EXPERIMENTAL INVESTIGATION OF A SUPERSONIC MICRO TURBINE RUNNING WITH HEXAMETHYLDISILOXANE

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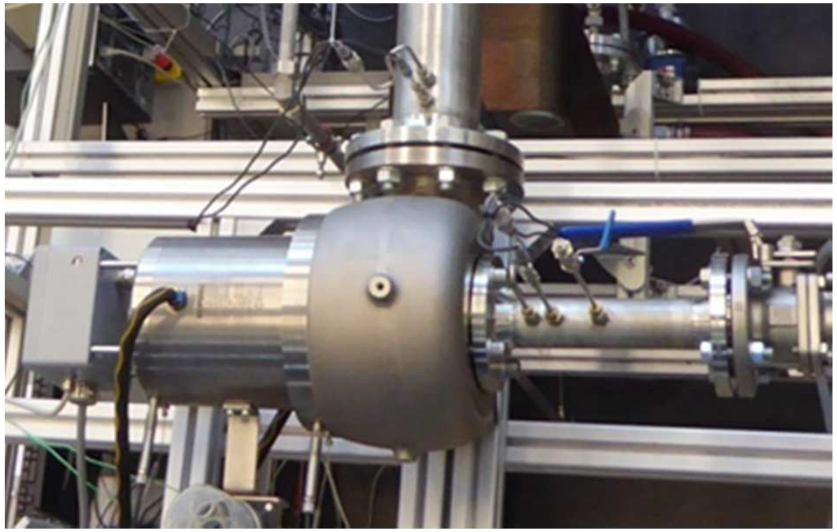
Outline

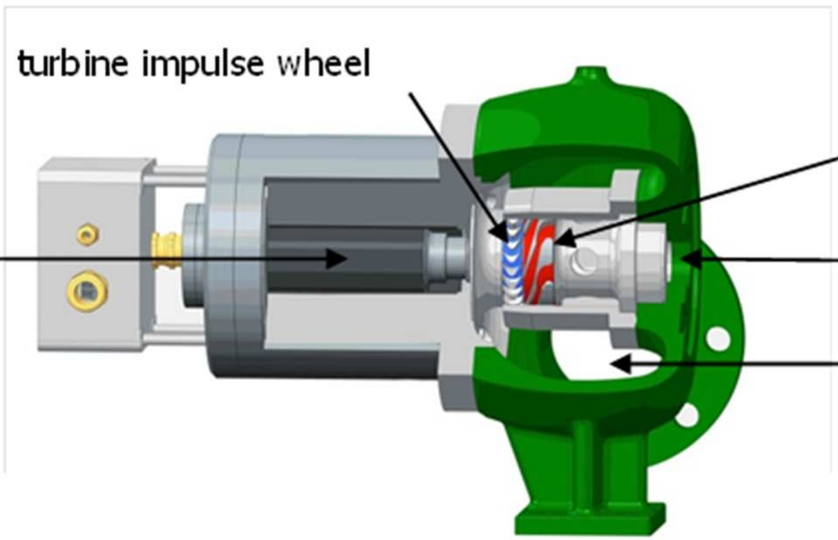
1. Design data of the tested supersonic micro turbine
2. The Micro-Turbine-Generator-Construction-Kit
3. The ORC research power plant at University of Bayreuth
4. Experimentally determined turbine characteristics
5. Conclusions

1. Design data of the hypersonic micro turbine running with hexamethyldisiloxane

wheel diameter	120 mm	pressure ratio (ts)	18.75
rotational speed	24000 rpm	degree of reaction	0.0
Laval nozzles	12	degree of admission	full
rotor blades	32		
		nozzle exit Ma number	**2.11**
mass flow rate	0.32 kg/s	**rotor inlet Ma number**	**1.14**
power output	12 kW	nozzle Re number	9.3×10^5
inlet pressure	6.00 bar	rotor Re number	3.1×10^5
outlet pressure	0.32 bar		
inlet temperature	176 °C		

