State of the Art and Potential Improvements for MGT and MGT-CHP

Goals

The Microturbine (MGT) shall be the strongest commercial alternative for small scale power generation in EU.

It will be a key technology on the European Renewable Decentralized Power Generation Market

It will be an important technology for European based Manufacturing Industry

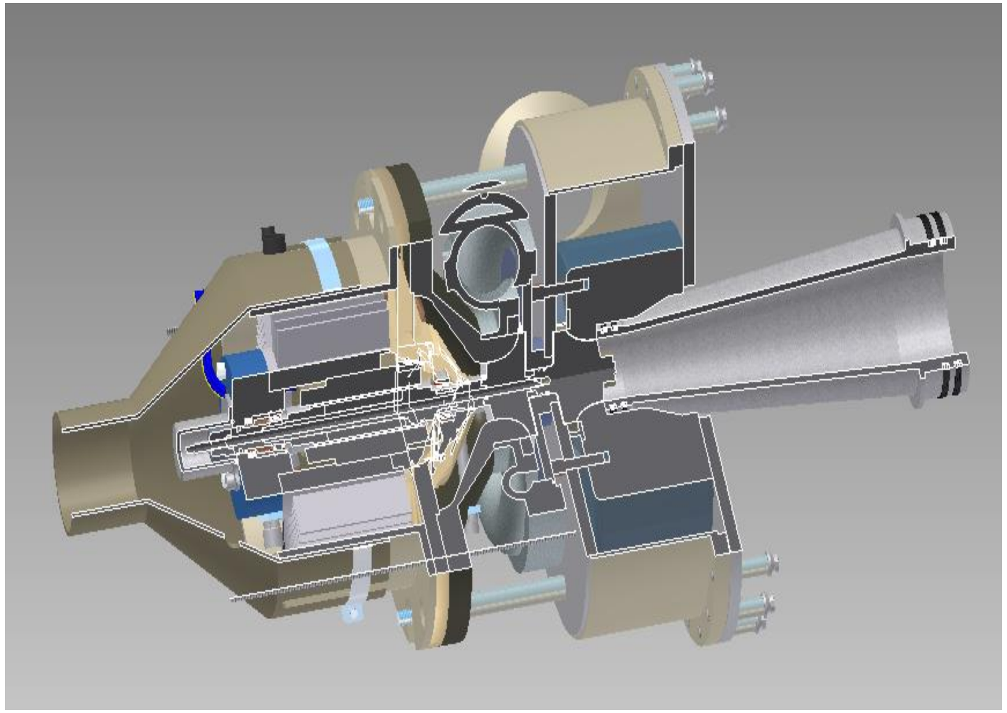
State of the Art and Potential Improvements for MGT and MGT-CHP

State of the Art

- Fuel flexibility: CNG, Low BTU gas, Biogas, Oil, Solid Bio mass, Hydrogen, Solar
- Emissions: Lowest emissions commercially available on CHP technologies
- size/weight: Very compact and high specific power
- noise emission: Suitable for residential installations
- system integration: Flexible

