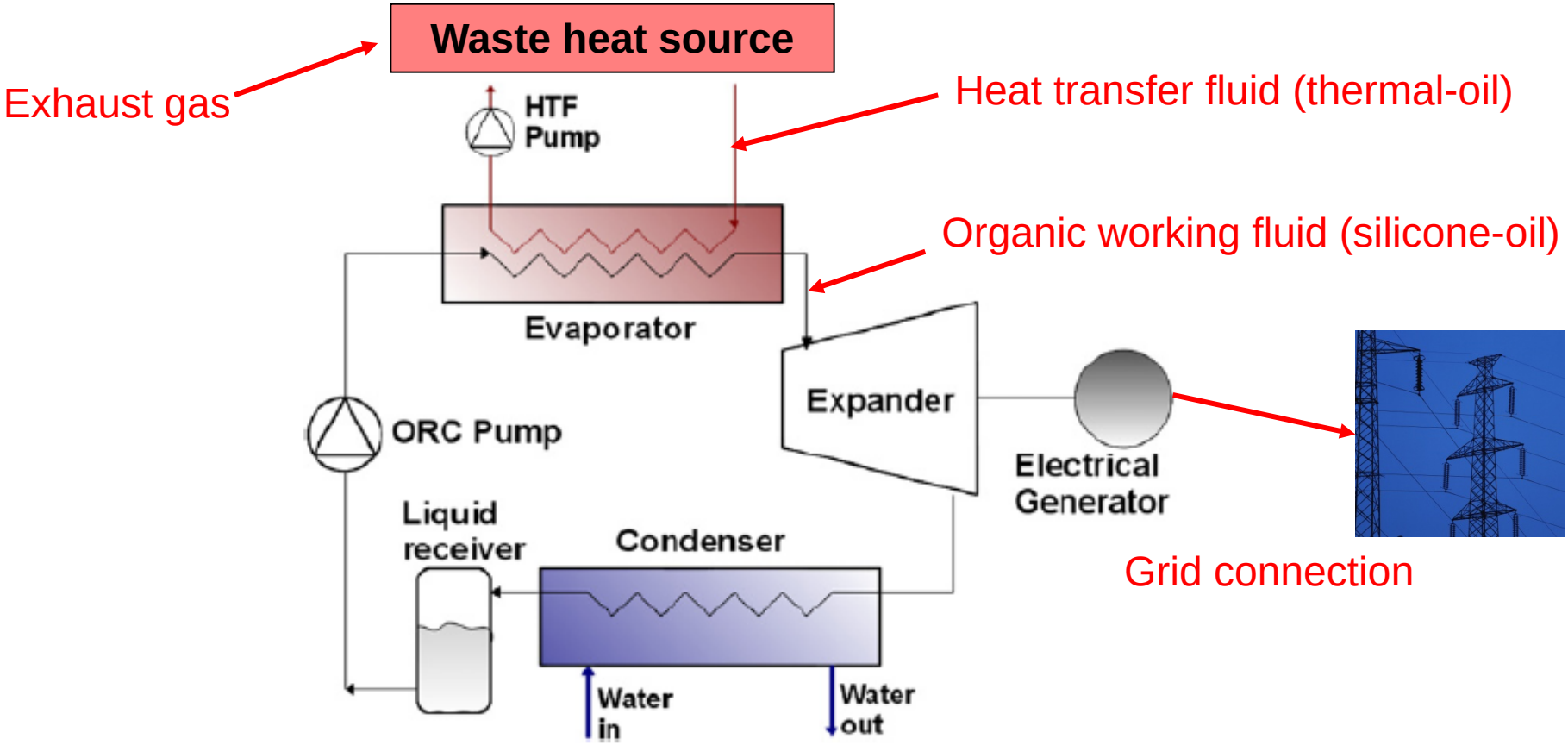

Figure by Quoilin S.et al. 2011

Project realisation

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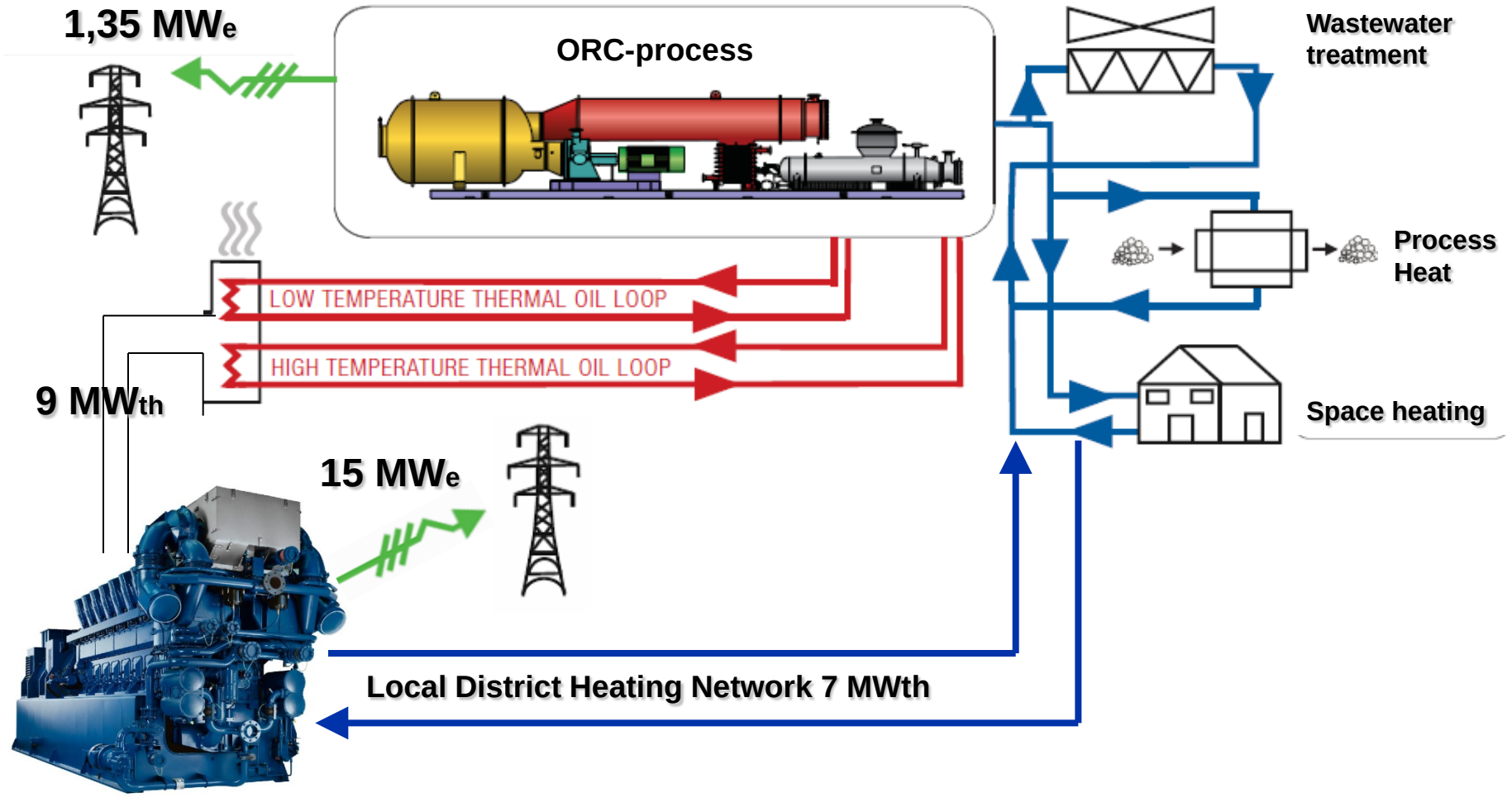


Thermal power recovery potential

Parameter	Unit	Value
temperature (before HR)	° C	495
temperature (after HR)	° C	180
flow rate (wet)	kg/s	5,90
specific heat capasity, cp	kJ/kgK	1,13

