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Biomass micro scale CHP

State of the art and recent R&D activities

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Structure

- State of the art and state of development in biomass micro scale CHP
- Recent R&D activities
- Examples:
  - Performance of pellets fired swinging piston CHP
  - Integration of thermoelectric generators into biomass boilers

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Micro scale CHP

Focus: smallest power

Source: Button Energy

<u>Characteristics:</u>

- Combined heat and electricity production
- High total efficiency
- Compact design
- Ready for installation or turn-key
- Close to mass or mass product

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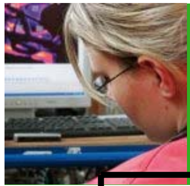
Development of modern (small scale) biomass combustion systems

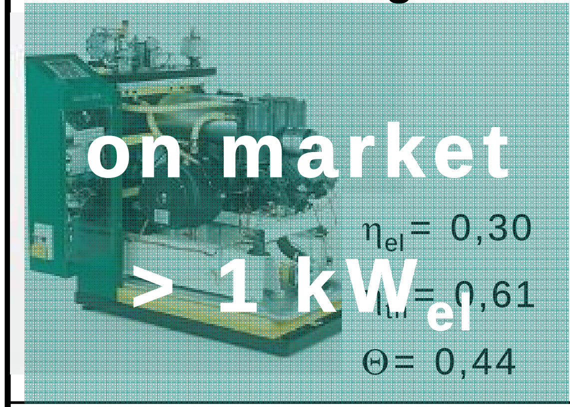
- ~1980: Type testing of small scale biomass boilers initiiates increase in efficiency and reduction of emissions
- 1980ies: Automatic wood chip boilers
- After 1996: Automatic pellets boilers
- 2000s: Emission reduction (above all PM10)
- 2010s: Increase of annual efficiencies
- 2020ies: Biomass micro CHP



