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External superheating in biomass power plants with pebble bed regenerators

Robert Daschner
Fraunhofer UMSICHT

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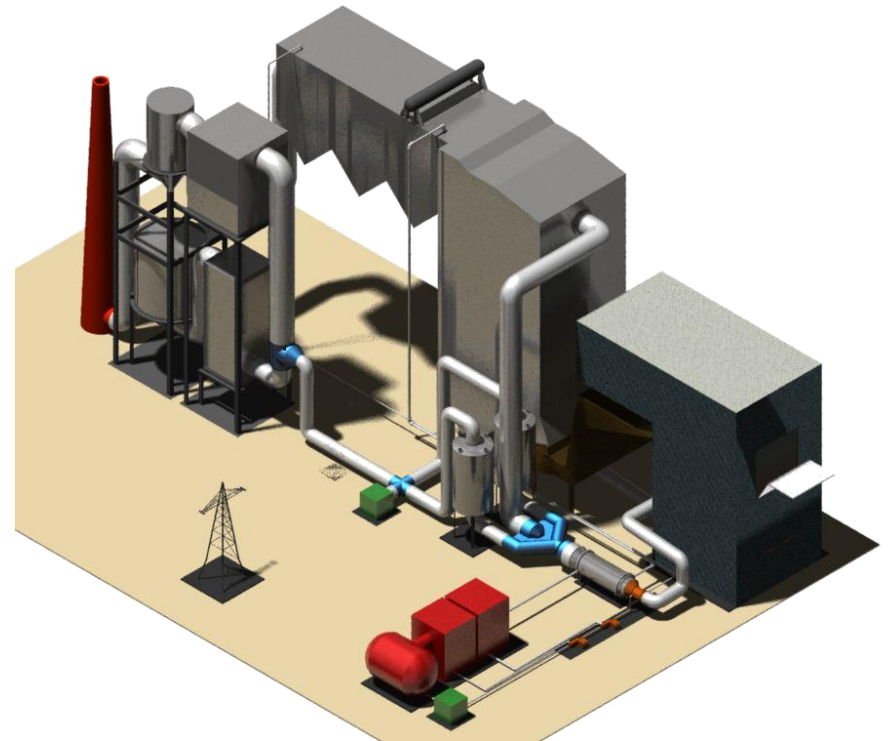
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**EXTERNAL SUPERHEATING
IN BIOMASS POWER PLANTS
WITH PEBBLE BED
REGENERATOR**



Robert Daschner

OUTLINE

1. Background
2. Principle
3. Pebble Bed Regenerator
4. Thermodynamic Model
5. Results
6. Conclusion and Outlook

Our motivation ...



Energy conversion and storage



Raw- and functional materials

External Superheating in Biomass Power Plants

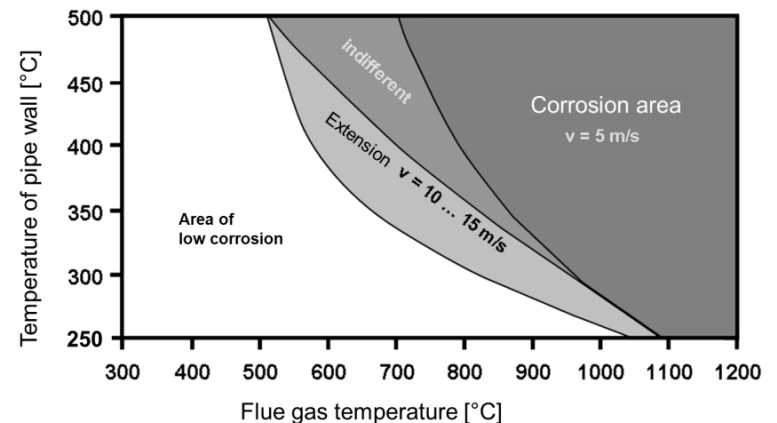
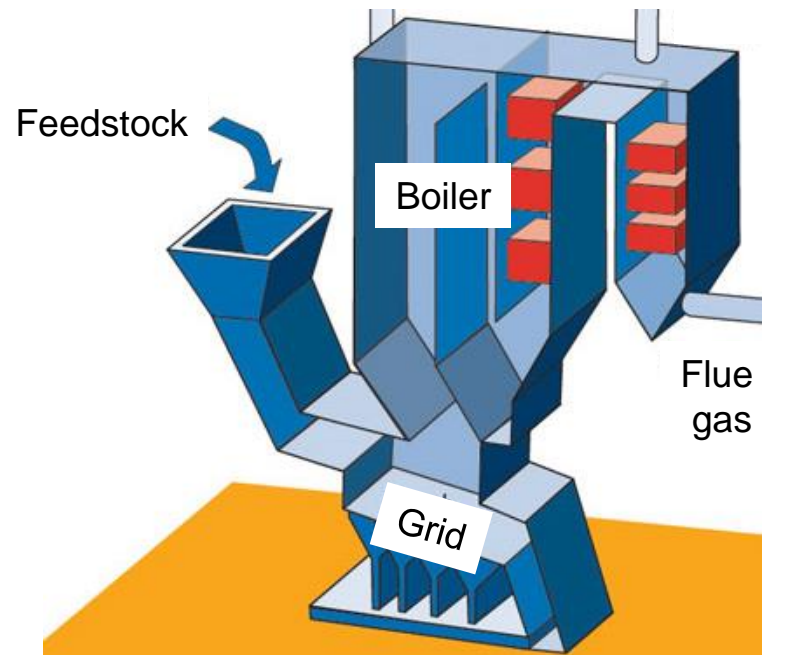
Background – Biomass power plant