$$\phi_{GAS} = c \cdot m \cdot \Delta t$$

, where

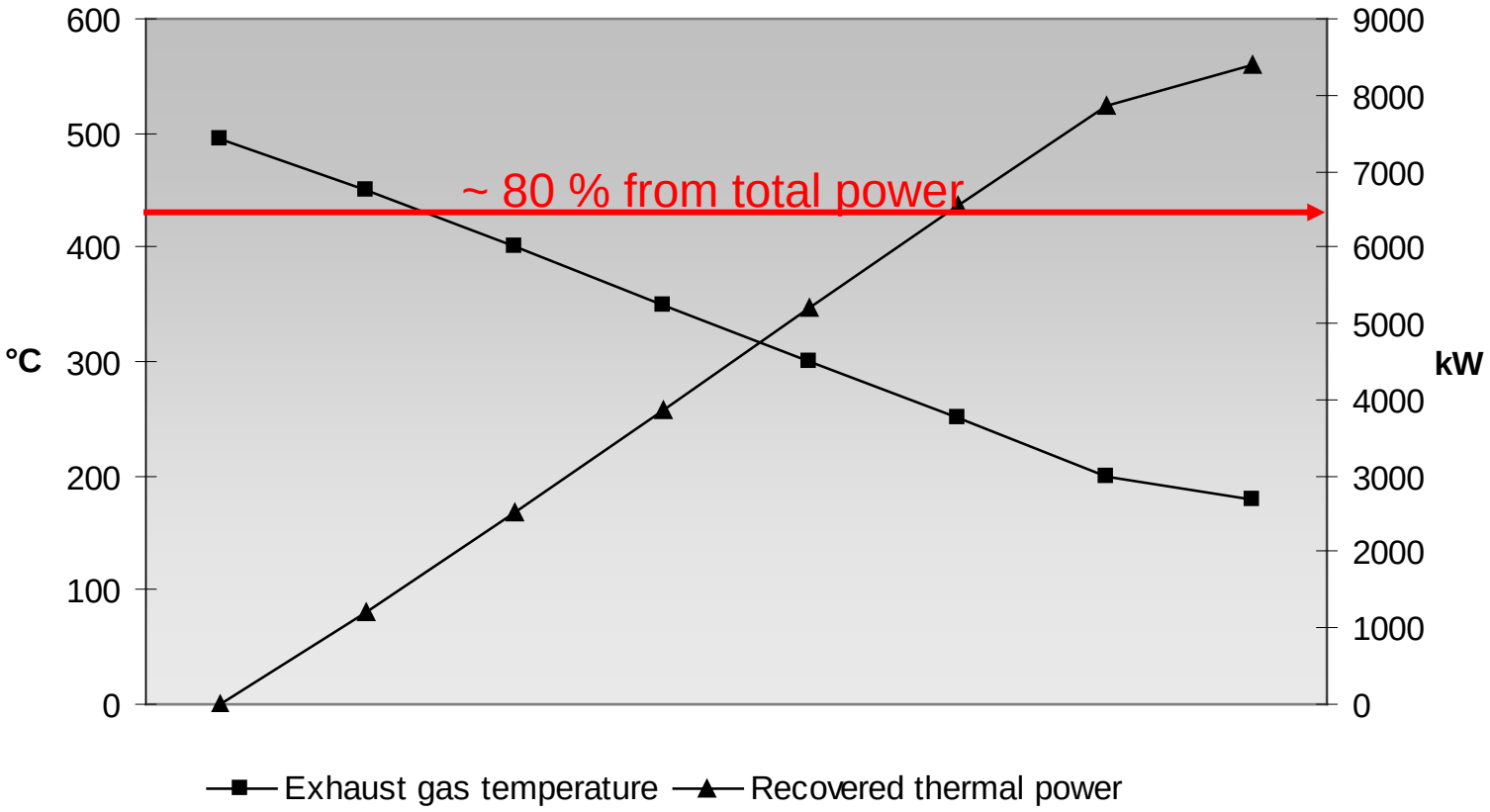
ϕ_{GAS} = recoverable thermal power from exhaust gas (kW)

c = specific heat capacity (kJ/kg K)