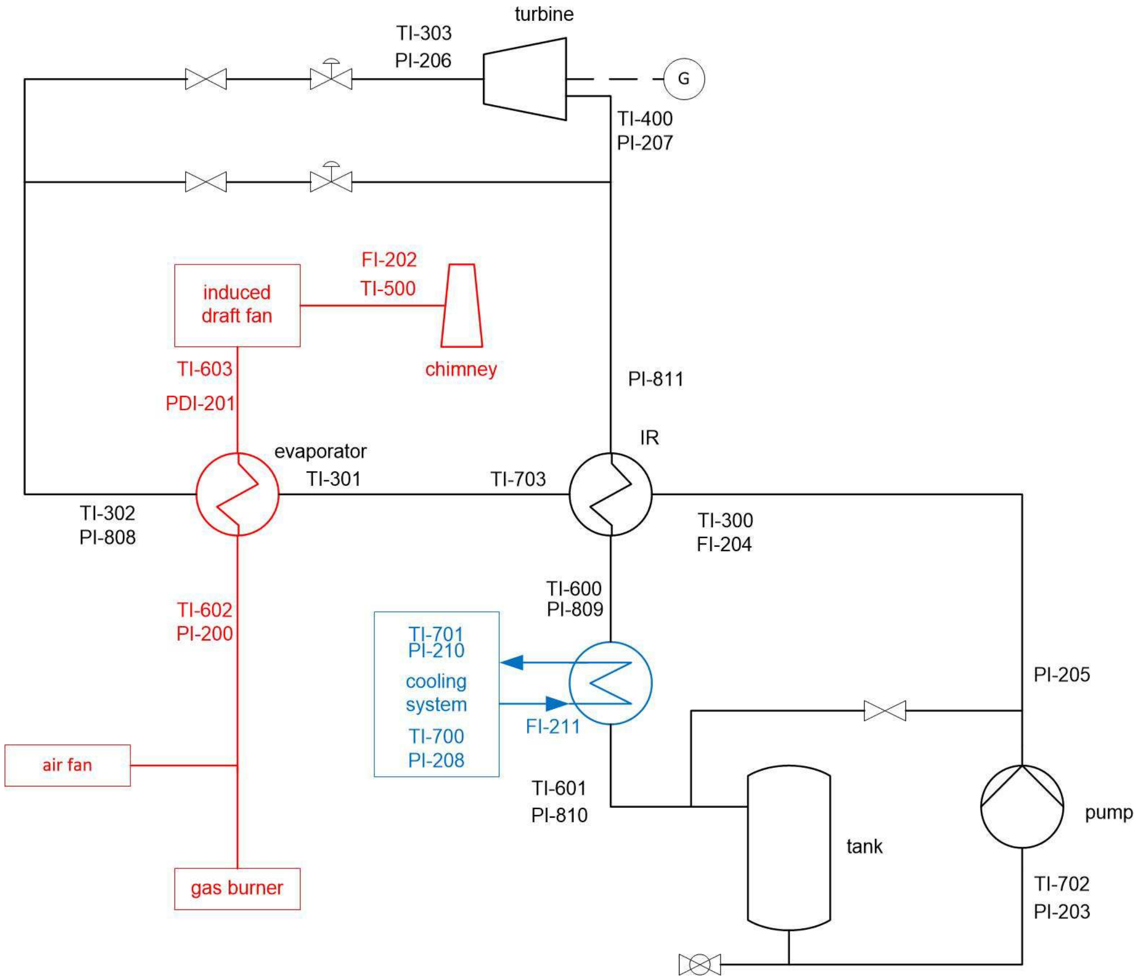


2. The Micro-Turbo-Generator-Construction-Kit (3–175kW$_{el}$)



- hermetically sealed turbine-generator (3 -175 kW$_{el}$, implemented with 5 different- sizes)
- single stage axial impulse turbine (10000 – 70000 rpm) which is able to process very high pressure ratios and small volume flow rate (partial admission)
- integrally manufactured turbine wheel (Ø 50 – 350 mm)
- permanent magnet high-speed generator
- turbine wheel directly mounted on generator shaft: just one set of bearings required, no gear, no coupling
- compact design, low material usage