External Superheating in Biomass Power Plants

Background

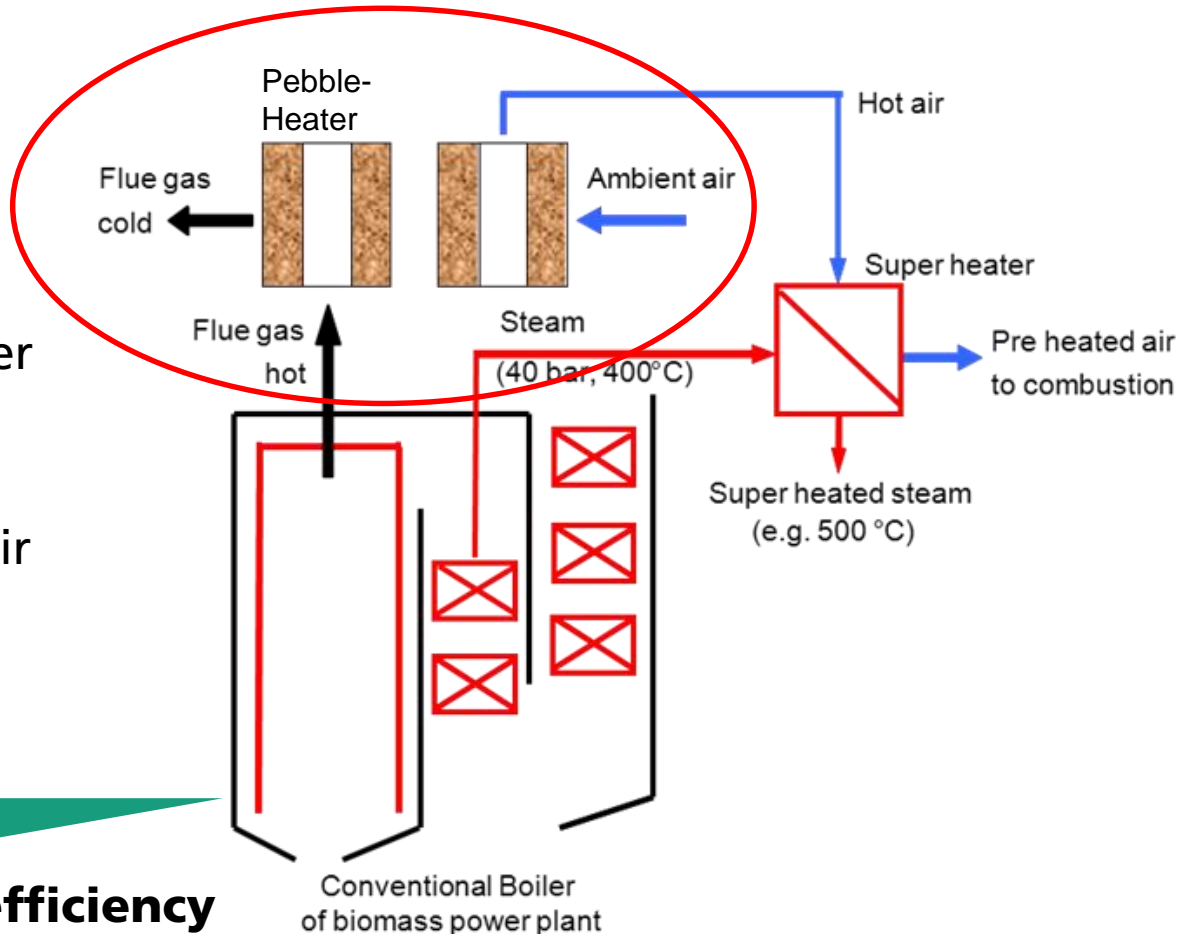
- Considered fuels:
biomass (except wood), domestic waste, sewage sludge, RDF
- Limited efficiency due to corrosion
- High temperature chloride corrosion:
Limited steam parameters of
 - ca. 450 °C at 50-70 bars (Biomass)
 - ca. 400 °C at 40 bar (WtE)
- Still high costs for maintenance due to corrosion effects



External Superheating in Biomass Power Plants

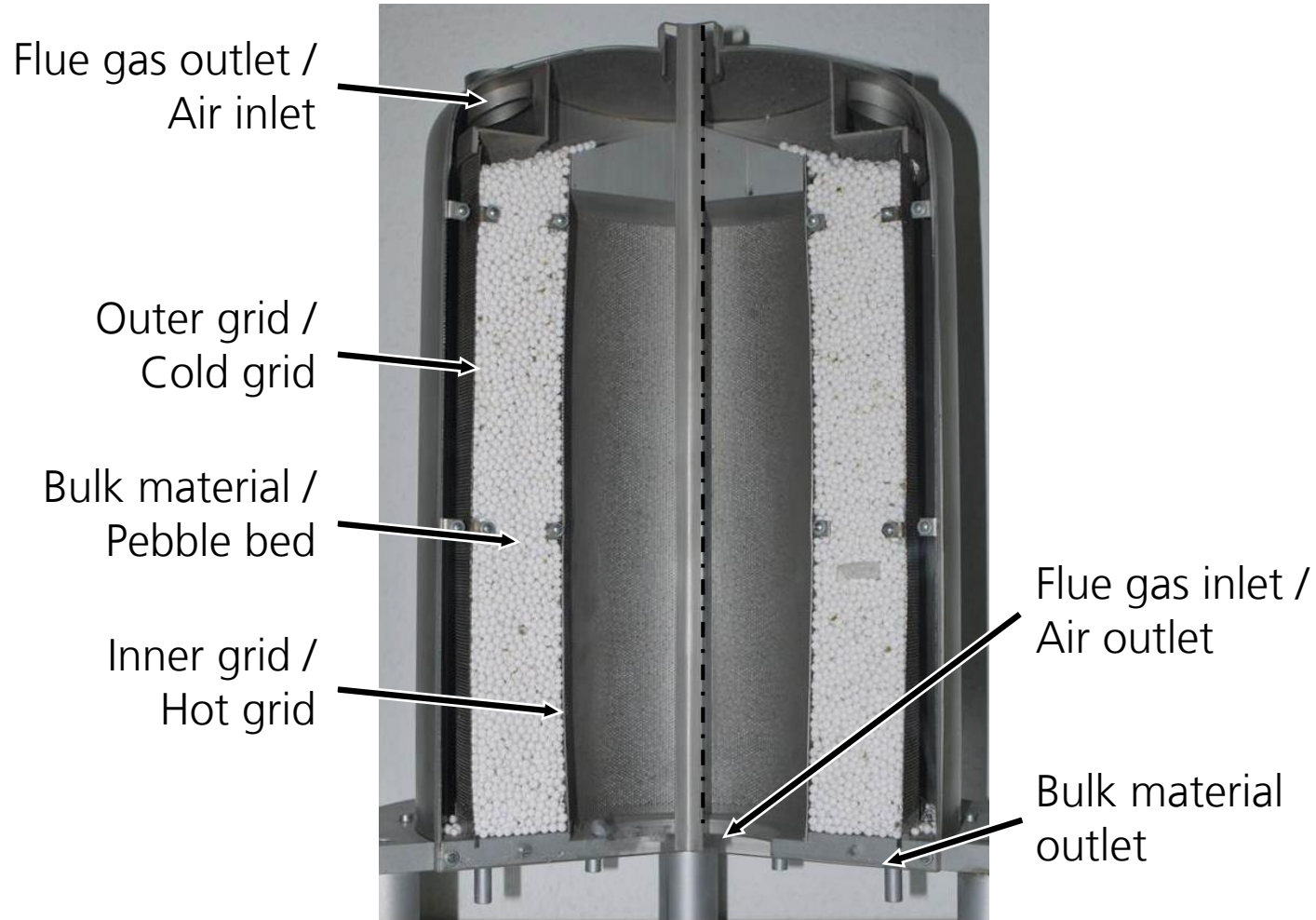
Principle

- Diversion of hot flue gas out of the boiler (ca. 700 – 800 °C)
- Regenerative heat transfer to ambient air
- Superheating of steam with the generated hot air
- Reduction of corrosion problematic in the air/steam superheater