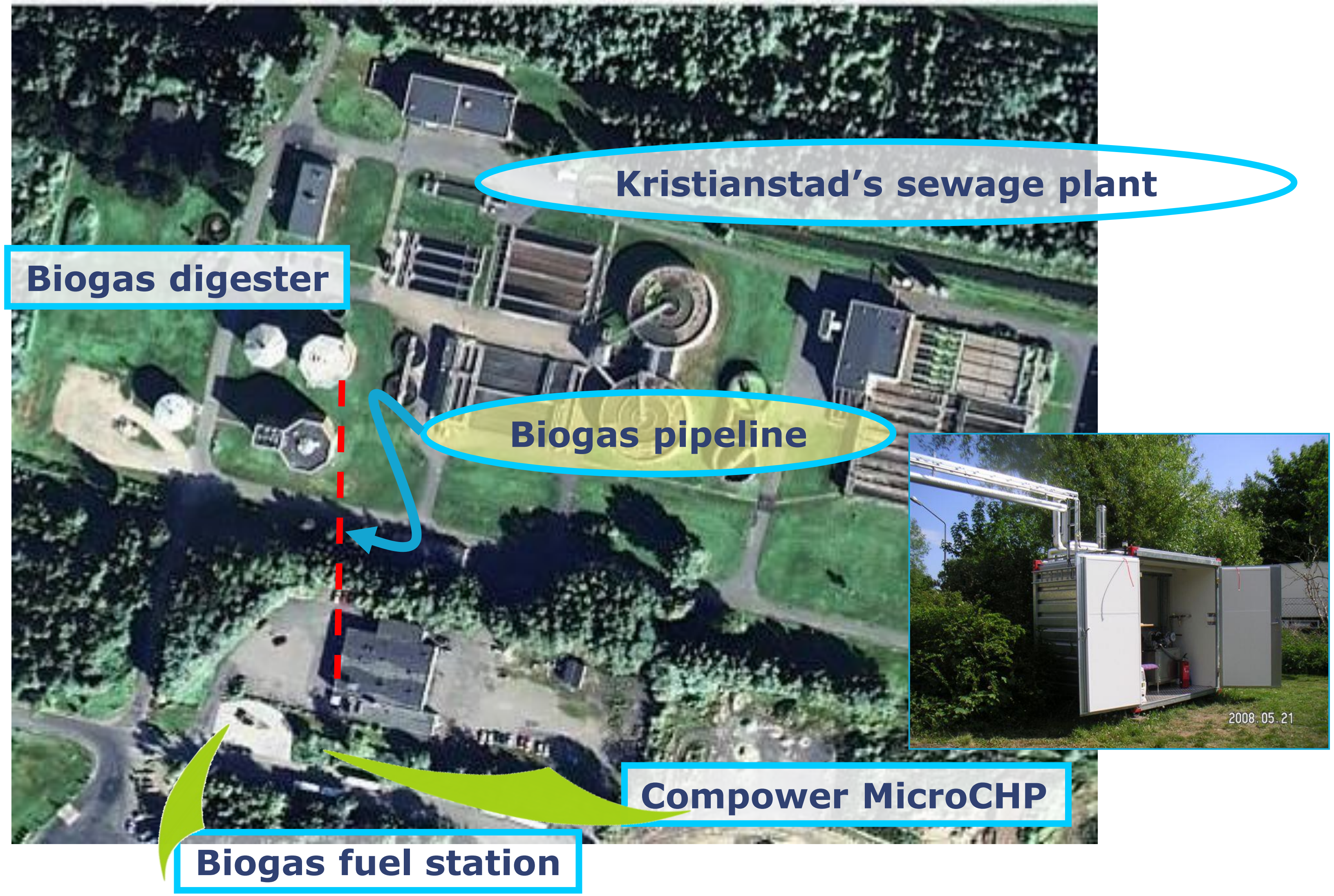
Needs to Improve

- Cost
- Efficiency, 30% today



Compower MGT 7 kW

KRISTIANSTAD FIELD TRIAL SITE



OSBYPARCA™
For professional users

ET10 FIELD TEST PROTOTYPE

Compower
ET10 7 KW

Biogas

In cooperation with Kristianstads kommun · Energimyndigheten · SGC Svenskt Gastekniskt Center AB · Bentone · REGION SKÅNES MILJÖVÅRDSFOND

Compower

ETN

State of the Art and Potential Improvements for MGT and MGT-CHP

What is required to achieve its full Potential?

- Capital cost must decrease considerable
  - First cost (500 €/kW in lower volume power generation applications and 50 €/kW in high volume vehicle applications)

- Performance must be better and outmatch current technology
  - Electric efficiency, 35-45 % depending on size
  - Emissions, <3 PPM NOx for fossil fuel

Compower

First cost – the biggest challenge to go for

MGT's are basically a very simple machine with only one rotating part

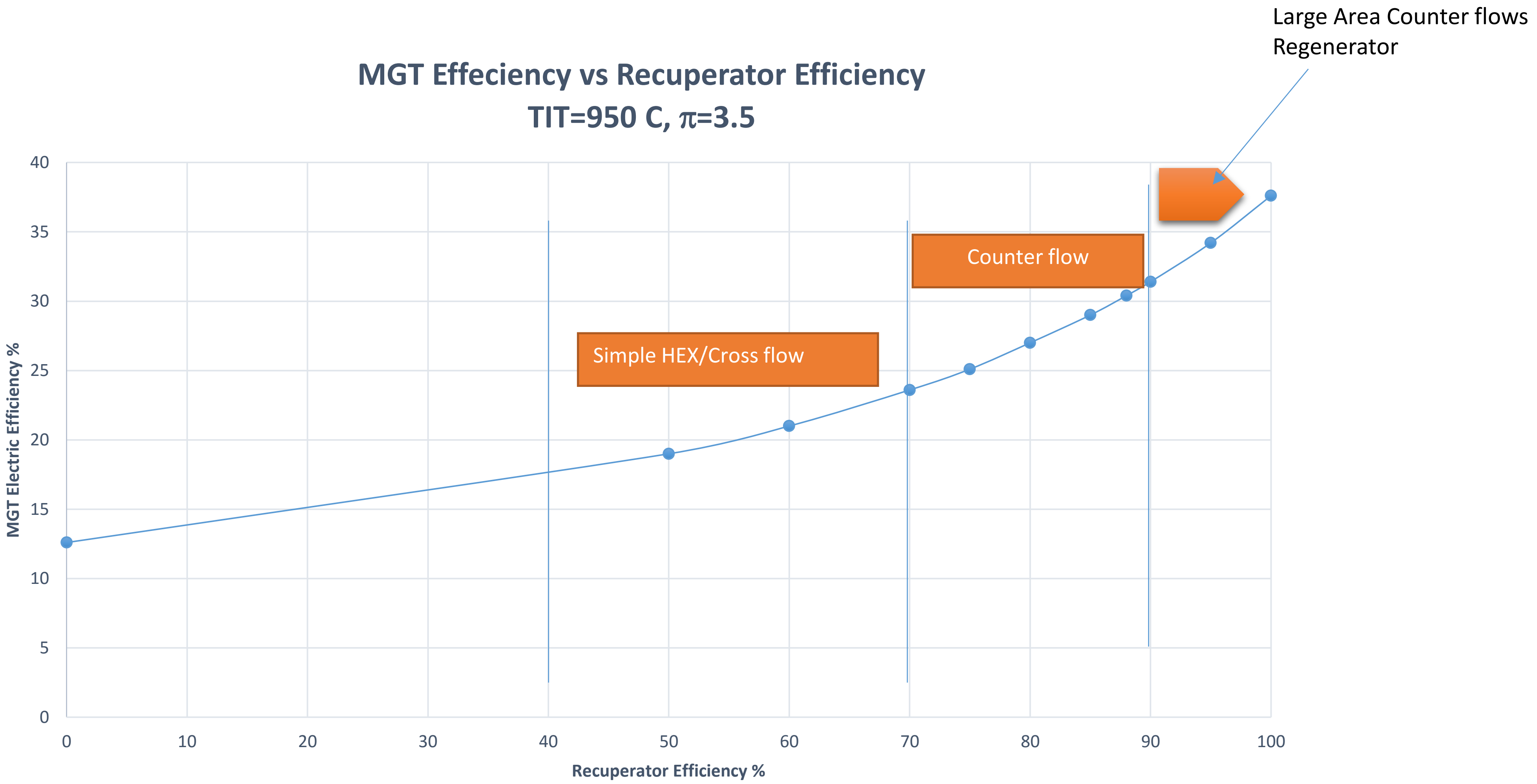
- The Turbomachinery shaft (with Turbine, Compressor and Generator rotor)