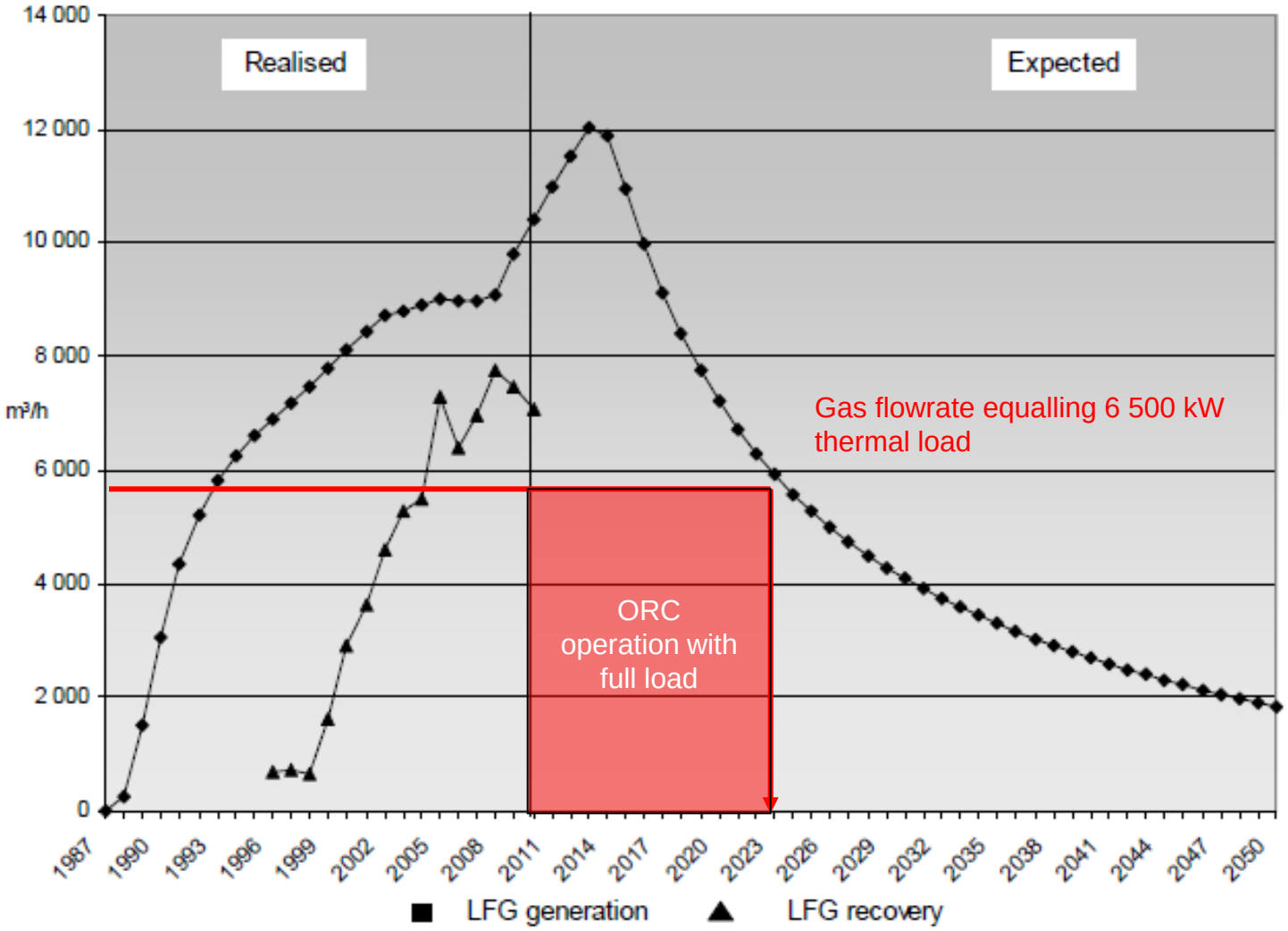
m = mass flow rate (kg/s)

Δt = temperature difference (°C)