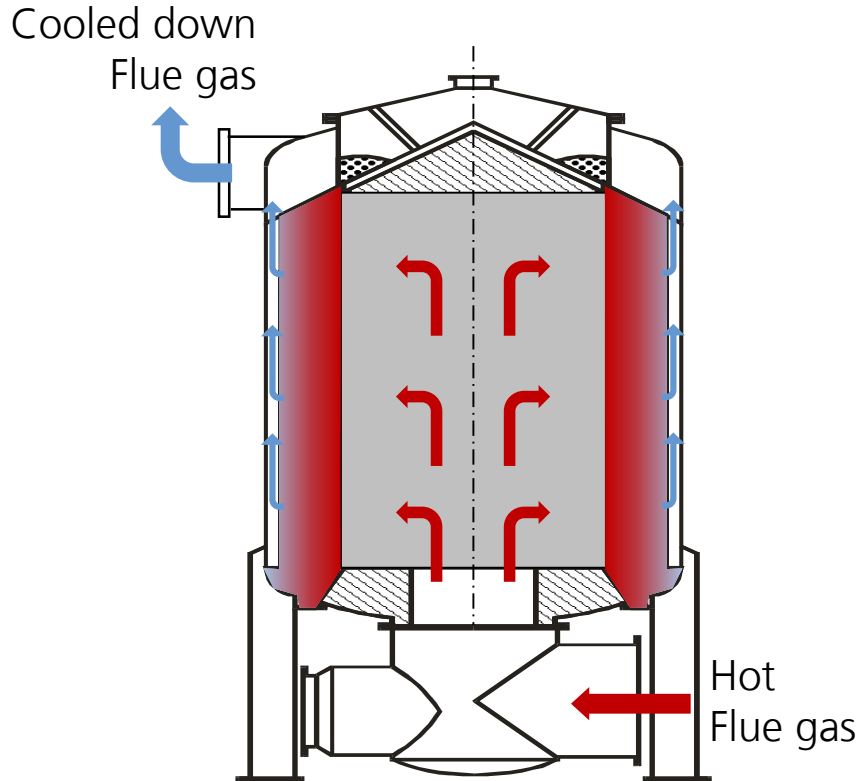


**Increase in electrical efficiency
and flexibility**

Pebble Bed Regenerator – Pebble-Heater Set-Up

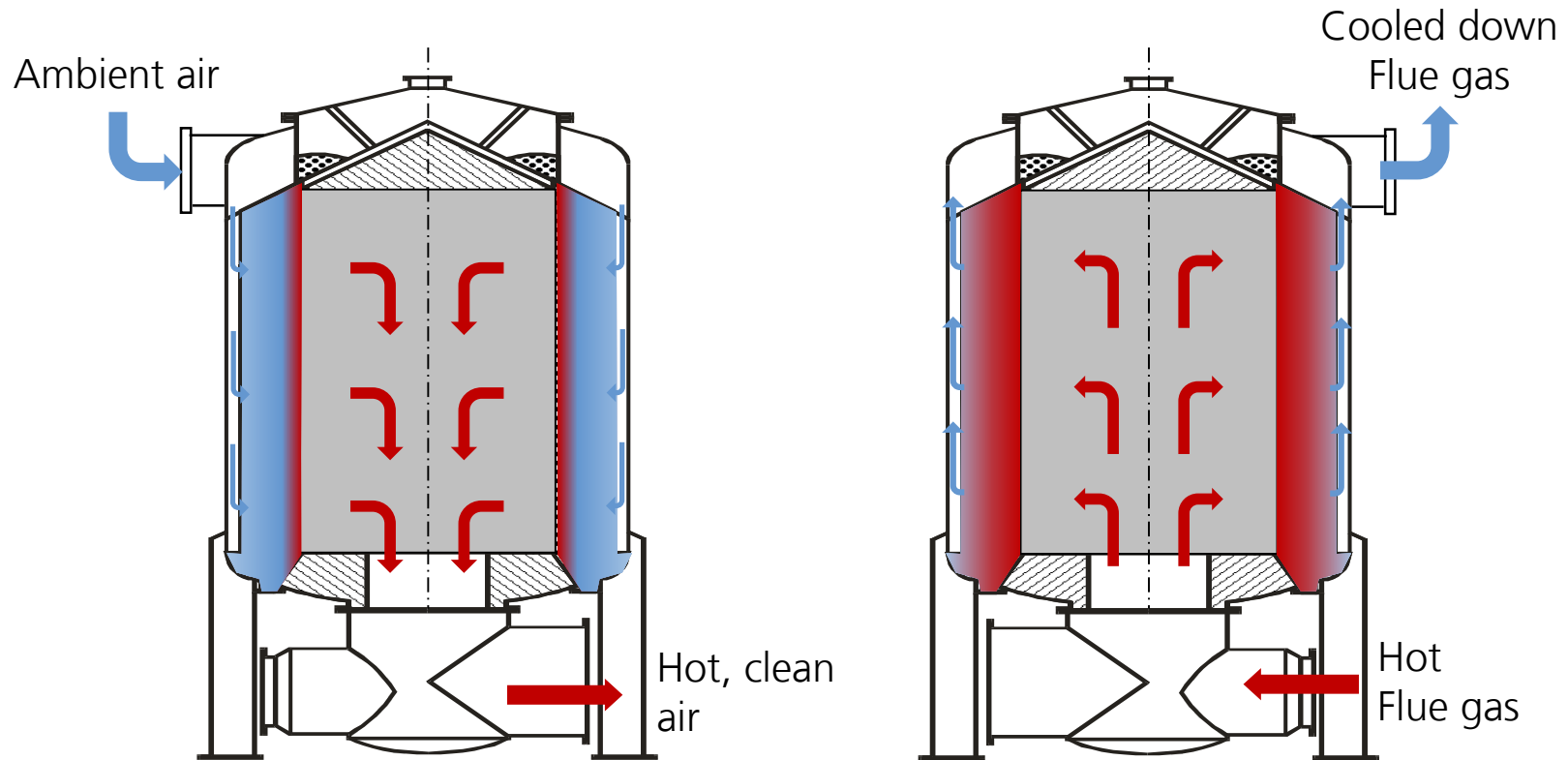


Pebble Bed Regenerator – Pebble-Heater Functionality



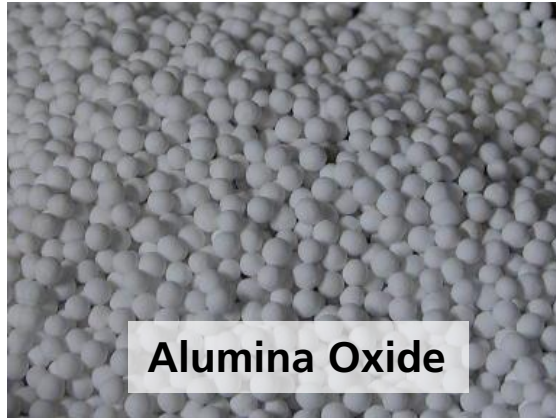
Pebble Bed Regenerator – Pebble-Heater

Functionality



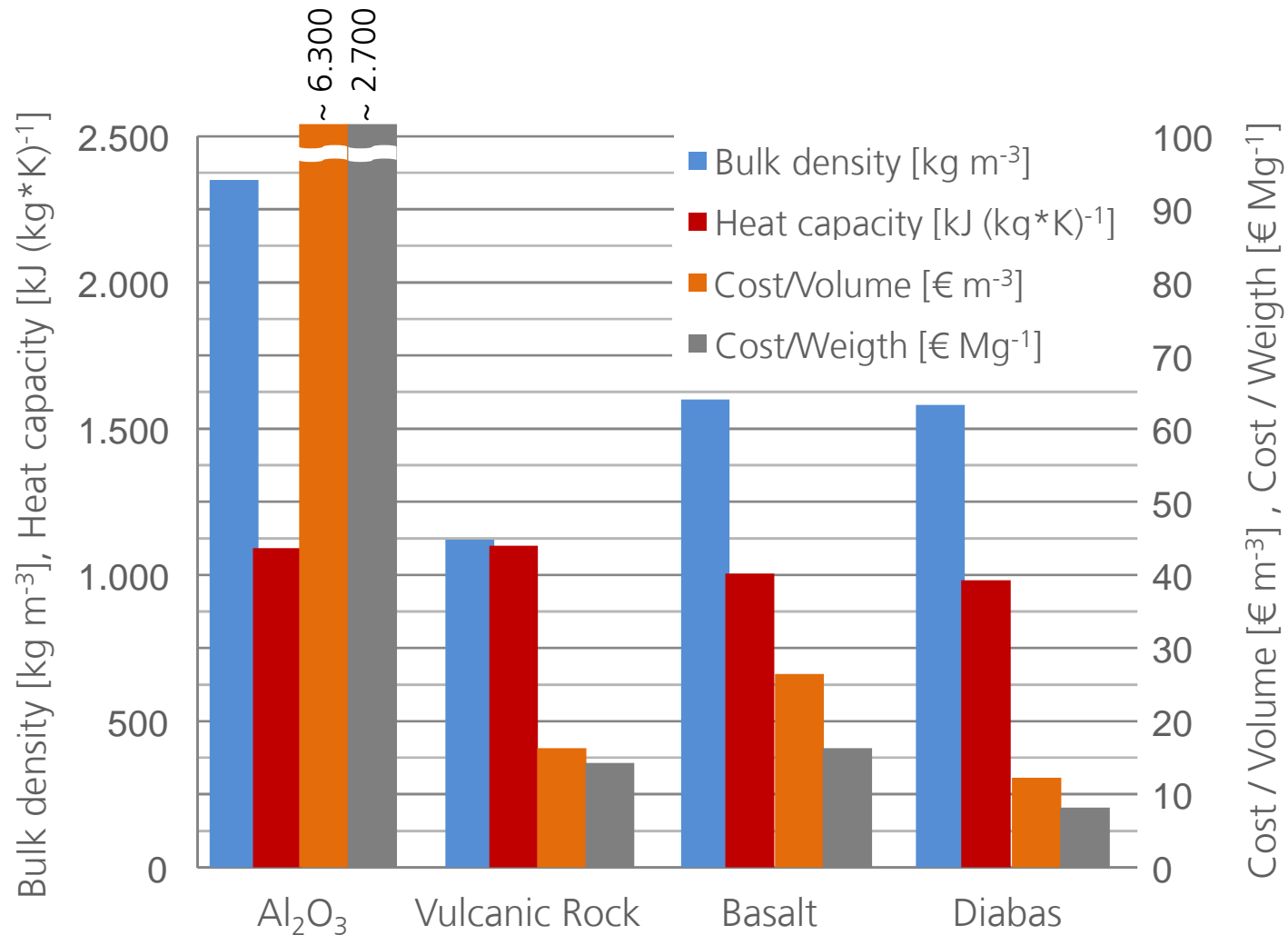
Pebble Bed Regenerator – Pebble-Heater

Bulk Materials – Overview



