FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
TECHNISCHE FAKULTÄT

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Pellets-Micro-CHP with a reversible Organic Rankine Cycle

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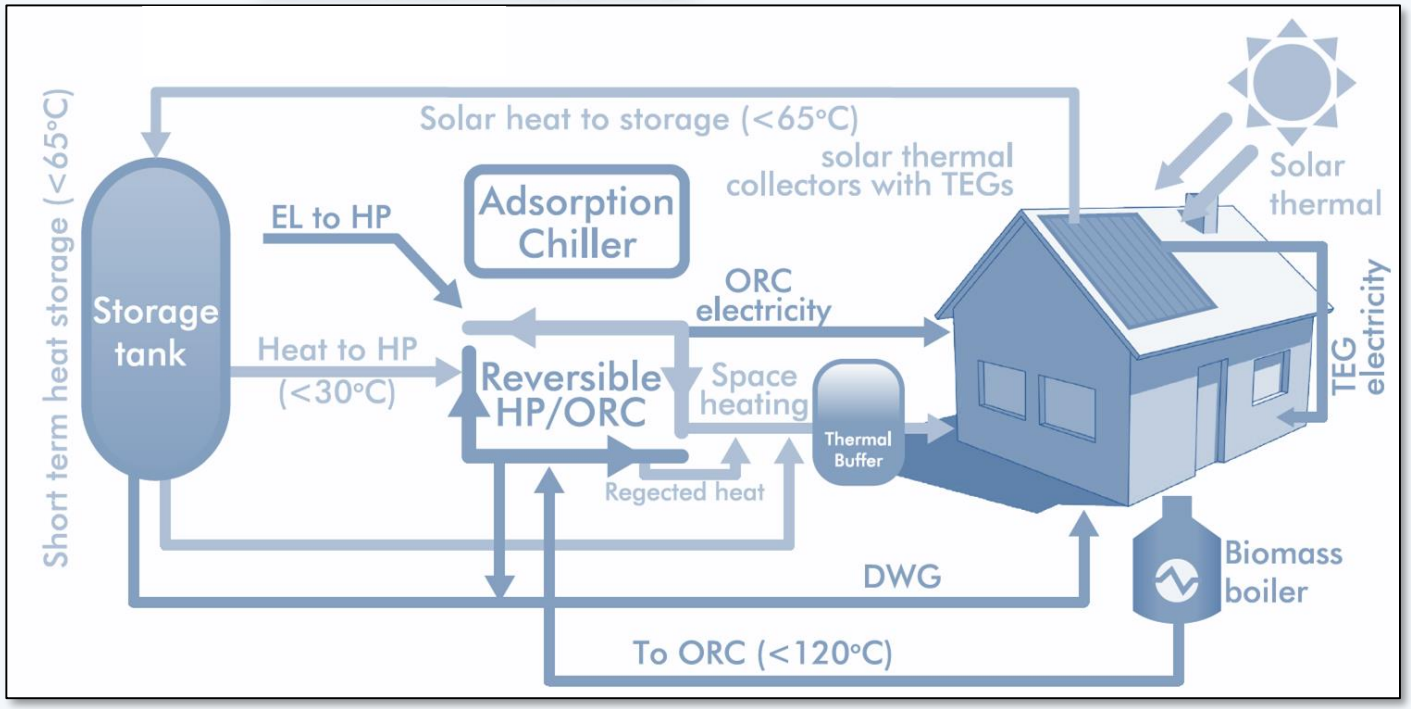
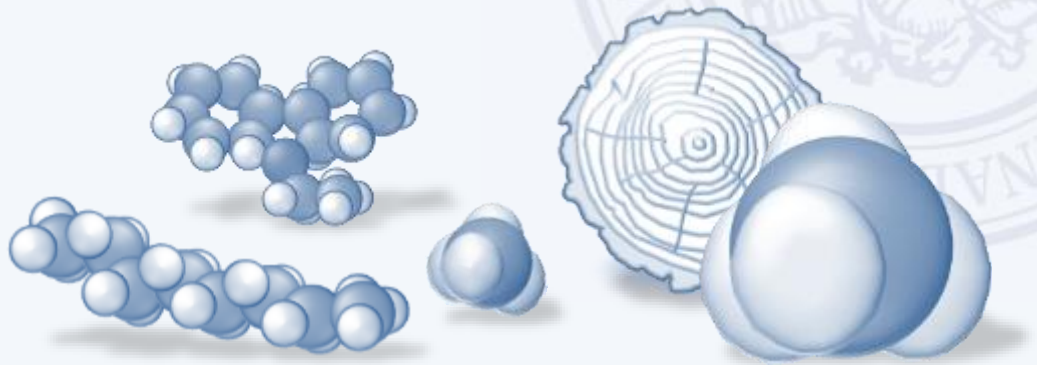




