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Next Generation Pellet Combustion with Thermoelectric Power Generation

Expert Workshop IEA Task 32 and Task 33:
Small scale biomass co-generation –
Technology status and market opportunities

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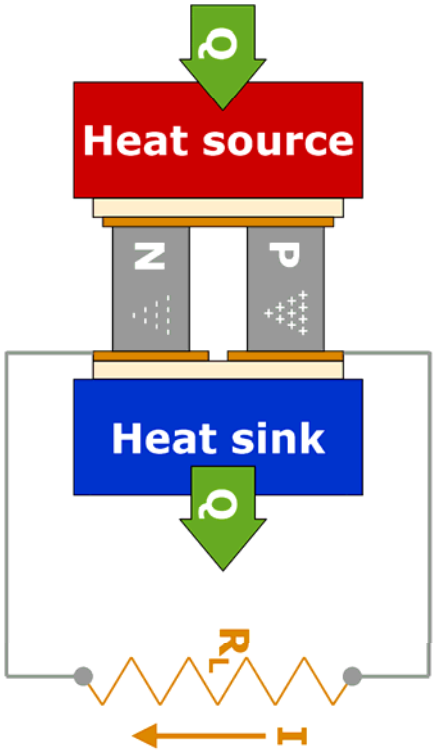
- Operation Principle and Idea
- Efficiencies & Maturity Status of the Technology
- Experience with Biomass
- Application Market & Economics
- Future Outlook

Operation Principle of Thermoelectric Power Generation

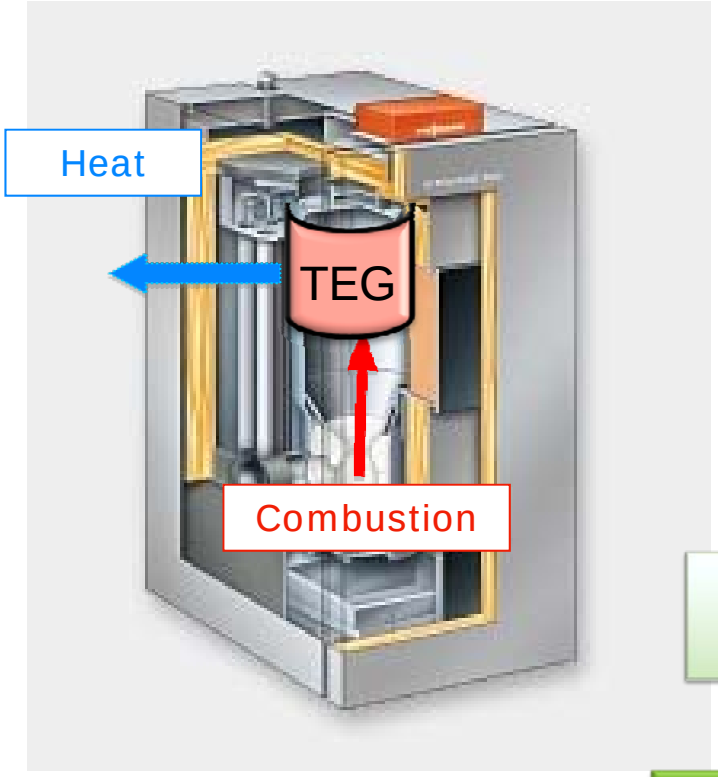


Principle of TE Power Generation

- Direct Energy Conversion
- No Moving Parts
- No Working Fluids
- Maintenance-free Durability
- Noiseless Operation