Pebble Bed Regenerator – Pebble-Heater

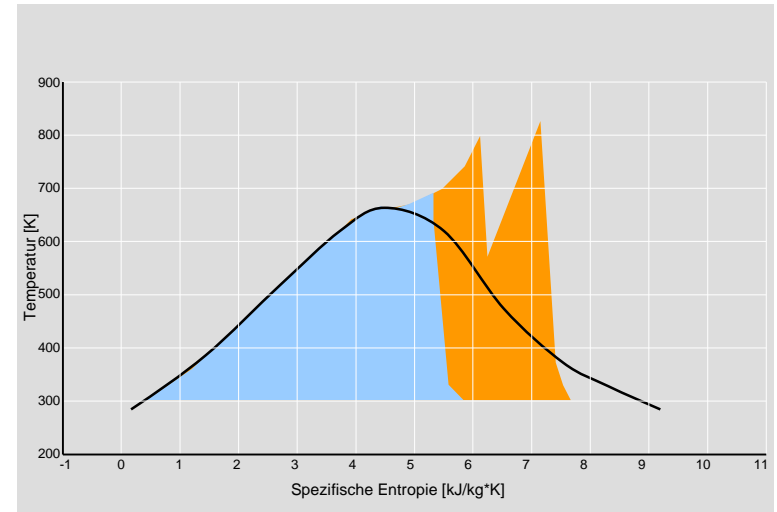
Bulk Materials – Physical conditions and prices



Thermodynamic Model

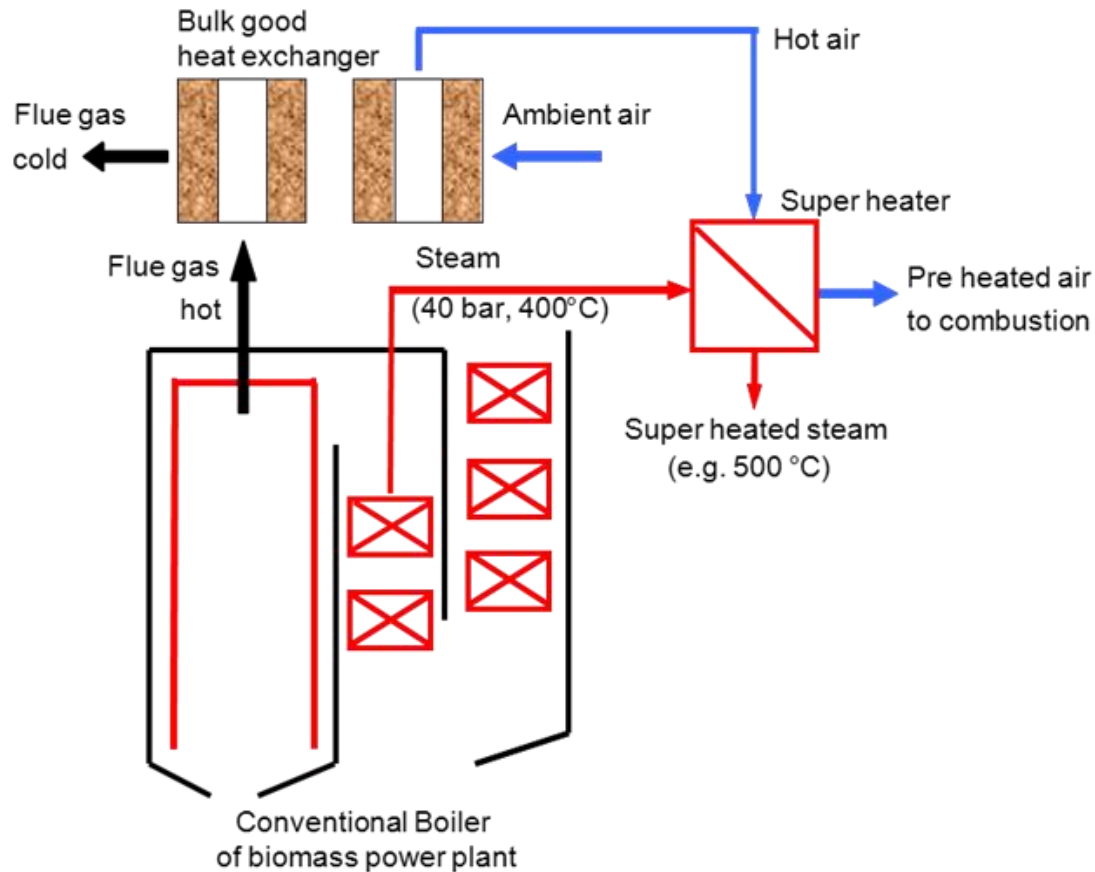
Goals of thermodynamic simulation

- Thermodynamic dimensioning of the process
 - Design for superheater
 - Turbine characterisation due to changed steam parameters
- ▶ **Increase of energy efficiency due to higher steam parameters**