State of development

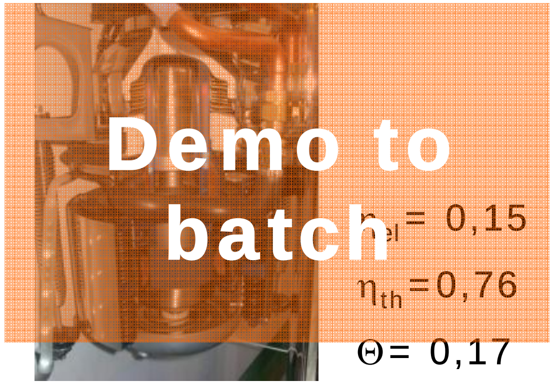
Company information

Combustion engine



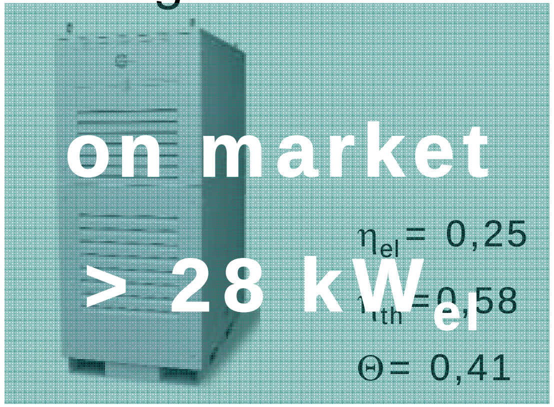
η_{el} = 0,30
η_{th} = 0,61
Θ = 0,44

Stirling engine



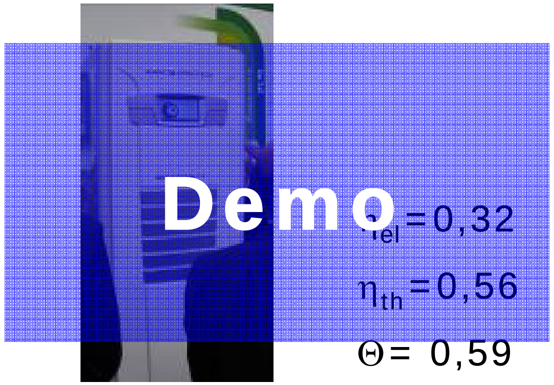
η_{el} = 0,15
η_{th} = 0,76
Θ = 0,17

Micro gas turbine



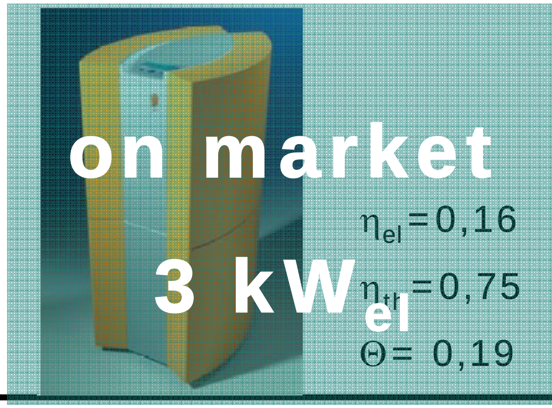
η_{el} = 0,25
η_{th} = 0,58
Θ = 0,41

Fuel cell



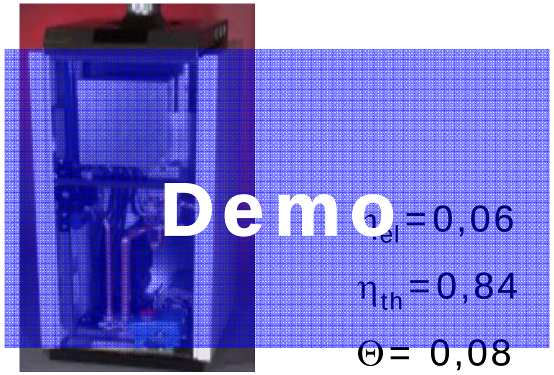
η_{el} = 0,32
η_{th} = 0,56
Θ = 0,59

Steam cycle



η_{el} = 0,16
η_{th} = 0,75
Θ = 0,19

ORC process



η_{el} = 0,06
η_{th} = 0,84
Θ = 0,08

$\Theta = P_{el}/Q_{th}$ Stromkennzahl

Sources: Company infos

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Biomass micro CHP

- For solid biomass micro CHP with external combustion
  - Steam engine
  - ORC
  - Stirling
  - Thermoelectric generators

R&D demand
for technology development

- Liquid biofuels for
  - ✓ (Diesel-) engines
- (Virtual) biogas for
  - ✓ Gas Otto engines
  - ✓ Micro gas turbines
  - Fuel cells

Arguments for micro CHP

- Decentralized production for decentralized utilization
- Production of electricity during periods of high heat demand and low offer of other renewables:
  - During winter
  - Whilst twilight
  - During times without sun and wind
- Mass production reduces production costs
- Integration into existing infrastructure
  - Closed heating room (cellar) or living room
  - Pellets or log wood boiler
- Increase of efficiency of the energy system

Recent R&D activities

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TECHNOLOGY INDEPENDENT

- Derivation of the state of the art of micro CHP systems in the frame of the development of a model for the future utilization of micro CHP systems
- Development of a standardized methode for the assessment of efficiency and dynamic behaviour of micro CHPs
- Monitoring of fieldtest installations

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Recent R&D activities

References of BIOENERGY 2020+

TECHNOLOGY SPECIFIC

- Swinging piston technology:
  - Monitoring of a pellets fired micro CHP
- Thermoelectric electricity production:
  - Integration of thermoelectric generators into small scale biomass (pellets) combustion systems
- Stirling engine:
  - Heat transfer from biomass combustion to nitrogen cycle of Stirling process
  - Integration of a 4 cylinder Stirling engine into a biomass CHP
- Plant oil CHP unit:
  - Assessment of the state of development of a novel working machine