Predestined for Micro-Scale CHP Based on Biomass

Idea – Integration of a Thermoelectric Generator (TEG) into a Biomass Furnace



Combustion Unit from Viessman

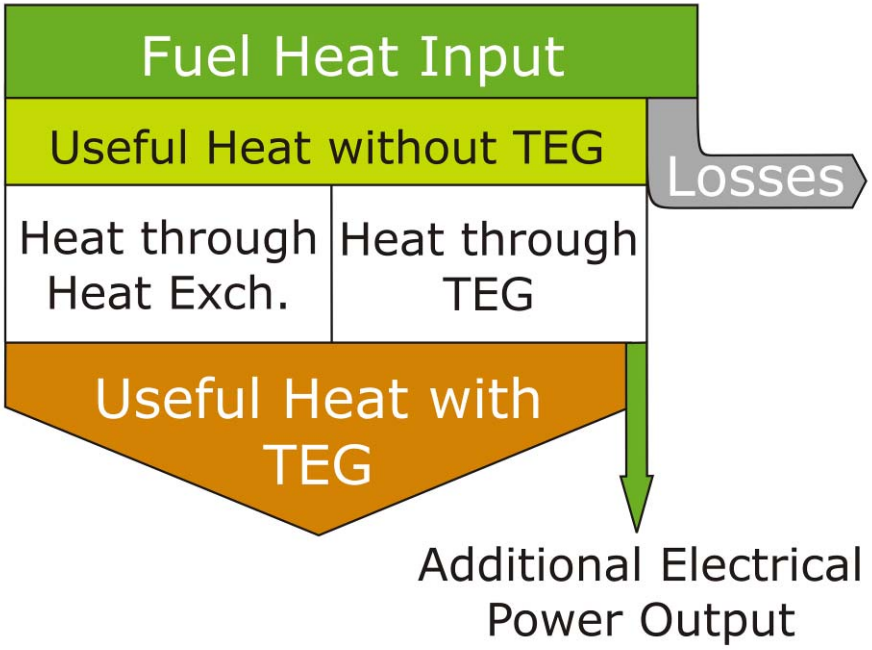
Hot combustion gases = Heat source for thermoelectric power generation

TEG Cooling Water or Air = Heat for domestic use

Micro Heating System → Micro CHP System

→ **Grid Independent Operation**

Thermal Efficiency of a micro-scale CHP with TEG



- **Maximising Heat Flow through TEG**
- **High Temperatures on Small Surfaces**
- **Maximum Efficiency of the TEG**

Efficiency and Maturity Status of TE Power Generation

Industrial available TEGs from Cooling Technology:

- Bismuth Telluride with maximum Efficiency 5-6 %
- Allowed Temperatures up to 250 °C

(Still) Under Development – Materials and Technology for higher Temperatures:

- Our Aim: 10 % with Temperatures up to 400 °C
- Published 15-18 % with higher Temperatures

First Prototype with TEG 250

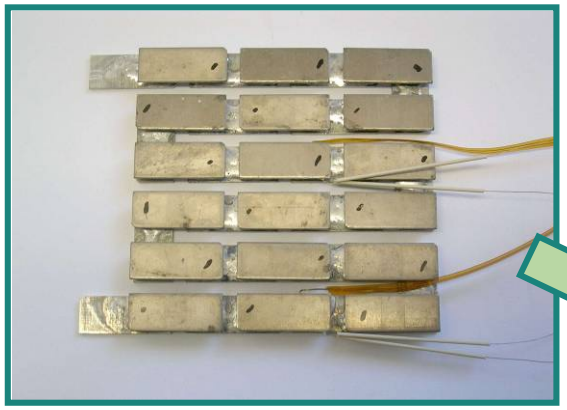
Design

- Thermoelectric Material: Bismuth Telluride
- Hot-side Temperature: 250 °C
- Cold-side Temperature: 60 °C

Target Values

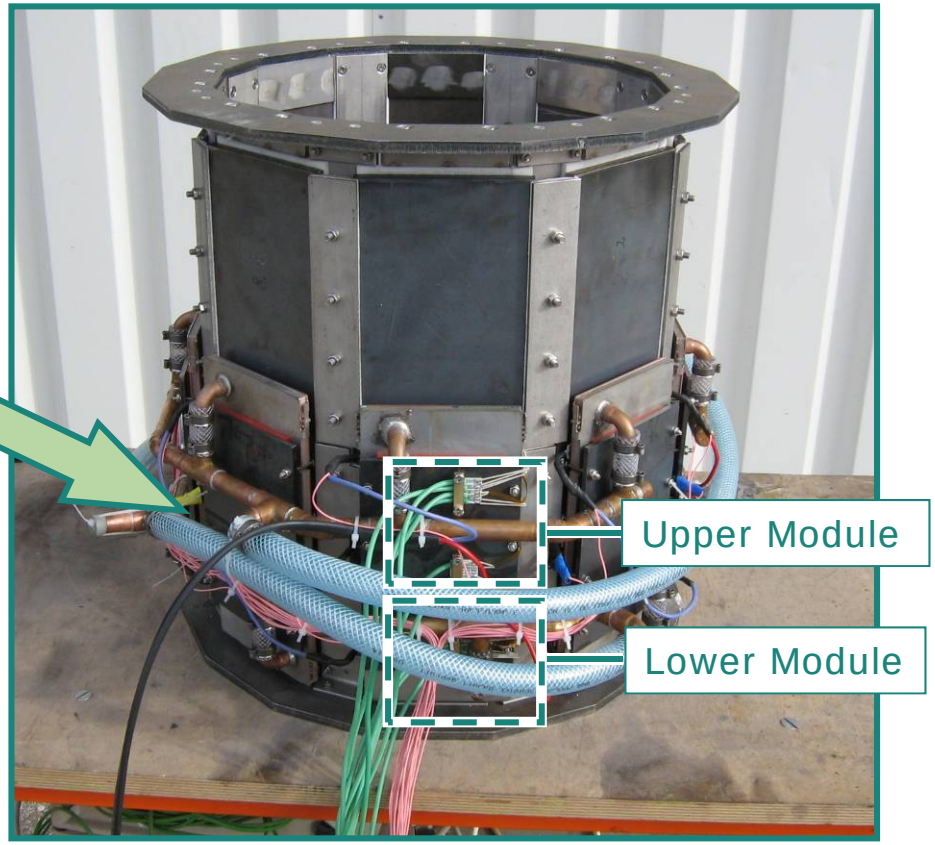
- Heat Input: 5 kW out of 10 kW
- Electrical Efficiency TEG: 4 %
- Nominal Electrical Power: 200 W
- Electrical Efficiency CHP: 2 %