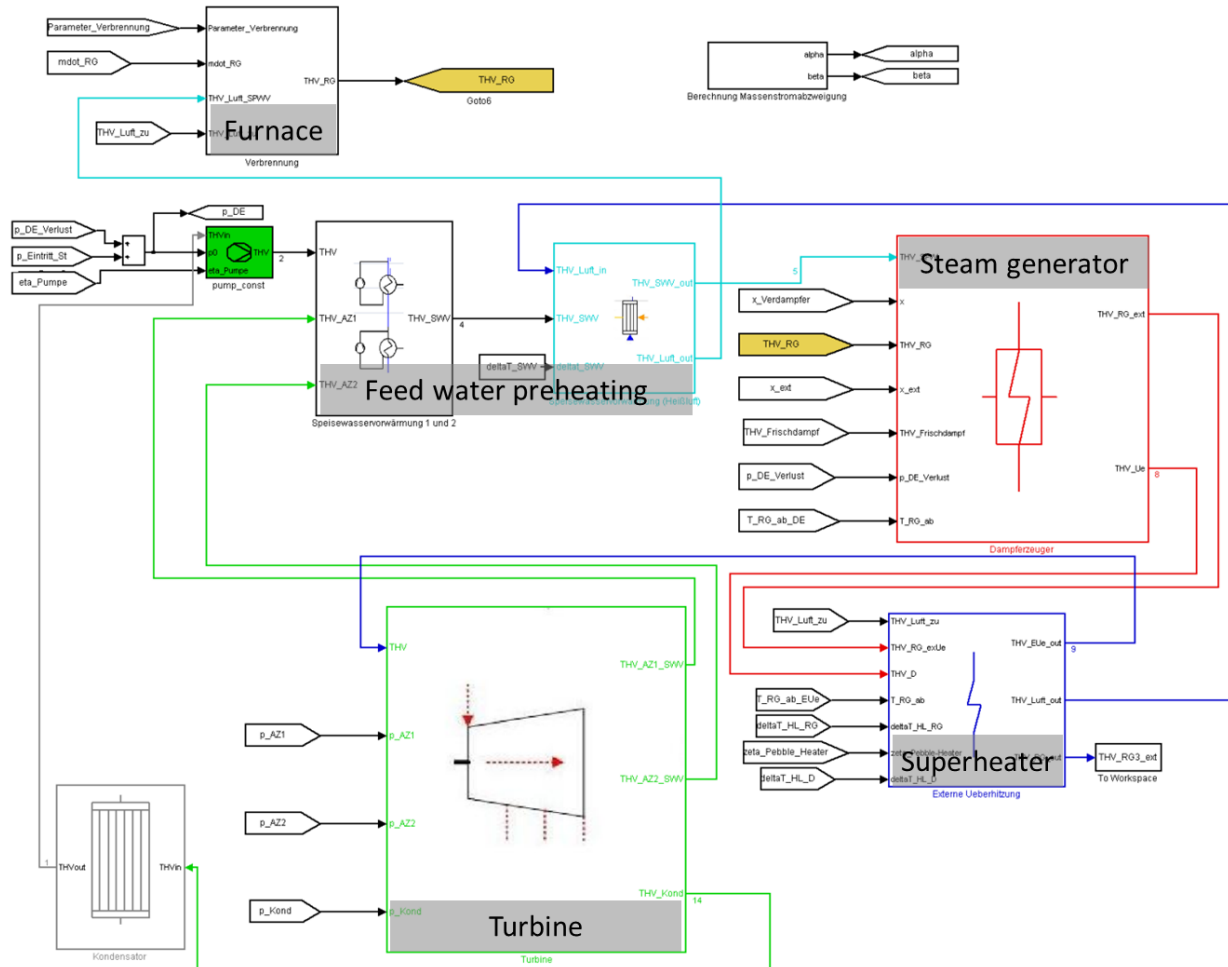
Thermodynamic Model

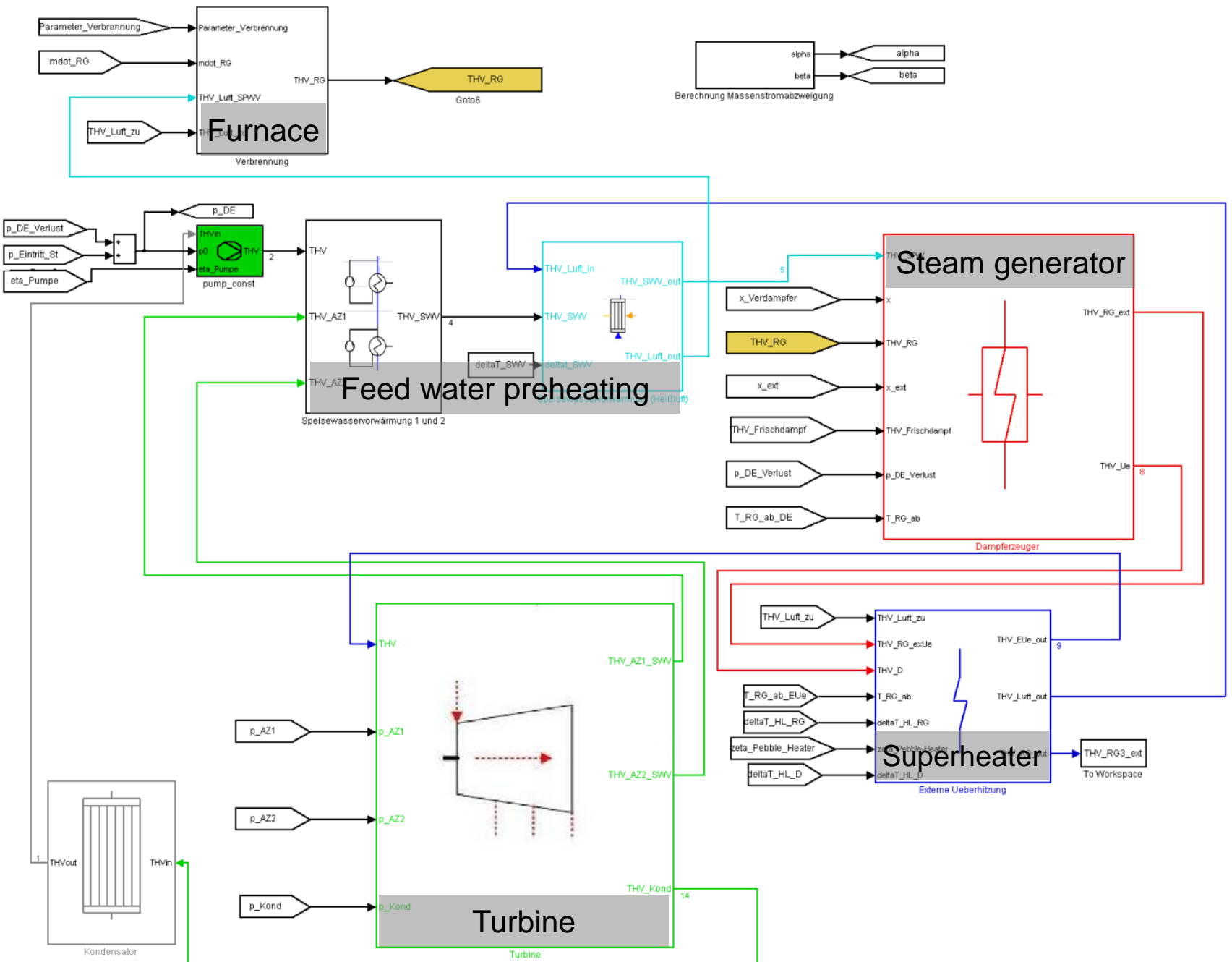
Implementation in Matlab®Simulink



Thermodynamic Model

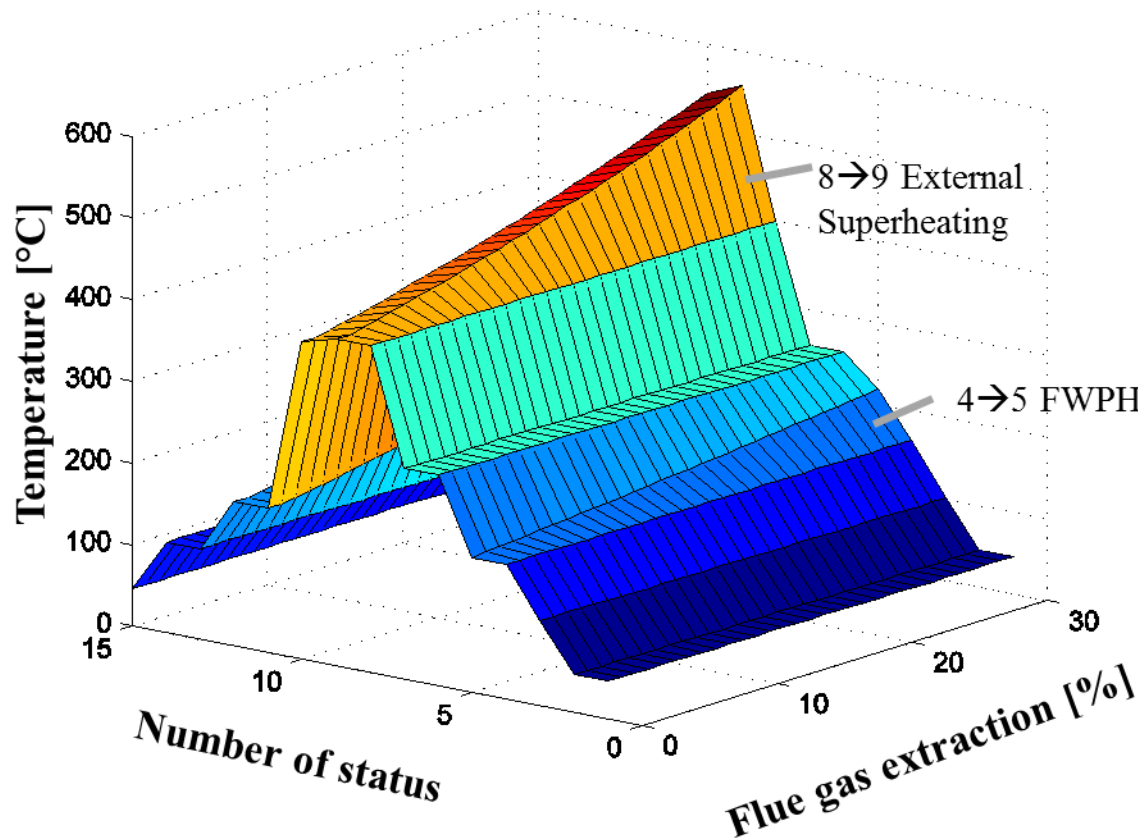