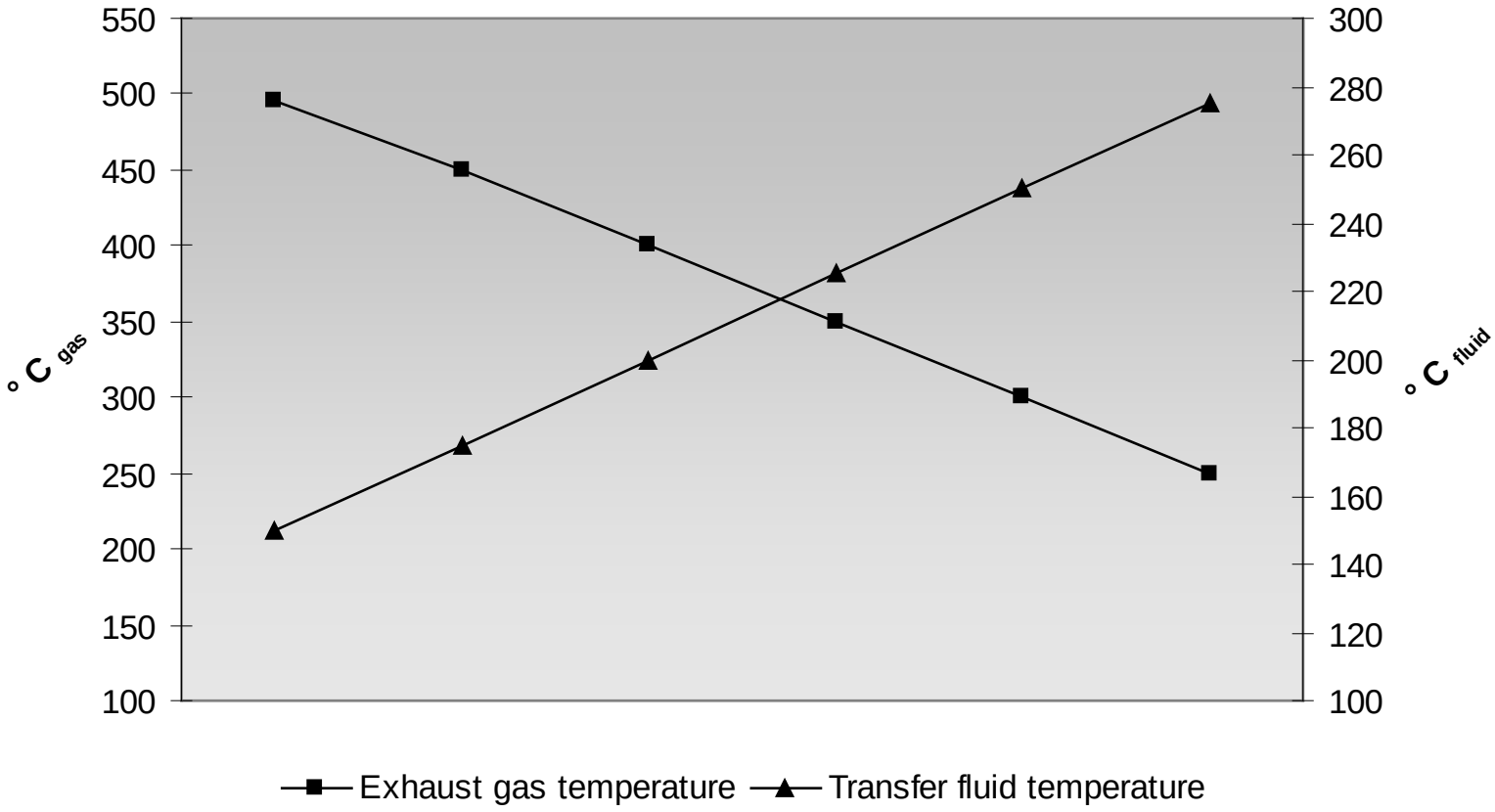
Thermal power recovery potential



LFG generation estimation



Gas temp. vs. transfer fluid temp.