Turbec T100 Rotor

However: there are a few parts outside the rotating parts that stands for considerable cost share of the total first cost.

- Recuperator (heat exchanger to utilize exhaust heat) - 20 % share
- Power electronics (To convert electricity into usable grid power) – 15% share
- Combustor – for Renewables can be bulky and need exotic materials - 5-10%

Recuperator is a essential for the MGT Efficiency



Recuperator Manufacturing/Design– Cost driver No 1

Cost Impact considerations:

- Choose right Recuperator performance depending on application
- Choose right Recuperator design depending on specification
  - primary surface counterflow
  - plate and fin counterflow
  - plate and fin crossflow
  - other
- Close cooperation with heat exchanger suppliers and material companies to develop designs/Manufacturing methods suitable for volume production

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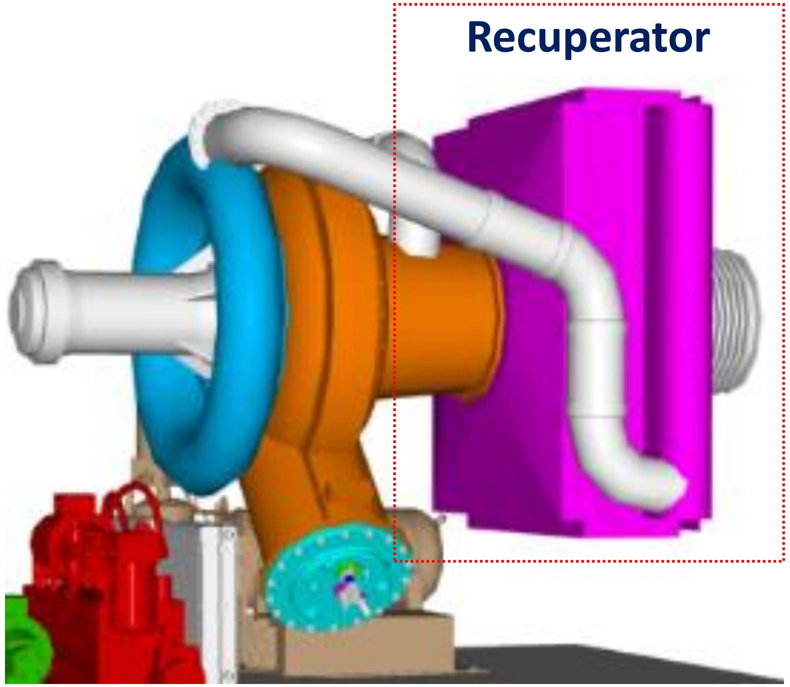
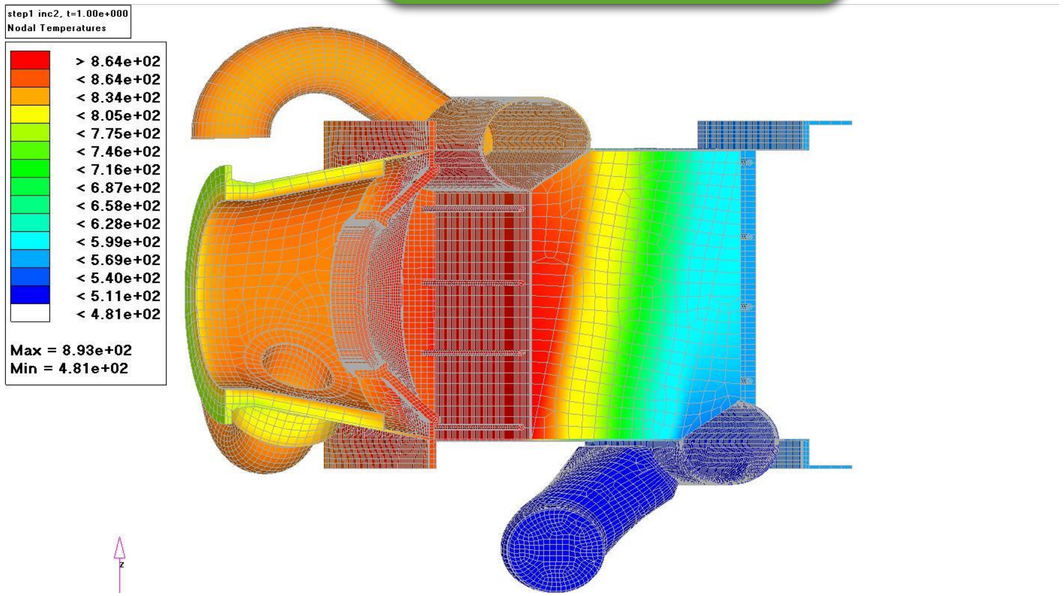
Recuperator Material – Cost driver No 2

High Exhaust temperatures

High temperature corrosion
Start and Stop cycles gives Low cycle fatique
Temperature + Stresses gives creep problems

High Temp Steel
Superalloys
Ceramics





What is the correct price for a Recuperator?