Implementation in Matlab®Simulink





Results of Thermodynamic Simulation

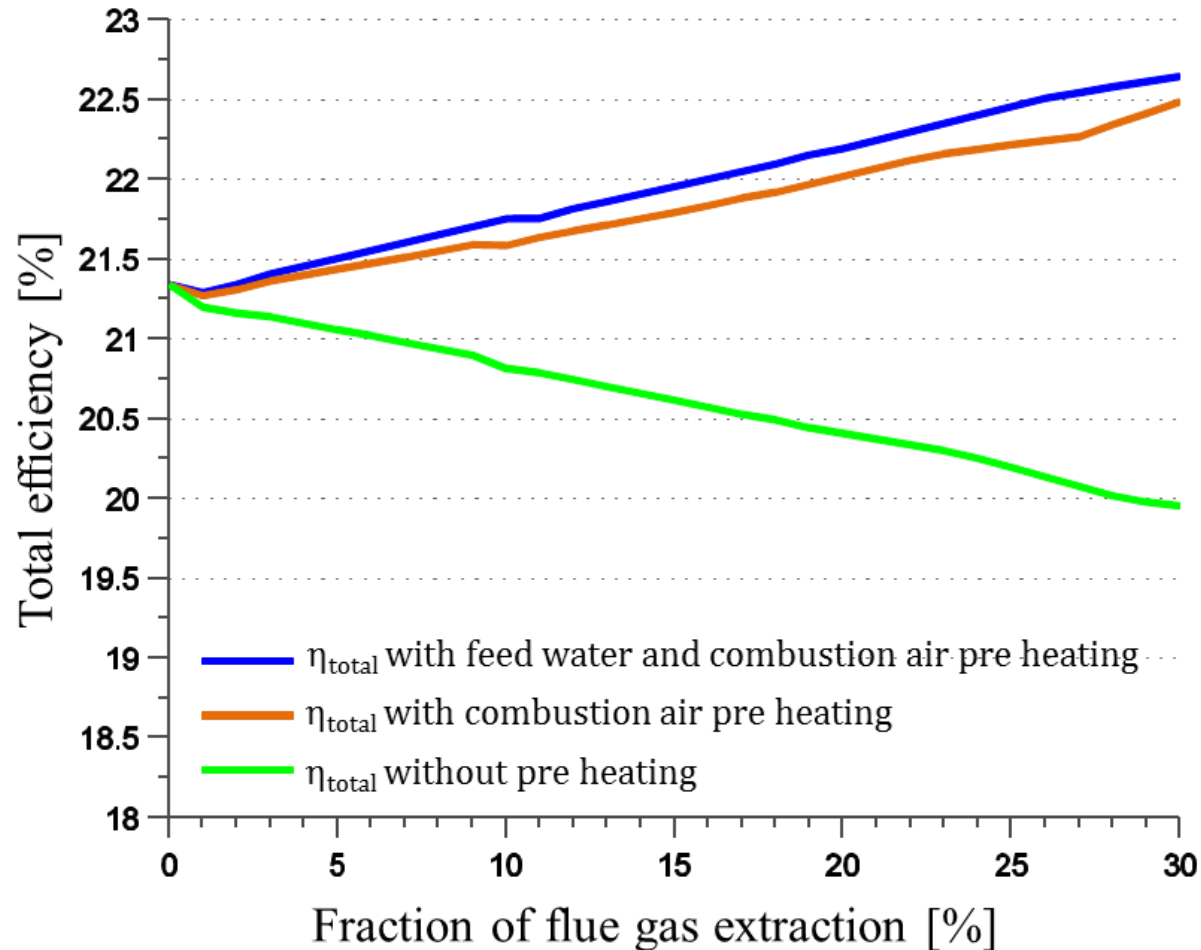
Temperature Profile at Various Procedural Steps