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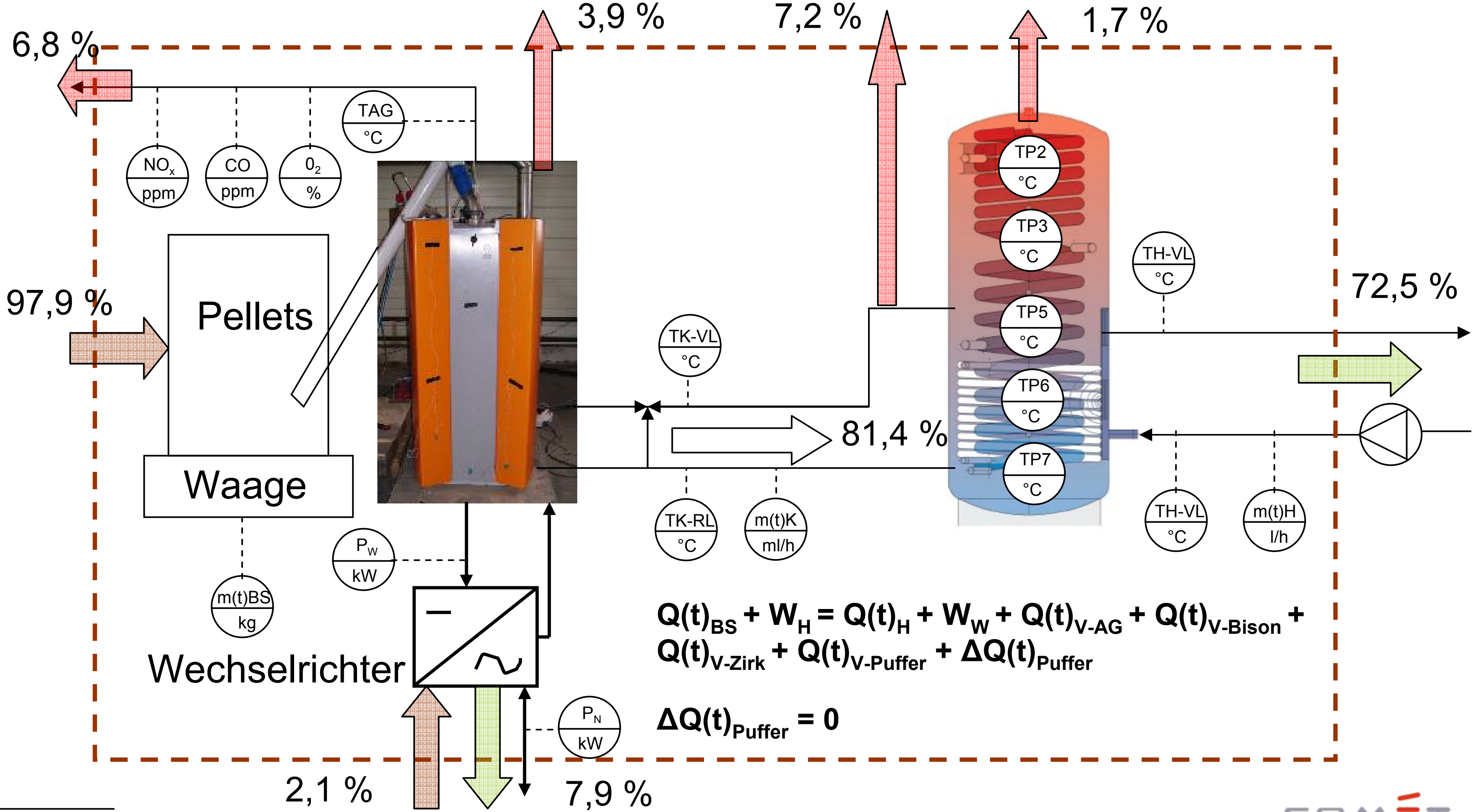
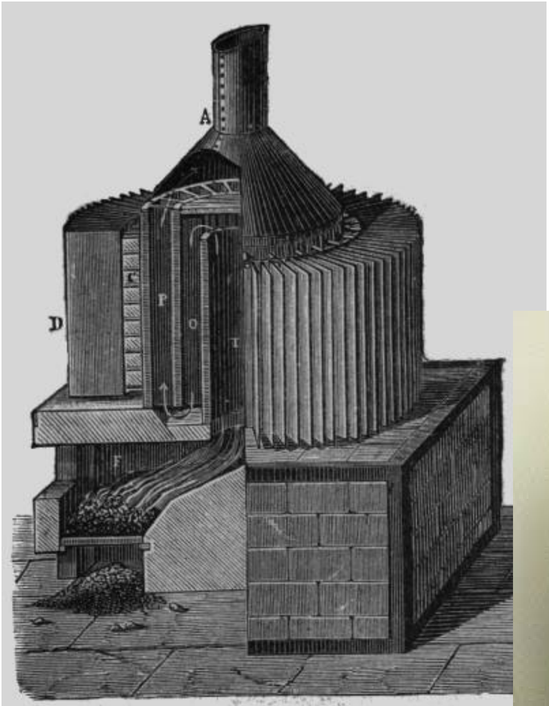
Swinging piston – pellets fired micro scale CHP