Current price for a high efficient Recuperator in Stainless steel:
80-100 €/kg

Material price:
8-10 € /kg

Processing cost is 10 times the material cost!

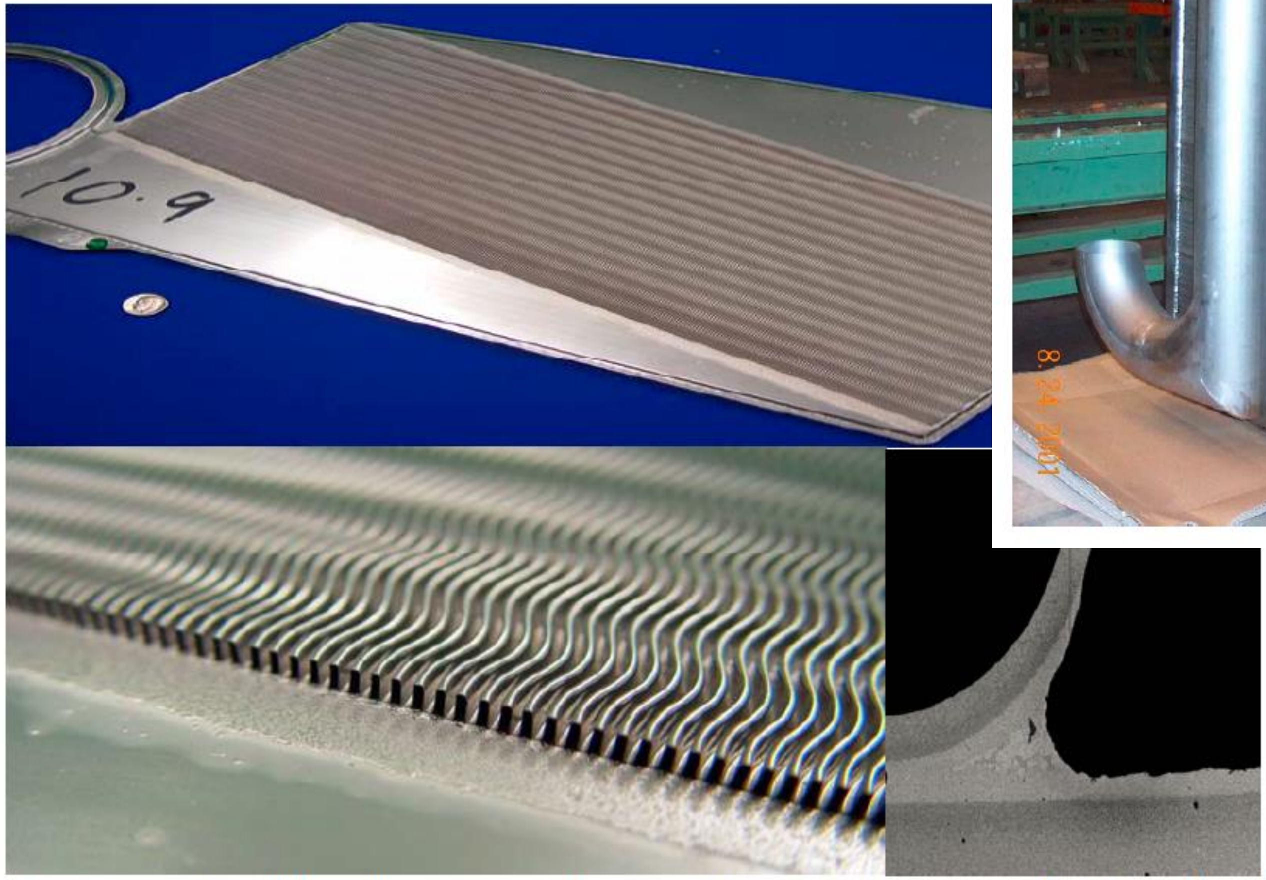


Figure 1 – An air cell from the recuperator of an Ingersoll-Rand 70 kW PowerWorks microturbine showing the folded fins brazed onto the plate at lower (upper) and higher (lower left) magnification, and SEM of a typical Ni-braze alloy joint cross-sectio

RSAB

So, What is the correct price for a Recuperator?

Comparing with automotive industry (Sheet metal forming): Processing should be around 20-40% of material cost.

Say we accept 50% for processing, then the correct price for a Recuperator should be:

15 €/kg

What is the correct price for the Power electronics?

Current price is in the range of 100-150 €/kW. Cost will decrease with its increasing use in automotive applications. For the same reason performance will improve

With high volumes and adoption to industrial standards it should be possibly to get down to 1/10 of current prices

Next Challenge - Performance

How to reach 35-45% electrical efficiency?