Prototype TEG 250



Design

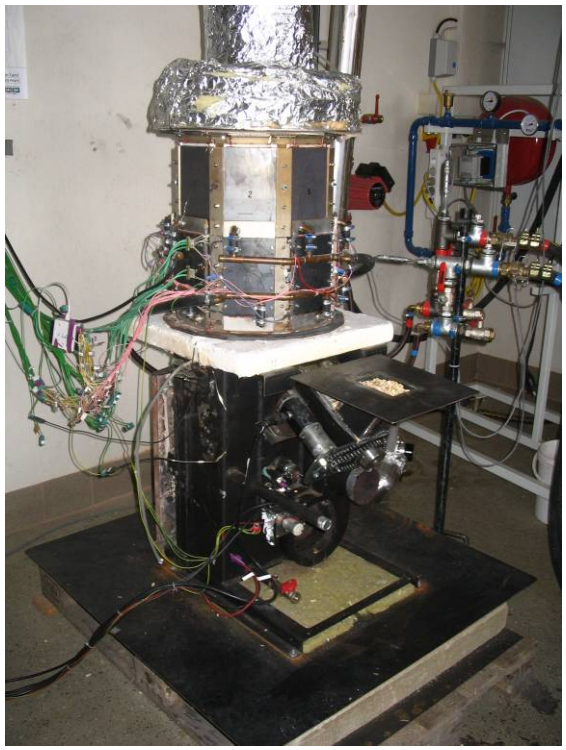
- 8 plates, each with 2 modules
- Positioned around flame
- Heated from inside, cooled from outside



Generator and Modules developed in cooperation with TECCOM

First Prototype with TEG 250

Boiler with TEG 250
10 kW_{th}, 200 W_{el}

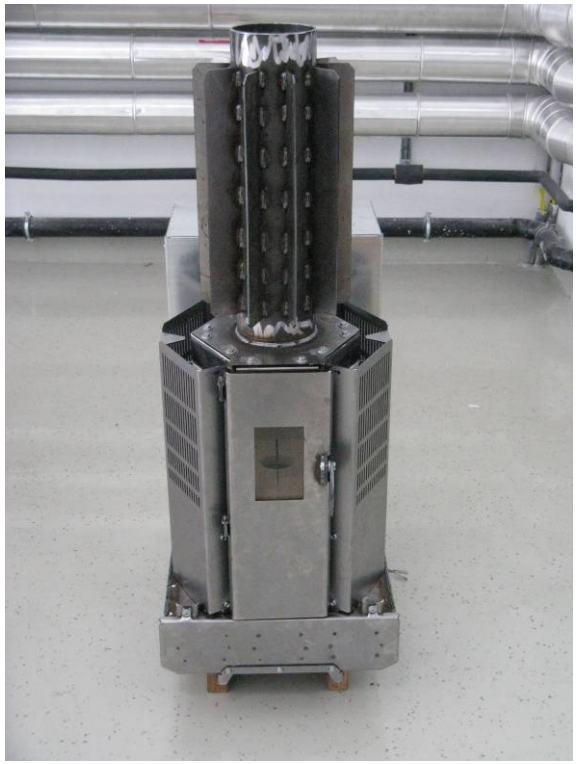


Results	Target	Achieved
Useful Heat Extraction	50 %	> 50 %
Generator Efficiency	4%	3,5 %
Electrical Efficiency	2 %	1,7 %
Electric Power	200 W	170 W