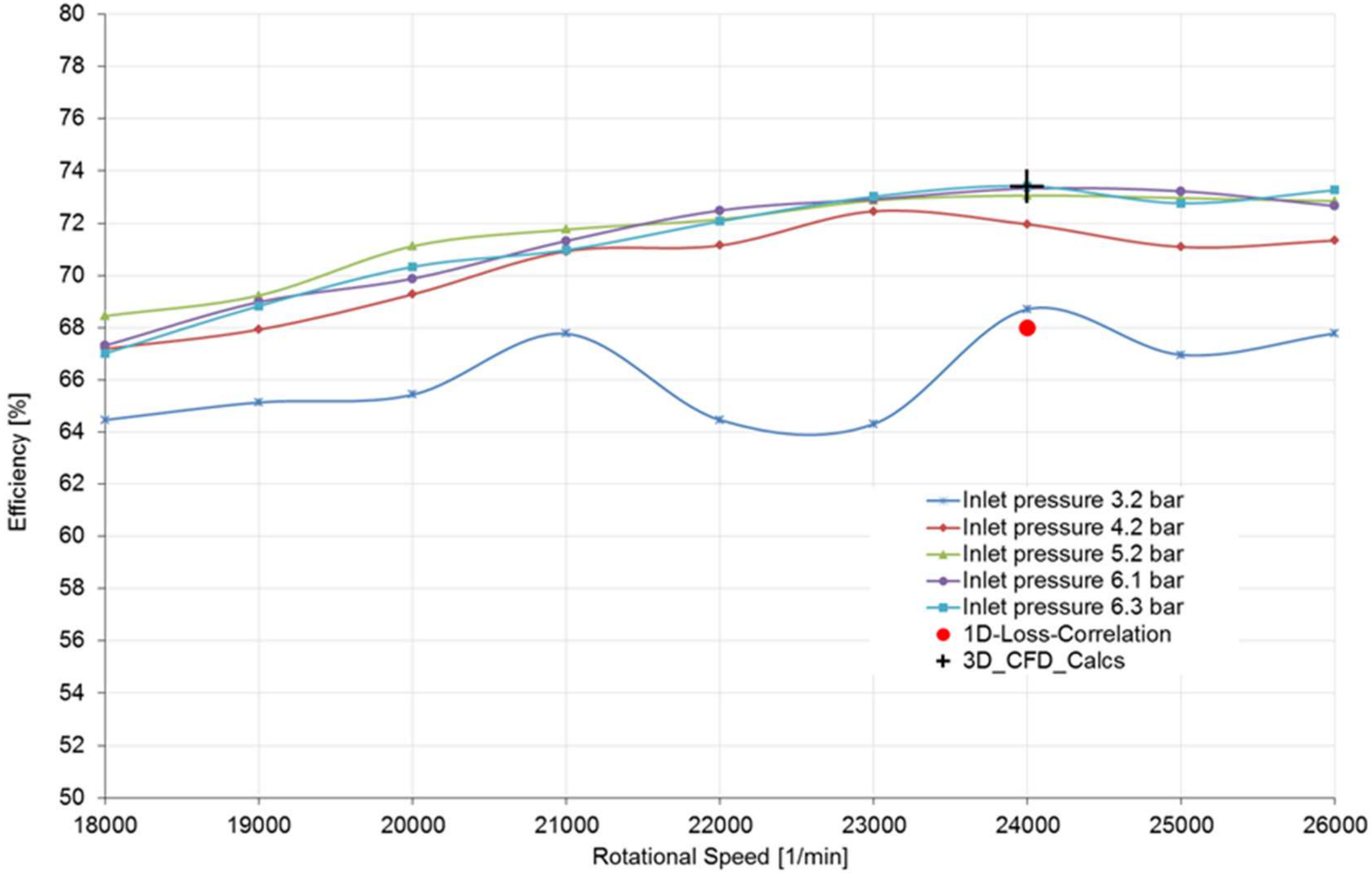
3. The ORC research plant at University of Bayreuth