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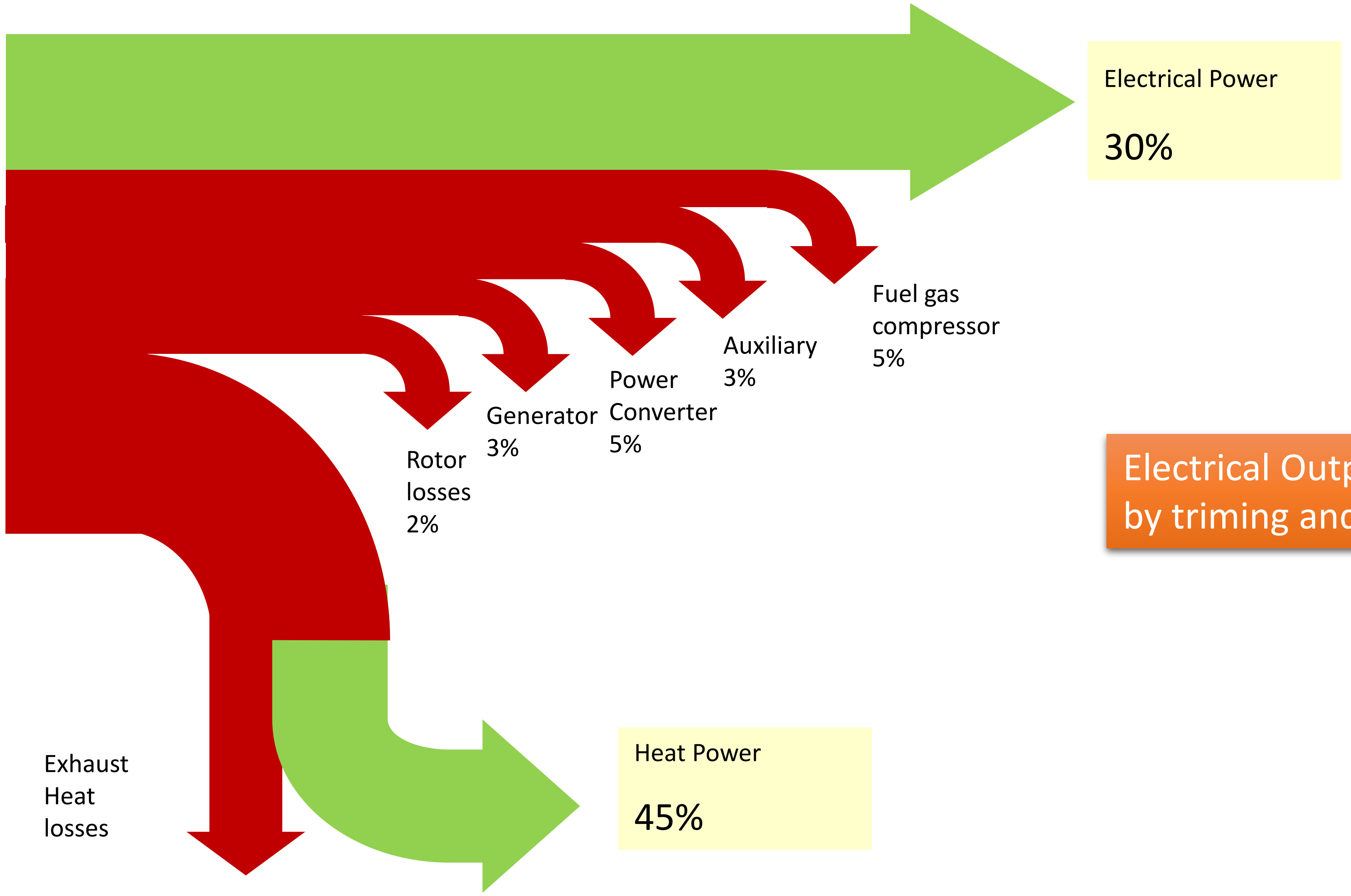
MGT CHP Energy loss distribution – Current situation



Electrical Output can be slightly increased by triming and fin tuning existing system.

Advanced Cycles

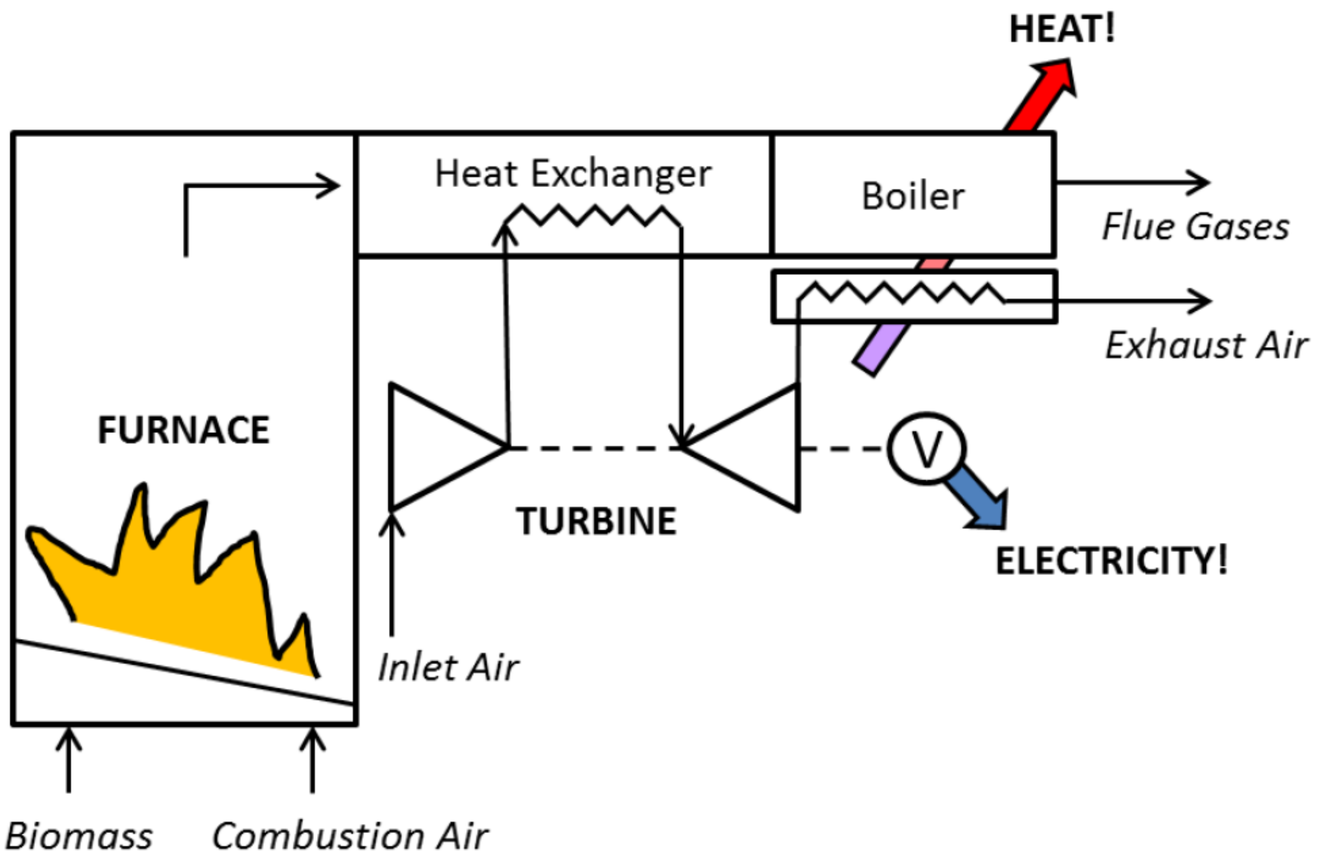
ICR – intercooled recuperated (optional reheat)
- higher efficiency
- more compact and lighter