1. Motivation

2. Pellet boiler concept

3. The EU project „SolBio-Rev“

4. Summary and outlook

Motivation

- **Micro-CHP (combined heat and power) with biomass** ist considered to still have a **large unused potential**
- Organic Rankine Cycles are an established technology for generating power from low temperature heat sources

Set-up of the pellet boiler with the flue gas analyzers in the EVT lab

Key challenges

- Reduction of specific **investment costs**
- Increase of **cogeneration efficiency**
- Reduction of **emissions**

Main goals

- Development of a **flexible and efficient small-scale unit** for CHP
- Contribution to the reduction of emissions
- Decentralization of energy systems

Pellet boiler concept

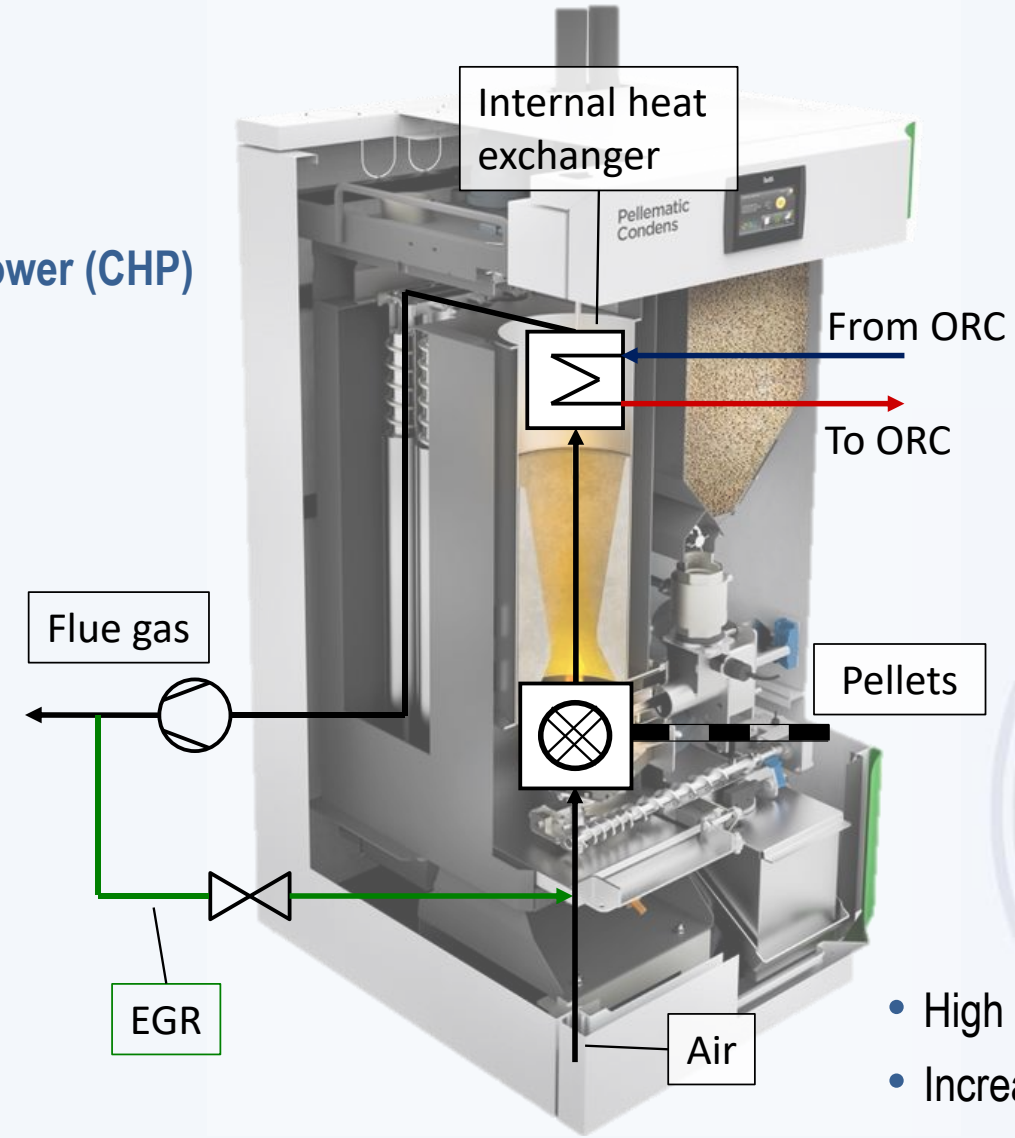
Development and lab-testing of a pellet boiler coupled with an ORC for combined heat and power (CHP)

Internal heat exchanger

- Determining factor for ORC efficiency:
  supply with **high temperature heat (> 100°C)**
  → integration of an internal heat exchanger
- Flexible heat supply at defined temperature level

Exhaust Gas Recirculation (EGR)

- Avoidance of hot spots and ash melting
  → **reduced emissions**
- Air-to-fuel ratio closer to stoichiometric
  → **higher combustion efficiency**



Scheme of an ÖkoFEN pellet boiler with internal heat exchanger and exhaust gas recirculation