→ Potential for grid independent operation confirmed

Prototypes planned for use of TEG 400 – Operation with “Thermal Models”

Stove with TEG 400
Max: 8 kW_{th}, 100 W_{el}



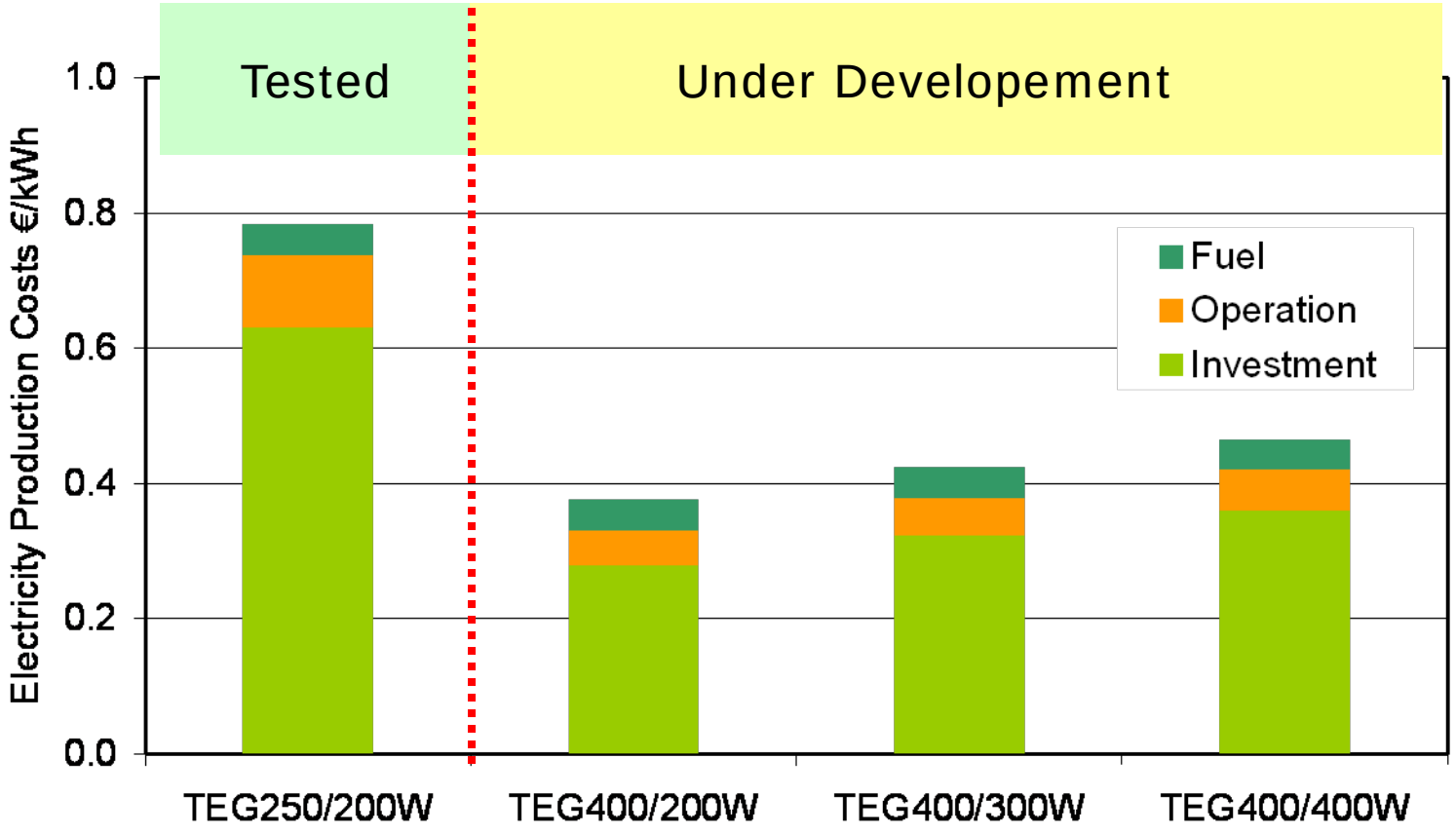
Boiler with TEG 400
Max: 12 kW_{th}, 300 W_{el}

Application Market

- Every established **Market for Automatic Pellet Furnaces**, especially Small Scale Combustion Units for End-Users