Externally heated cycle
- can burn wider range of fuels
- energy recovery

Inverted cycle
- for very small systems
- integration in other systems

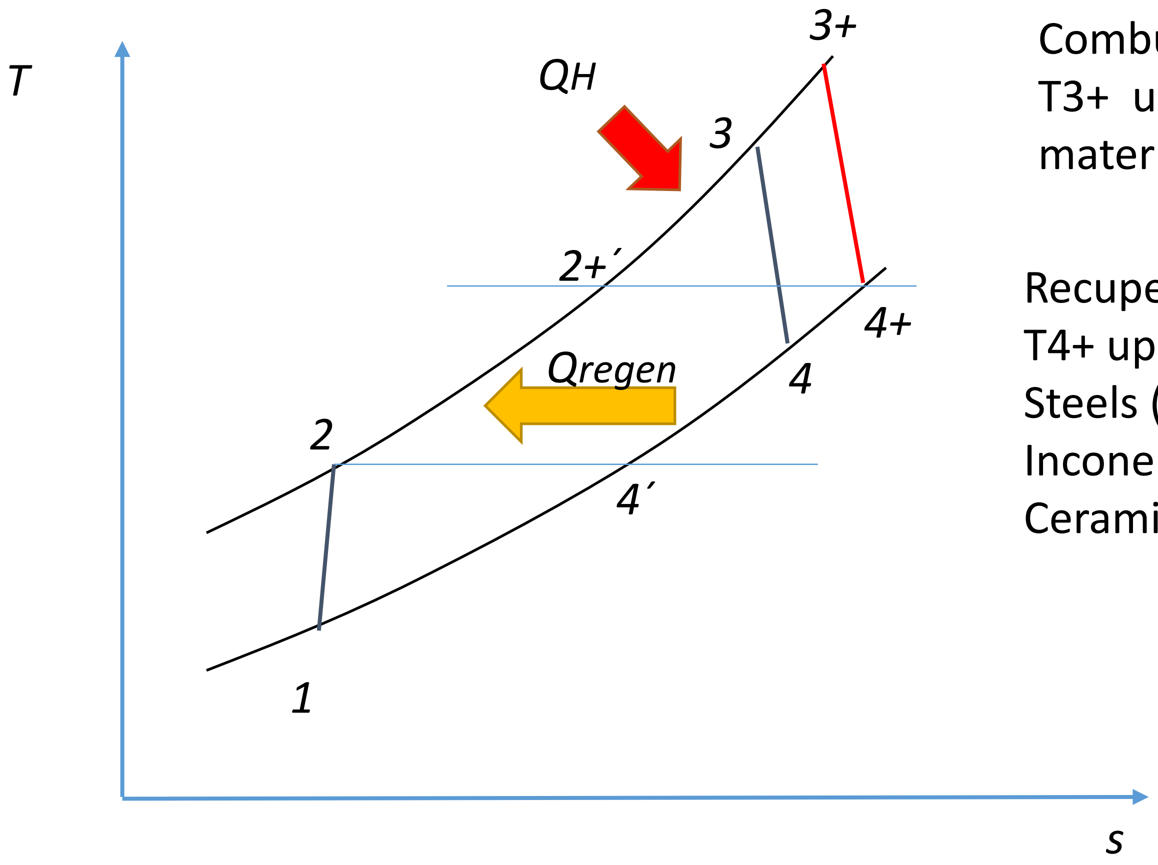
Closed cycle
- best transient behaviour
- lowest noise
- best part load efficiency