Electricity production potential

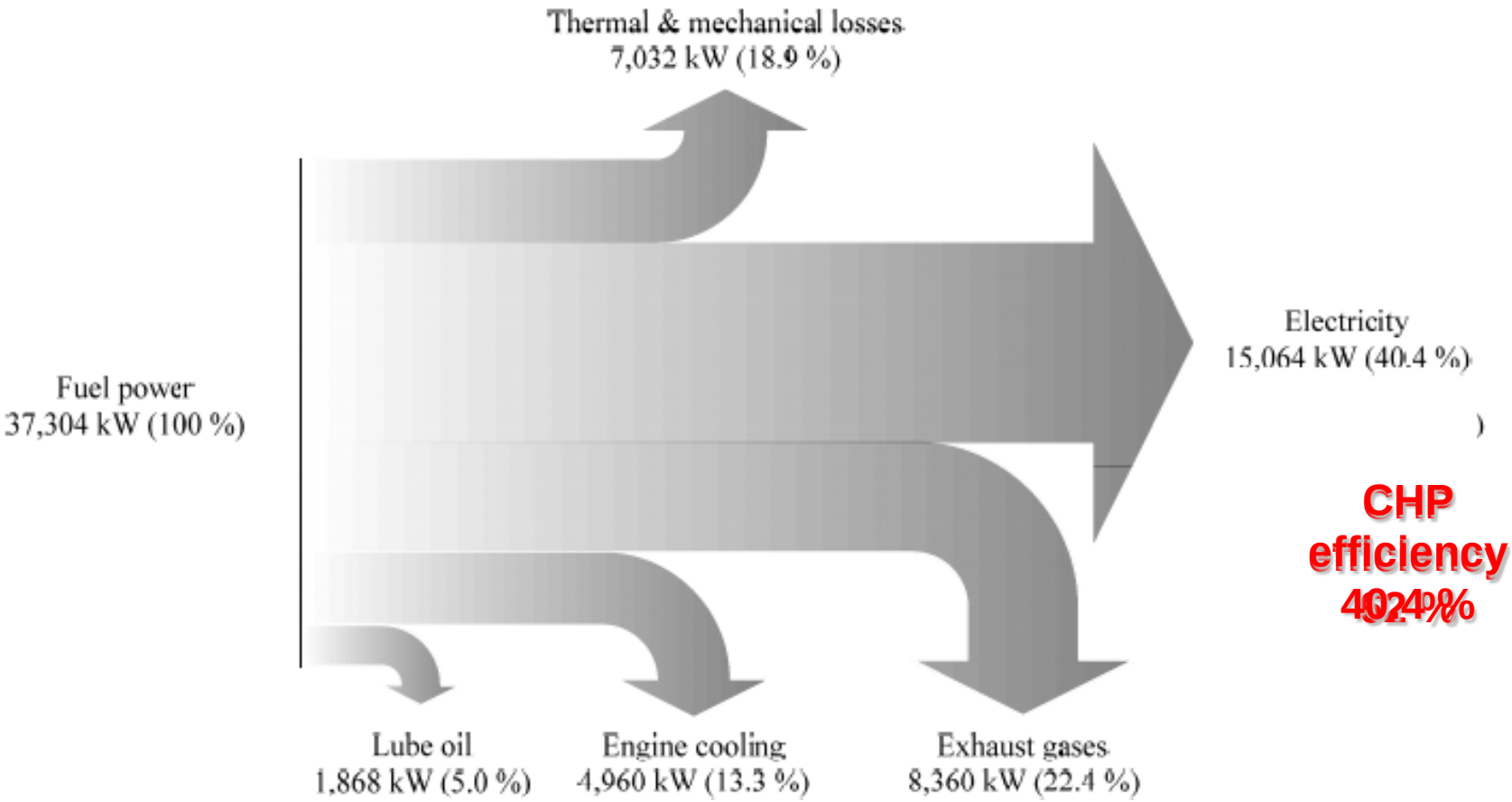
150 °C 275 °C

Parameter	Unit	Value
nominal voltage	V	400
ambient temperature	° C	+ 15 …+ 40
heat transfer media	type	thermal oil
thermal oil temperatures	° C	275 / 150
thermal oil mass flow	kg/s	23,0
thermal load	kW	6 442
power production [7]	kWe	1 315
electrical efficiency [7]	%	20,4
heat output	kW	5 075

→ 1 315 kW

23 °C 37 °C

Energy conversion (after HR)



CHP efficiency 40.4%

Results & Conclusions

- Application of heat recovery and ORC technology for the studied power plant increased the power production by nearly 9 %
- Power plant overall CHP efficiency can be increased from initial 40,4 % to about 62 %
- Waste heat utilisation can potentially produce annually > 10 000 MWh electricity, hence covering the total electricity consumption within the studied site.
- If this ~ 10 GWh power production would replace similar production in a traditional condensing coal fired power plant, this would result an annual CO_2 reduction of nearly 8 500 tons.

Results & Conclusions

- A brief economical analysis also gives positive result for the investment.
  - Realised total investement ~ 2 130 000 € (vat. 0%)
  - Average O&M cost of 0,007 €/MWh
  - Estimated plant availability 90 %
  - IRR 10 %
  - Payback time with electricity market price is 5,8 years
  - Payback time with feed-in tariff scheme is only 3,3 years
- Application of ORC technology increased the process CHP efficiency up to 62 %, which is still below required 75 % by the feed/in tariff
- Efficiency could still be much more optimised by finding suitable utilisation for the waste heat in the form of hot water (originating from engine and ORC cooling)

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THANK YOU FOR YOUR ATTENTION !