$$Q(t)_{BS} + W_H = Q(t)_H + W_W + Q(t)_{V\text{-}AG} + Q(t)_{V\text{-}Bison} + Q(t)_{V\text{-}Zirk} + Q(t)_{V\text{-}Puffer} + \Delta Q(t)_{Puffer}$$

$$\Delta Q(t)_{Puffer} = 0$$

Historical applications of thermogenerators



1879

1925

1951

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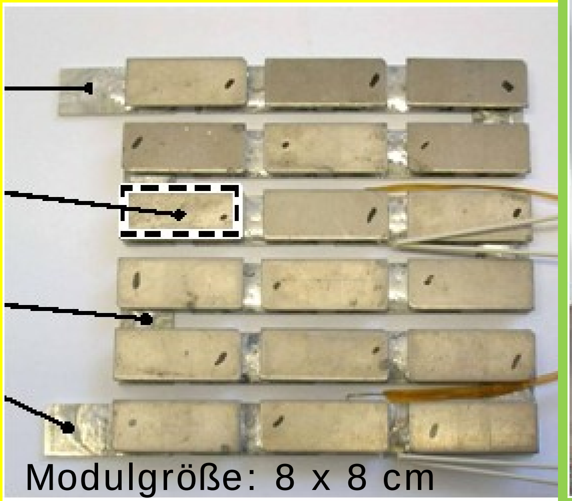
Pellets boiler with thermogenerator
Prototype