- 1 → 2: Pump
- 2 → 3: Feed Water Preheating 1
- 3 → 4: Feed Water Preheating 2
- 4 → 5: Feed Water Preheating 3 (Hot air)
- 5 → 6: Economizer
- 6 → 7: Evaporizer
- 7 → 8: Superheating
- 8 → 9: External Superheating
- 9 → 10: Heat losses (Pipes)
- 10 → 11: High pressure turbine
- 11 → 12: Extraction 1
- 12 → 13: Medium pressure turbine
- 13 → 14: Extraction 2
- 14 → 15: Low pressure turbine

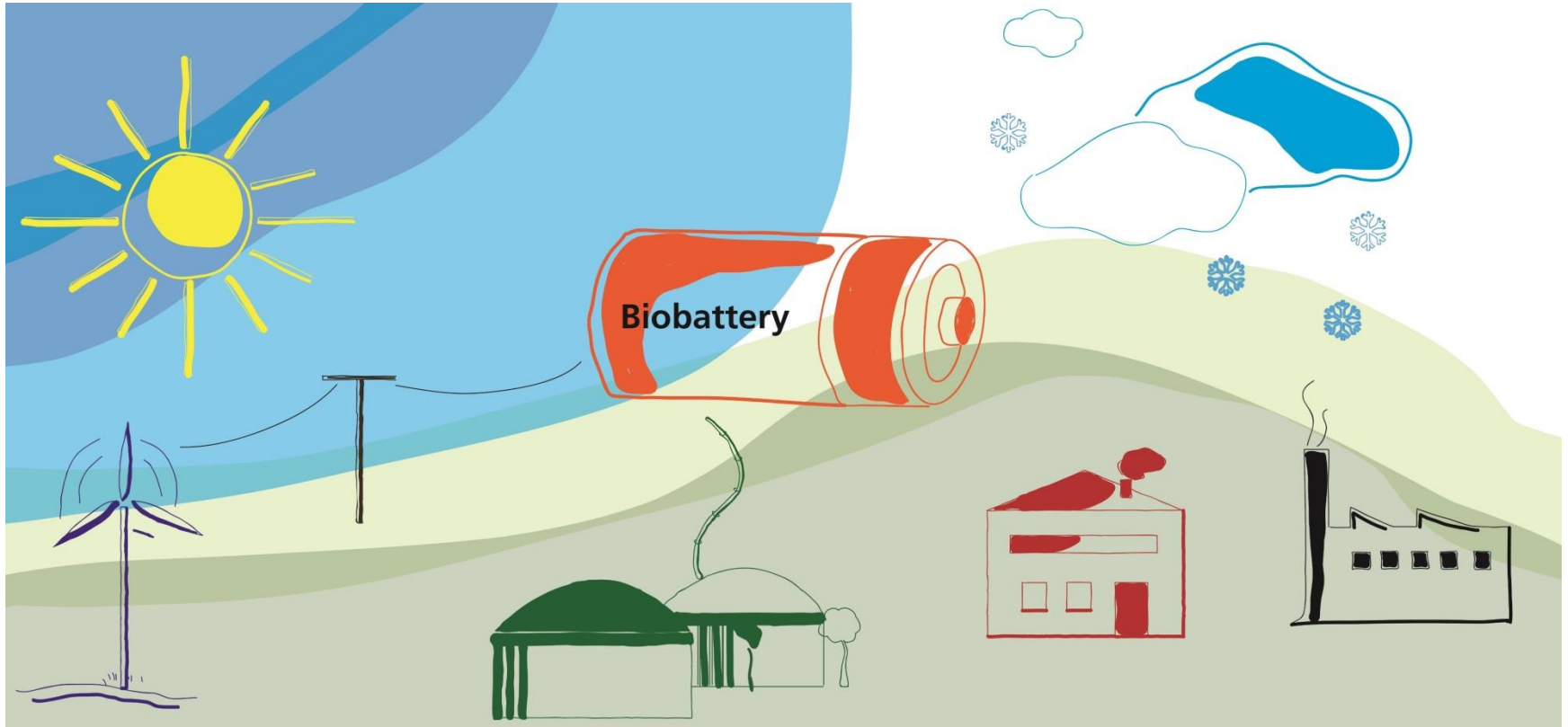
Results of Thermodynamic Simulation

Overall Efficiency



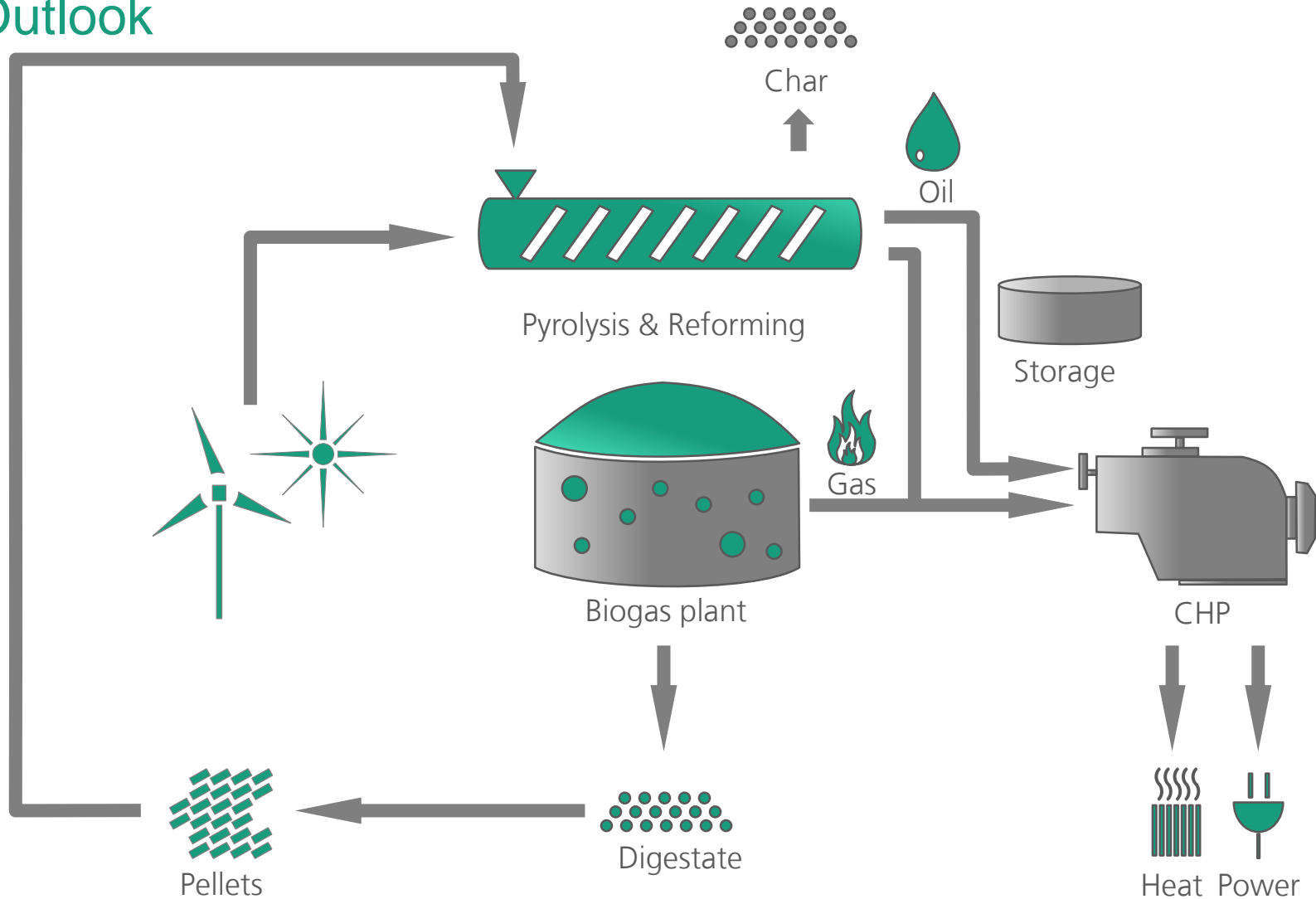
Use of Pebble-Heater in Integrated System

Outlook



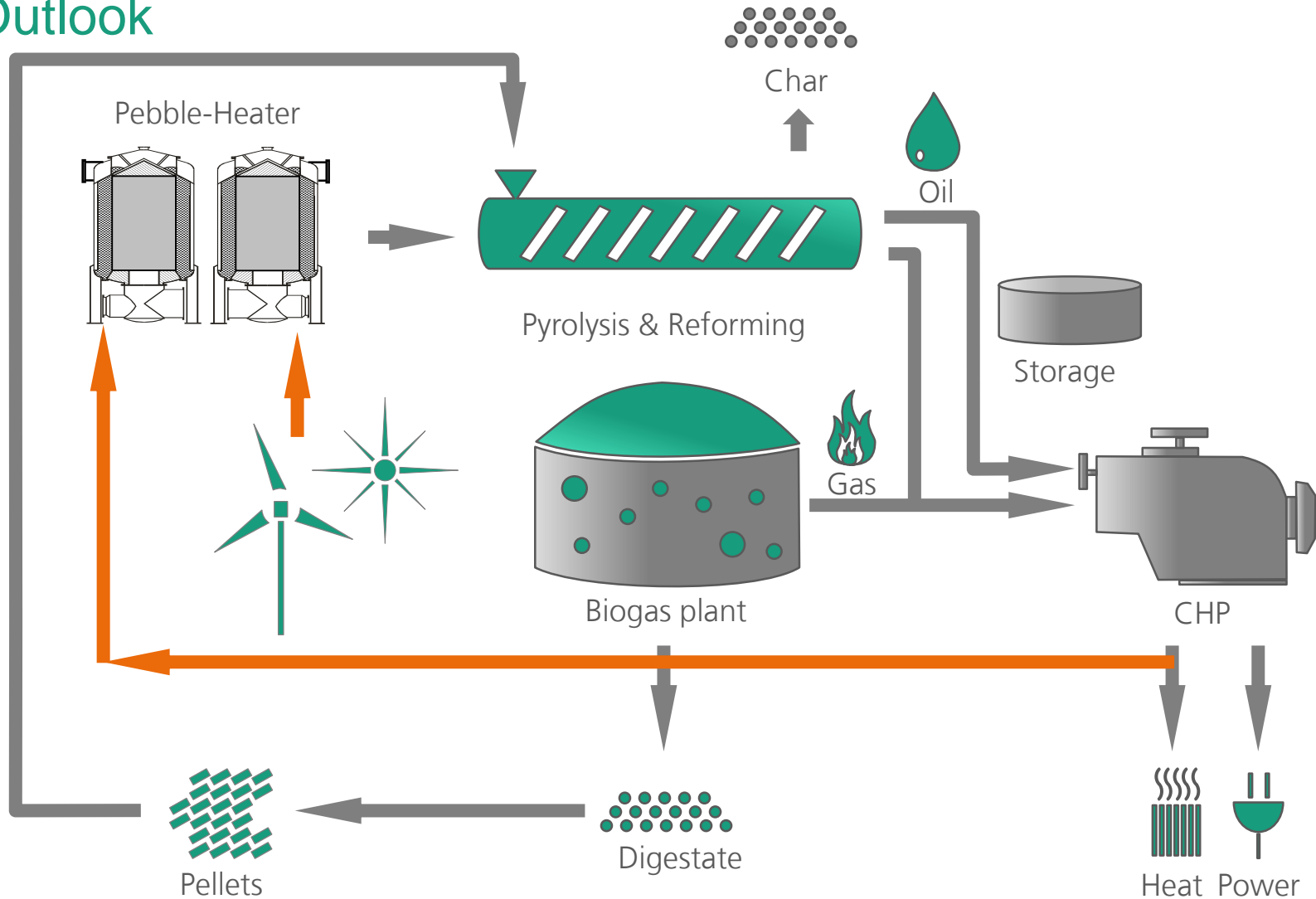
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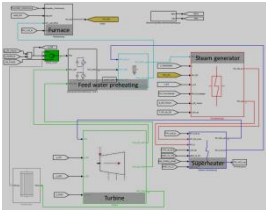
Use of Pebble-Heater in Integrated System

Outlook



External Superheating in Biomass Power Plants

Conclusion



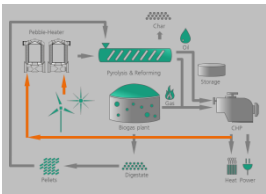
- Matlab model for simulation of
- different types of power plants
 - different operation modes



Verified in experimental test rigs



Increase in electrical efficiency



Pebble-Heater usable as Heat Storage in integrated energy systems

External Superheating in Biomass Power Plants with Pebble Bed Regenerator

Thank you
for your kind attention

Contact

Fraunhofer UMSICHT

Fraunhofer-Institut für Umwelt-, Sicherheits-
und Energietechnik UMSICHT

Institute Branch Sulzbach-Rosenberg

An der Maxhütte 1

D-92237 Sulzbach-Rosenberg / Germany

E-Mail: info-suro@umsicht.fraunhofer.de

Internet: <http://www.umsicht-suro.fraunhofer.de>

Samir Binder

Tel.: 09661-908 410

E-Mail: samir.binder@umsicht.fraunhofer.de