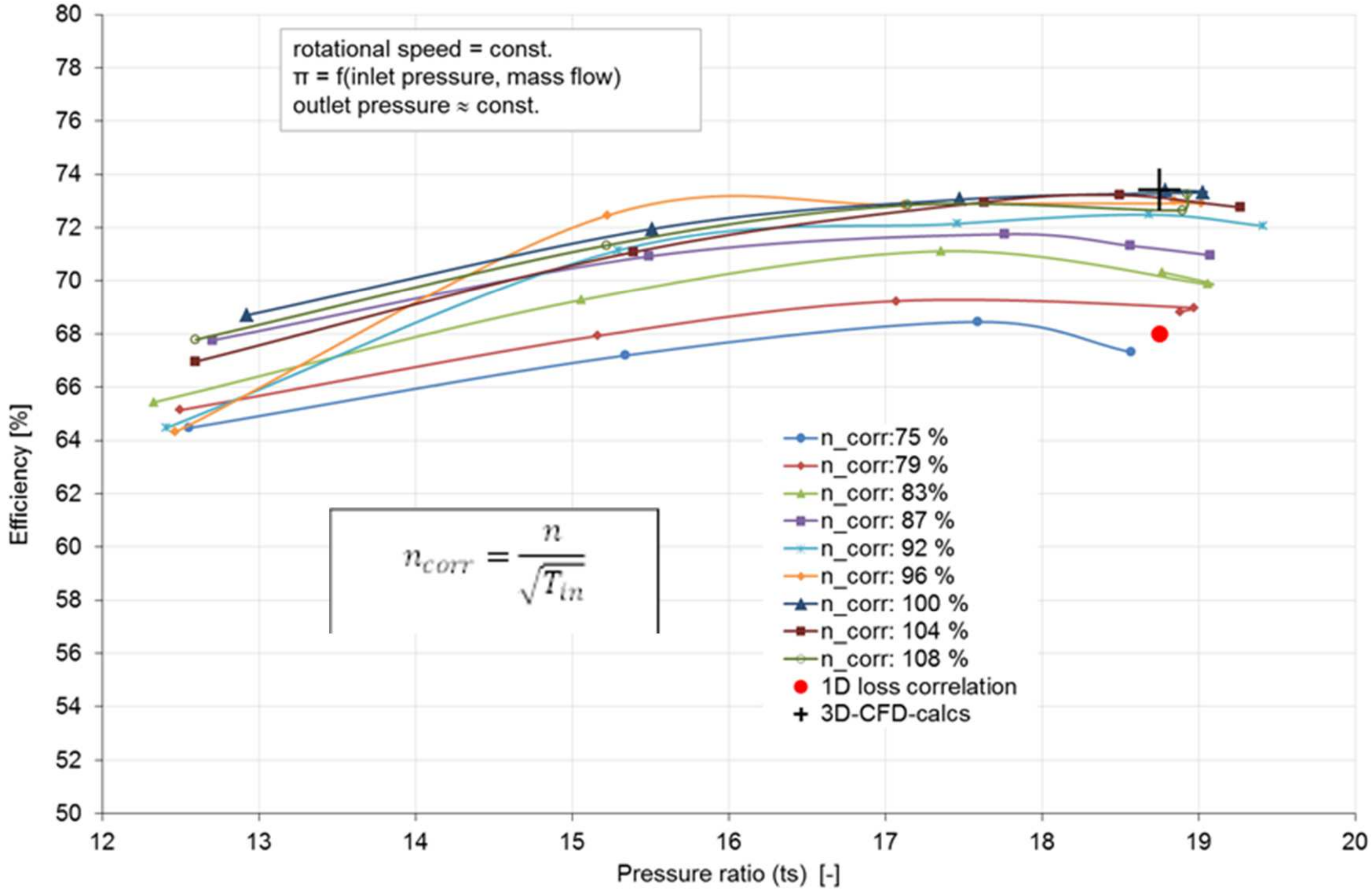
view from top

4. Experimentally determined turbine characteristics

Isentropic total-to-static efficiency vs rotational speed



Experimentally determined turbine characteristics
Isentropic total-to-static efficiency vs pressure ratio (ts)