Fuel heat output:	10 kW
Nominal electric power:	200 - 400 W

Thermoelectric module



Thermogenerator

Micro CHP prototype

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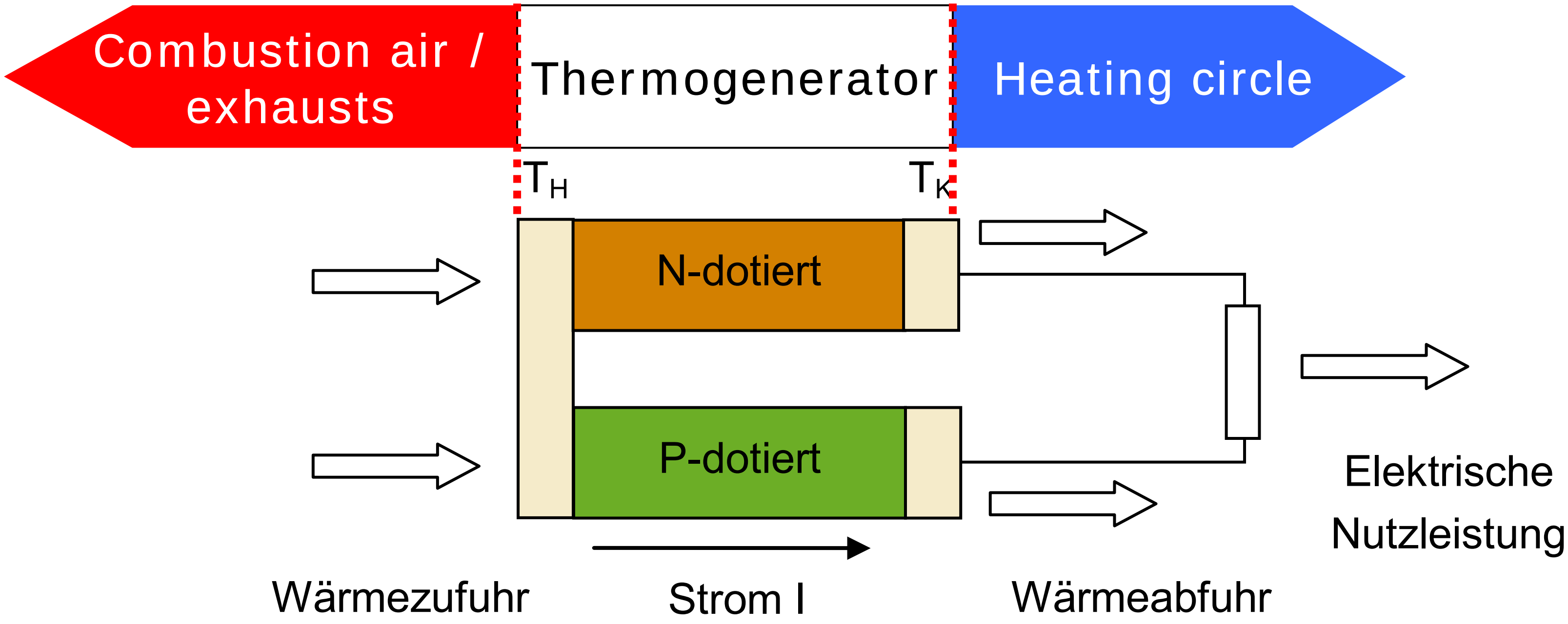
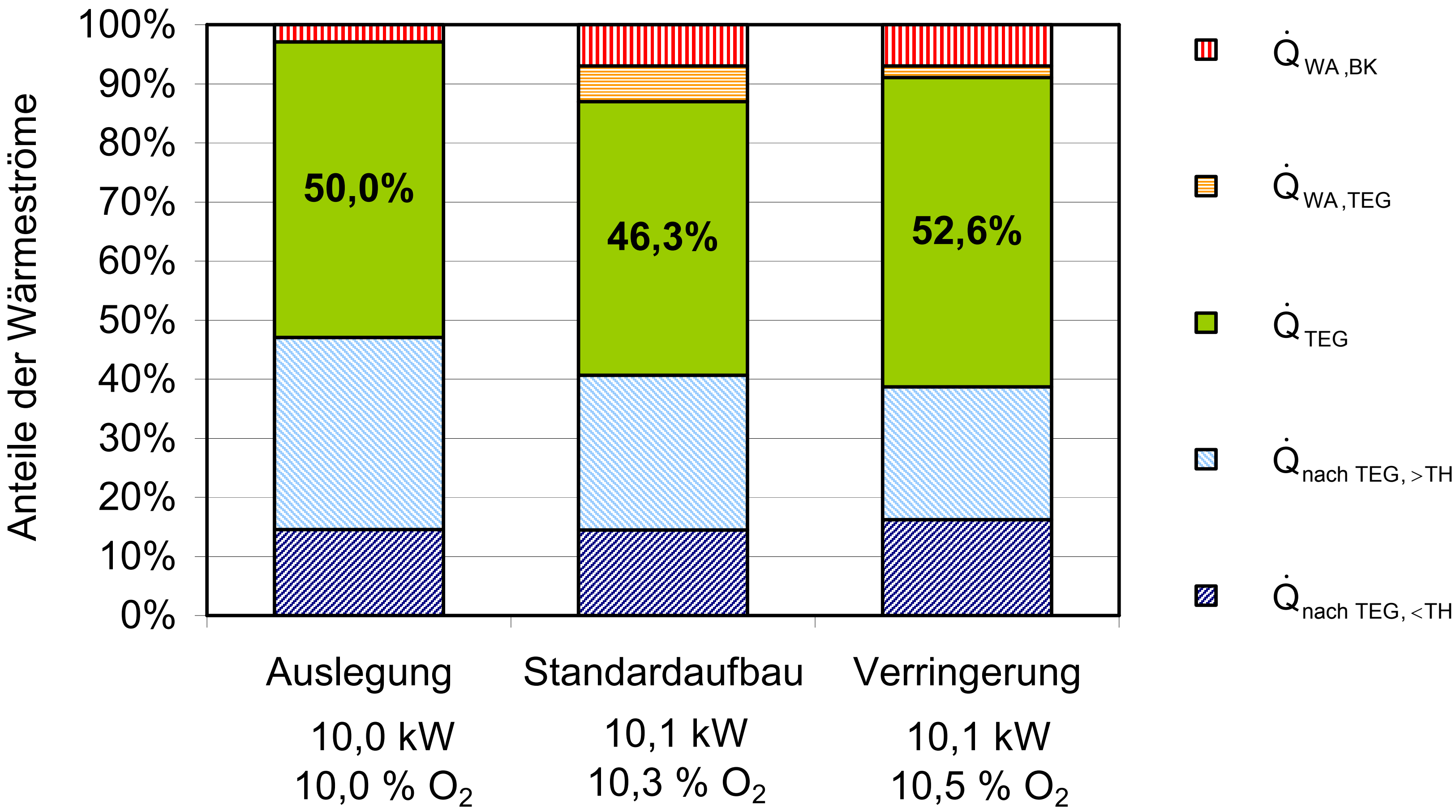
Principle of thermoelectric electricity production