Renewable Energy Source: Externally fired Biomass **MGT**



Higher Turbine Inlet Temperature

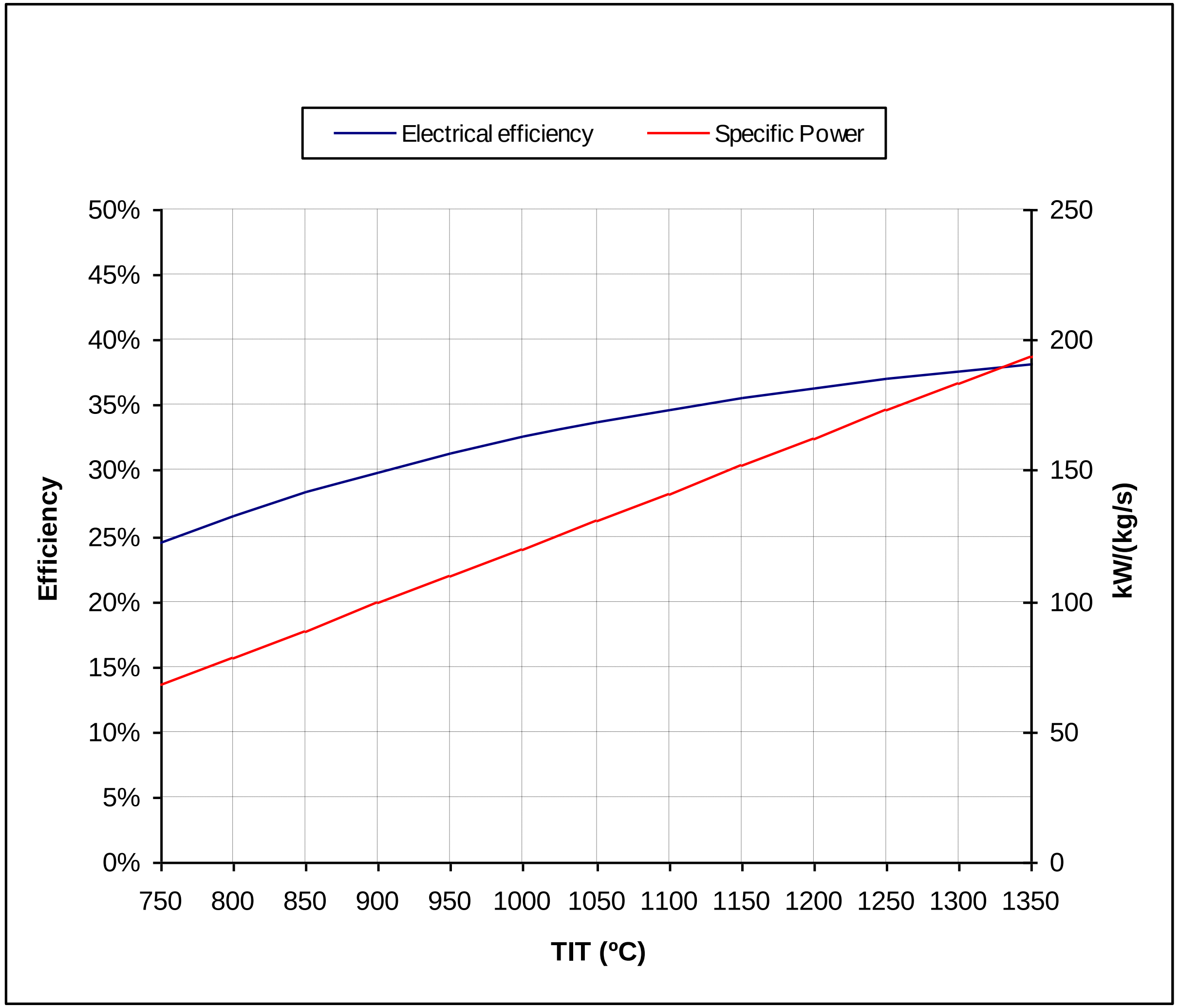
Simple Regeneration cycle – 38 % Efficiency – Higher Temperature



Combustor/Turbine
T3+ up to 1300C for ceramic materials

Recuperator
T4+ up to 850 C for Special Steels (252 MA)
Inconel types up to 900 C
Ceramics – 1300 C