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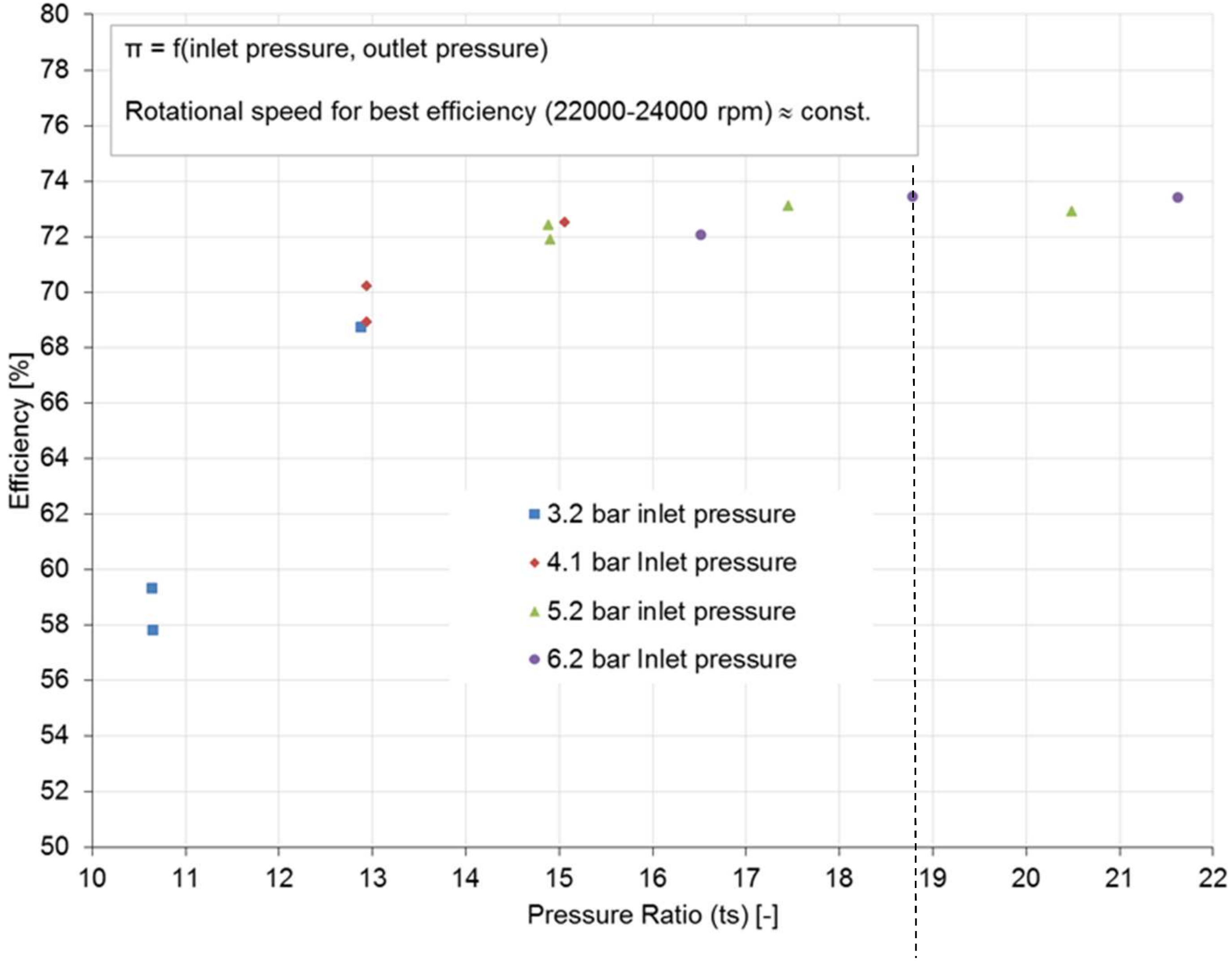
Experimentally determined turbine characteristics
Isentropic total-to-static efficiency vs pressure ratio



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5. Conclusions

- The achieved design point efficiency of 73.4 % (total-to-static) is an excellent figure, keeping in mind the small size of the turbine in combination with the high pressure ratio which it must process.

- The efficiency characteristics are almost constant over a wide range of pressure ratios and, furthermore, show a rather flat maximum over rotational speed.

- Both qualities are very valuable for a micro-turbine-generator applied in any small waste heat recovery plant where exact operating condition can not be guarenteed or foreseen, respectively.