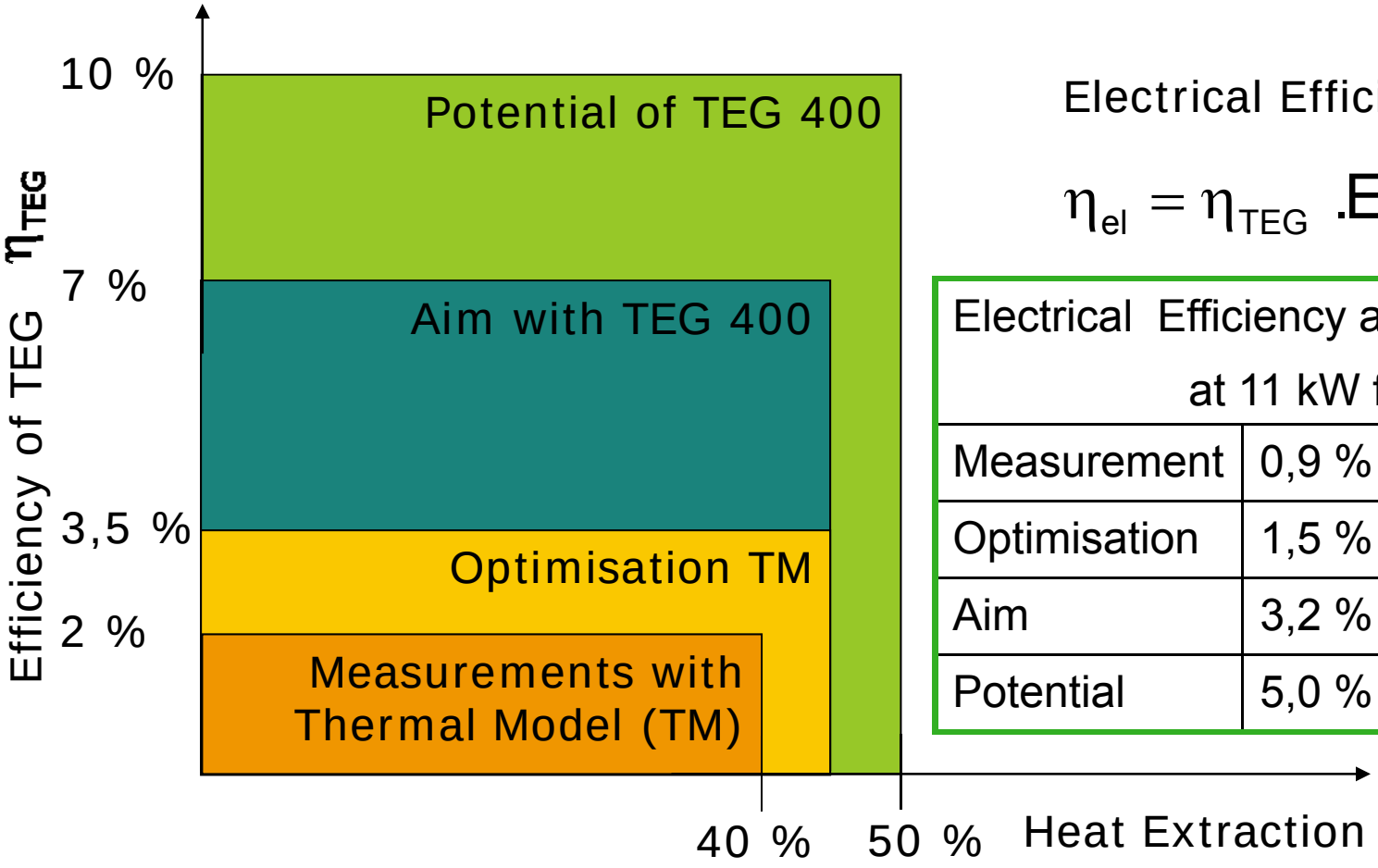
- Great Chance for **East of Europe and North-America** because of unreliable Electric Power Grids

Economics



Assumed 9 kW Heat Output for Calculation

Potential of Pellet Combustion with Thermoelectric Power Generation



Electrical Efficiency

$$\eta_{el} = \eta_{TEG} \cdot E_{HEAT}$$

Electrical Efficiency and Power at 11 kW fuel heat input		
Measurement	0,9 %	100 W
Optimisation	1,5 %	170 W
Aim	3,2 %	300-350 W
Potential	5,0 %	380-550 W

Areas correspond to total electrical efficiency

Vision – Grid Independent Operation and...

- Decentralized production for decentralized utilization
- Production of electricity during periods of high heat demand and low offer of other renewable electricity
- Mass production reduces production costs
- Integration into existing infrastructure
- Increase of efficiency of the energy system

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Thank you for your Attention!

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