Higher Turbine Inlet Temperature



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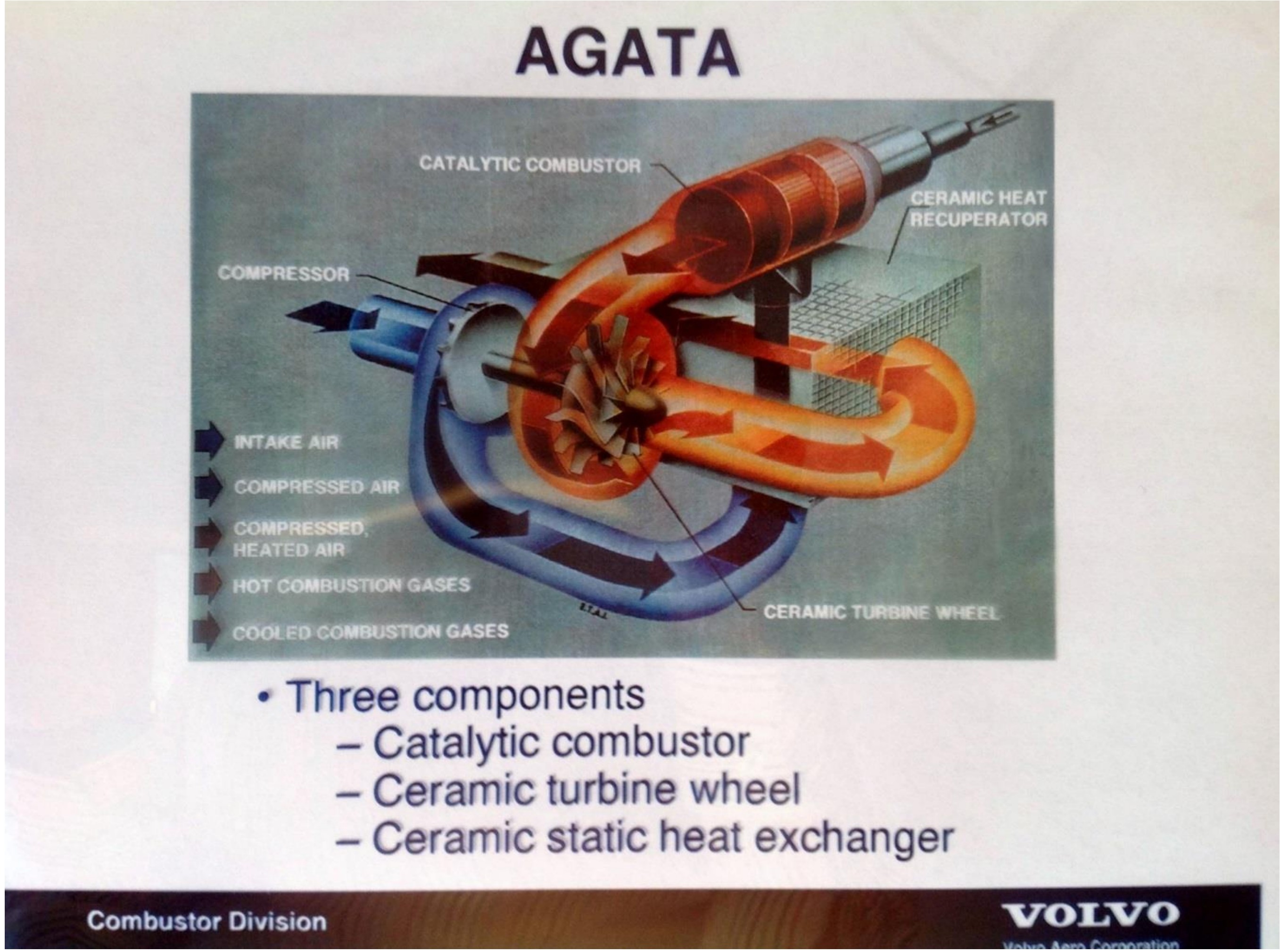

In the European Project "AGATA" Ceramic Components was demonstrated 1993-1996

New developments can now make that technology suitable for production


Turbine-compressor rotating group
SN237
Silicon
Nitride
turbine rotor

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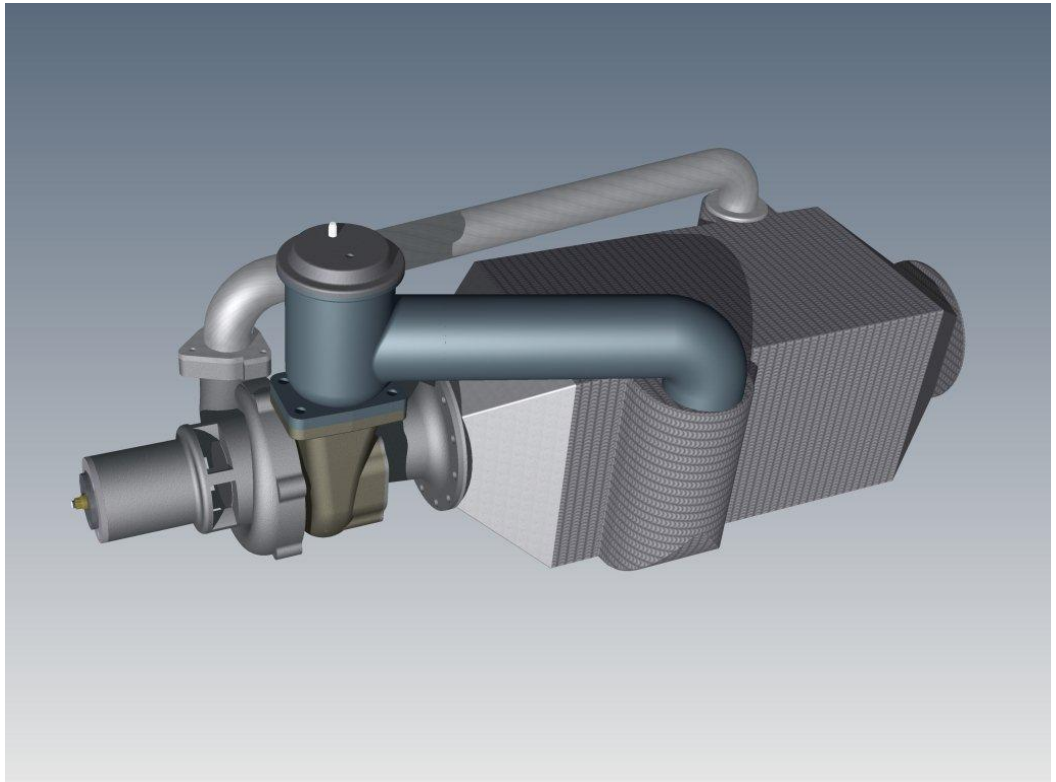
Ceramic heat exchanger with casings and seals



A future ceramic based MGT with 38% Efficiency

First generation of MGT’s has proven itself on the decentralized power generation market

The MGT technology is still early on the learning curve (compered to ICE)

Technical and Industrial Development will make it a leading power technology for Renewable Power Generation

Europe is in a good position to lead that Development