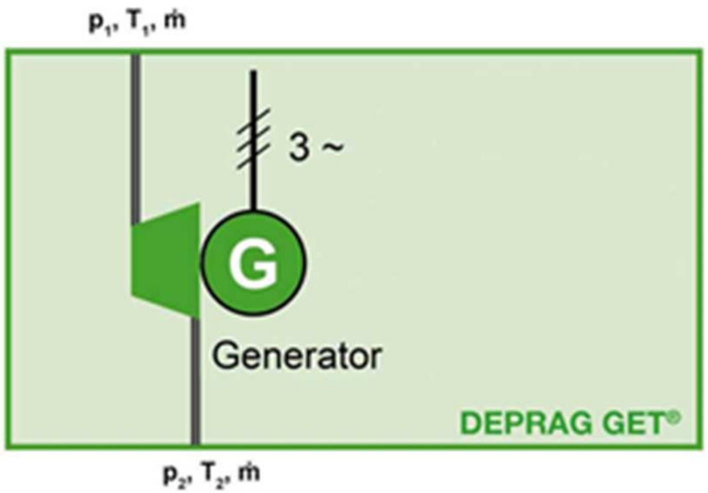
- Nonetheless, we work on an alternative turbine concept. This is a radial inflow cantilever turbine which provides a higher efficiency potential without losing partial admission capability. A representative of this concept will be tested in near future within the research ORC plant at the University of Bayreuth.

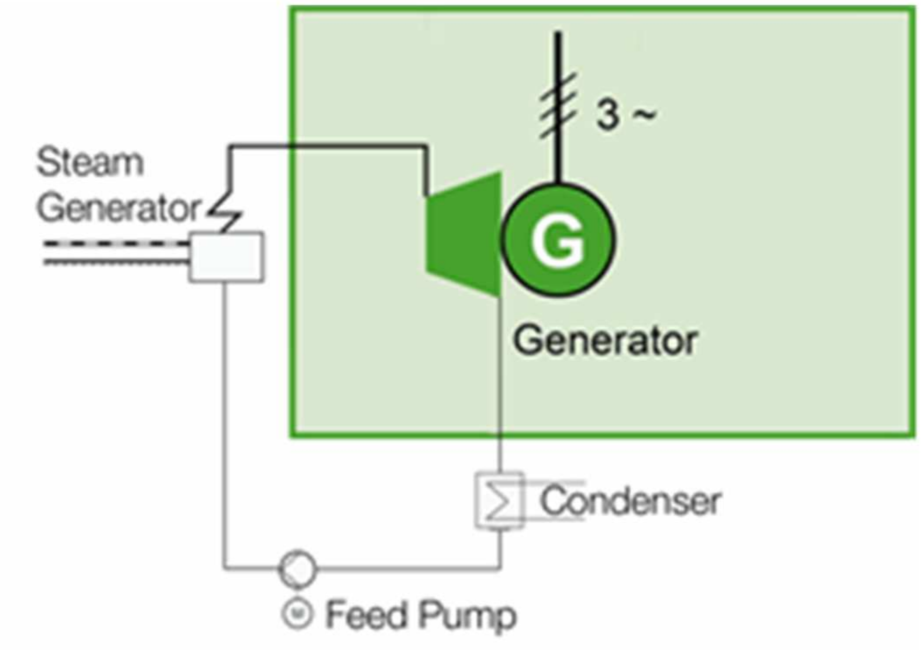
Motivation for Micro-Turbo-Generator-Construction-Kit

- In german industry 88 TWh of waste heat (> 140°C) occur every year.
- Converted to electricity assuming 10% conversion efficiency, this waste heat could substitute a 1000 MW_{el} power plant!
- For recovering of waste heat in a multi-MW scale, there are already solutions available on the market.
- However, in a small scale, below 100 kW, there is a need for waste heat recovery in industry as well, but there are only very few providers of appropriate systems.

- For those applications, the Amberg company DEPRAG has been developping the introduced micro-turbo-generator-construction-kit with close support of the UAS Amberg-Weiden.

The Micro Turbo Generator Construction Kit (3–100kW$_{el}$)





Direct conversion of waste heat occuring in form of pressurized (exhaust) gases (air) or vapours by means of a **G**reen **E**nergy **T**urbine (GET®) as expander

Indirect use of waste heat occuring in form of (exhaust) gases or vapours on ambient pressure by a steam or organic Rankine cycle with GET as expander