Integration of the thermogenerator

1. <u>Heat exchange</u>
   - Share of heat flow passing the generator
   - Constant and defined heat flow
   - Constant and defined hot and cold side temperatures
   - Even temperature distribution
2. <u>Material durability</u>
   - Temperature durability
   - Corrosion
3. <u>Operational reliability</u>
   - Fouling
   - Breakdown / malfunction of electricity generating technology
4. <u>Costs</u>

Share of heat flow passing generator



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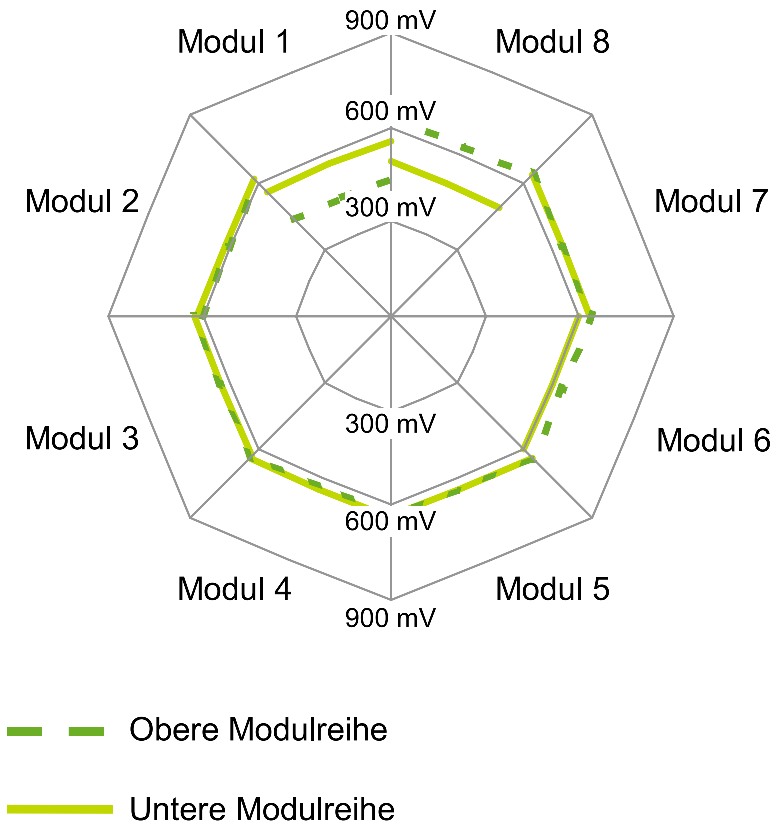
Uniformity of temperature distribution



R&D results:

Temperature level on hot side
250 °C → ΔT < 10 K

Temperature level on hot side
400°C → ΔT < 15 K

in both cases no fouling / depostion problems observed

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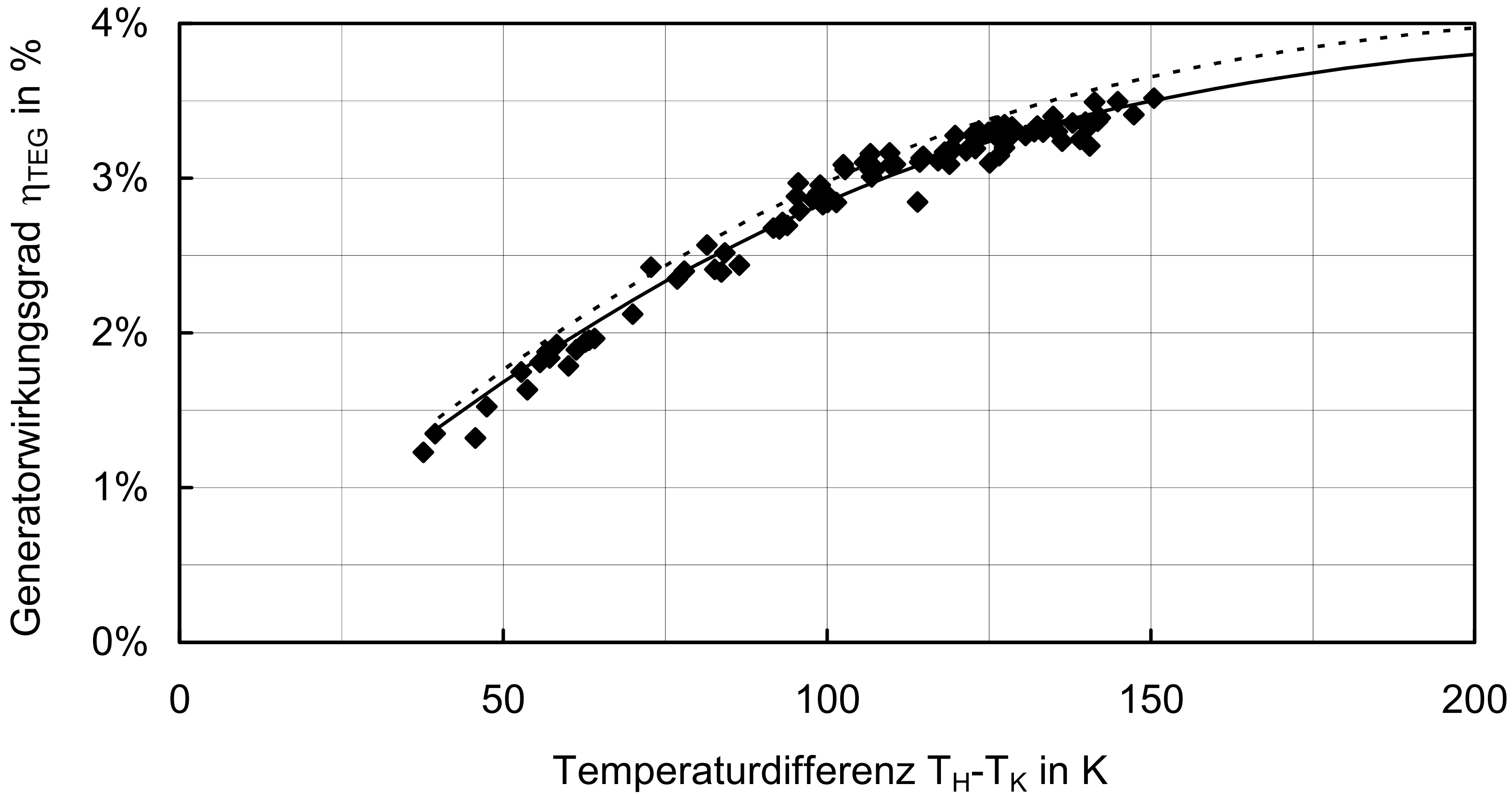
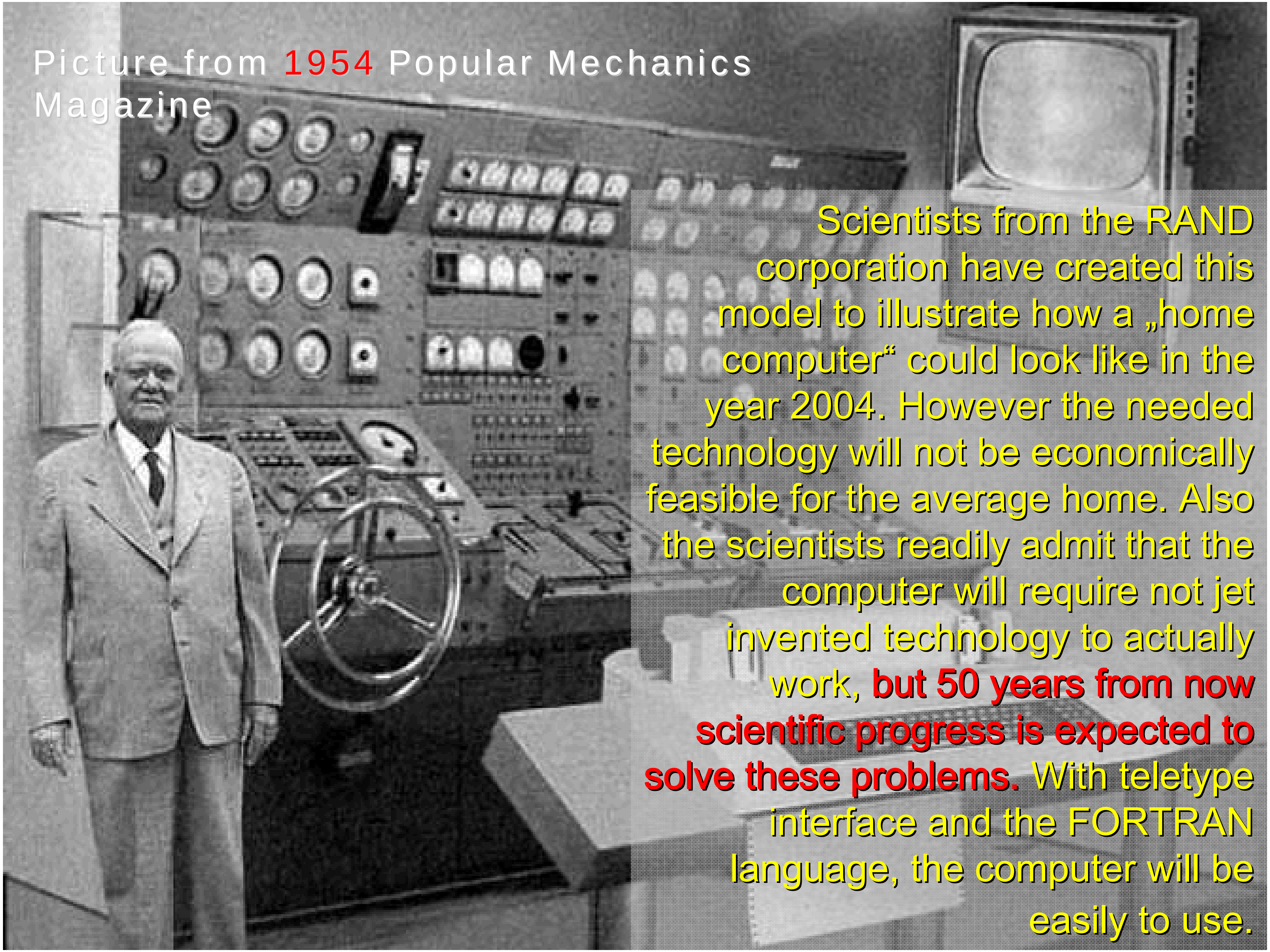
Testing results of generator efficiency



Picture from 1954 Popular Mechanics Magazine



Scientists from the RAND corporation have created this model to illustrate how a „home computer“ could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not jet invented technology to actually work, **but 50 years from now scientific progress is expected to solve these problems.** With teletype interface and the FORTRAN language, the computer will be easily to use.

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ACKNOWLEDGEMENT

The results of the presented R&D projects have been derived in the frame of the *Kplus*-rogram and have been financially supported by the Federal Ministry of Innovation, the provinces of Styria and Lower Austria and the City of Graz.

We would further like to thank our company partners

HET, KWB, RIKA, Schrödl, SHT, Viessmann, and Button Energy

the scientific partners Vienna University of Technology and HBLFA Francisco Josephinum and the partners

TEC COM and DLR.

FFG
RIKA
SHT Heiztechnik aus Salzburg
VIESSMANN
TU VIENNA Technische Universität Wien Vienna University of Technology
F J BLT WIESELBURG
TEC COM
DLR
HET ENERGIETECHNIK
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Thank you for your attention!
Mille grazie per la sua attenzione!

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