Key advantages

- High cogeneration efficiency
- Increased electrical output
- Reduction of boiler emissions

Set-up in the laboratories of EVT

ÖkoFEN
Pellematic Condens
14 kW_{th}

Flue gas

Gas Analyzer
ABB AO2020 (Uras26)
CO, CO_2, NO

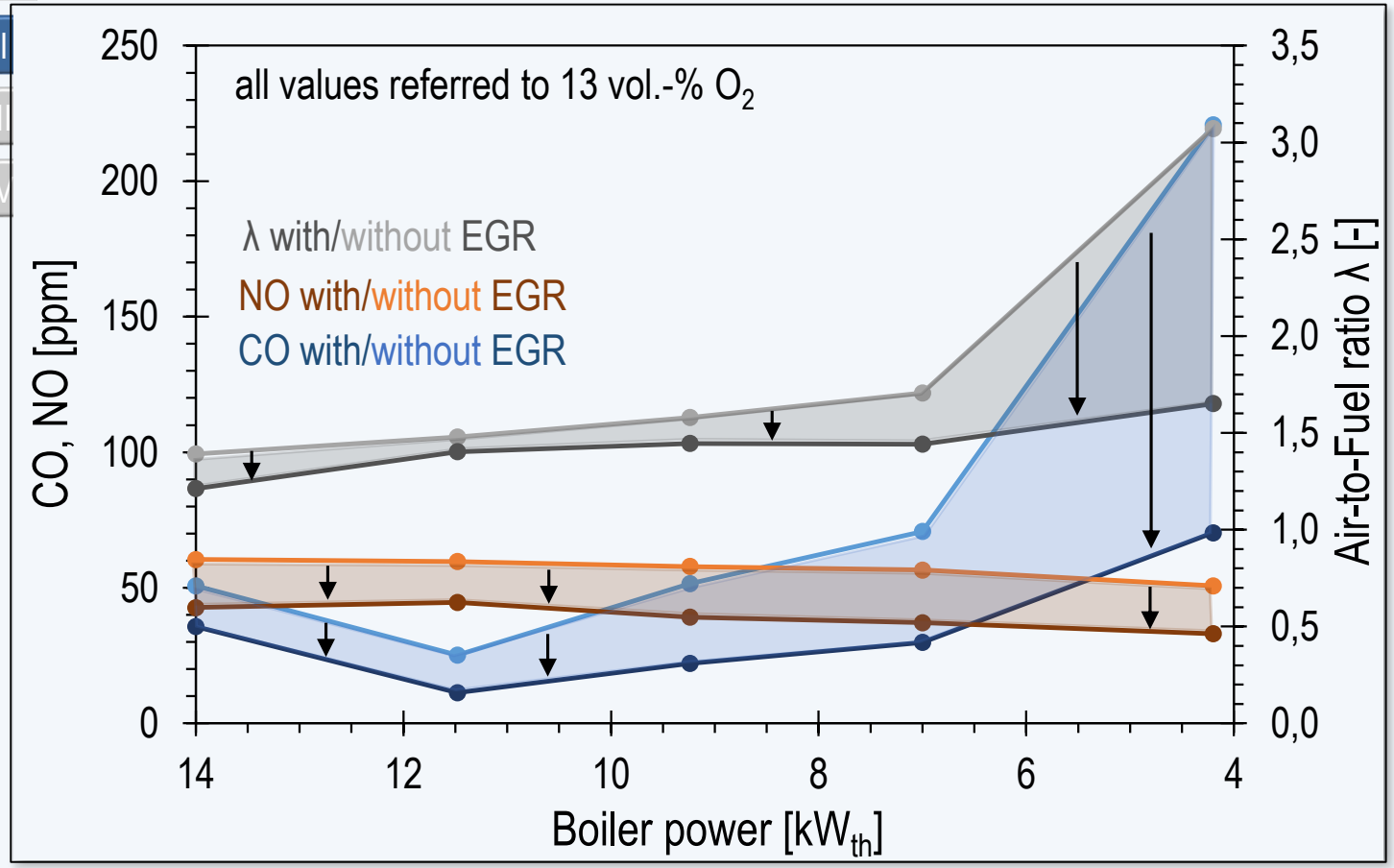
Cryostat

Testo 380
particulate matter

Set-up of the pellet boiler with the flue gas analyzers in the EVT lab

First lab-tests with EGR

First tests in the laboratories of EVT and ÖkoFEN show promising results



Emissions and air-to-fuel ratio of the pellet boiler with and without EGR depending on the boiler power

Integration of a EGR retrofitting developed by ÖkoFEN

EGR leads to a …

- … considerable **reduction of CO and NO emissions**
- … reduced air-to-fuel ratio at similar flue gas temperatures
  → **increase of combustion efficiency**

Next steps

- Further extensive tests at full and part load

→ **development of load-depending EGR strategies**

The EU project „SolBio-Rev“

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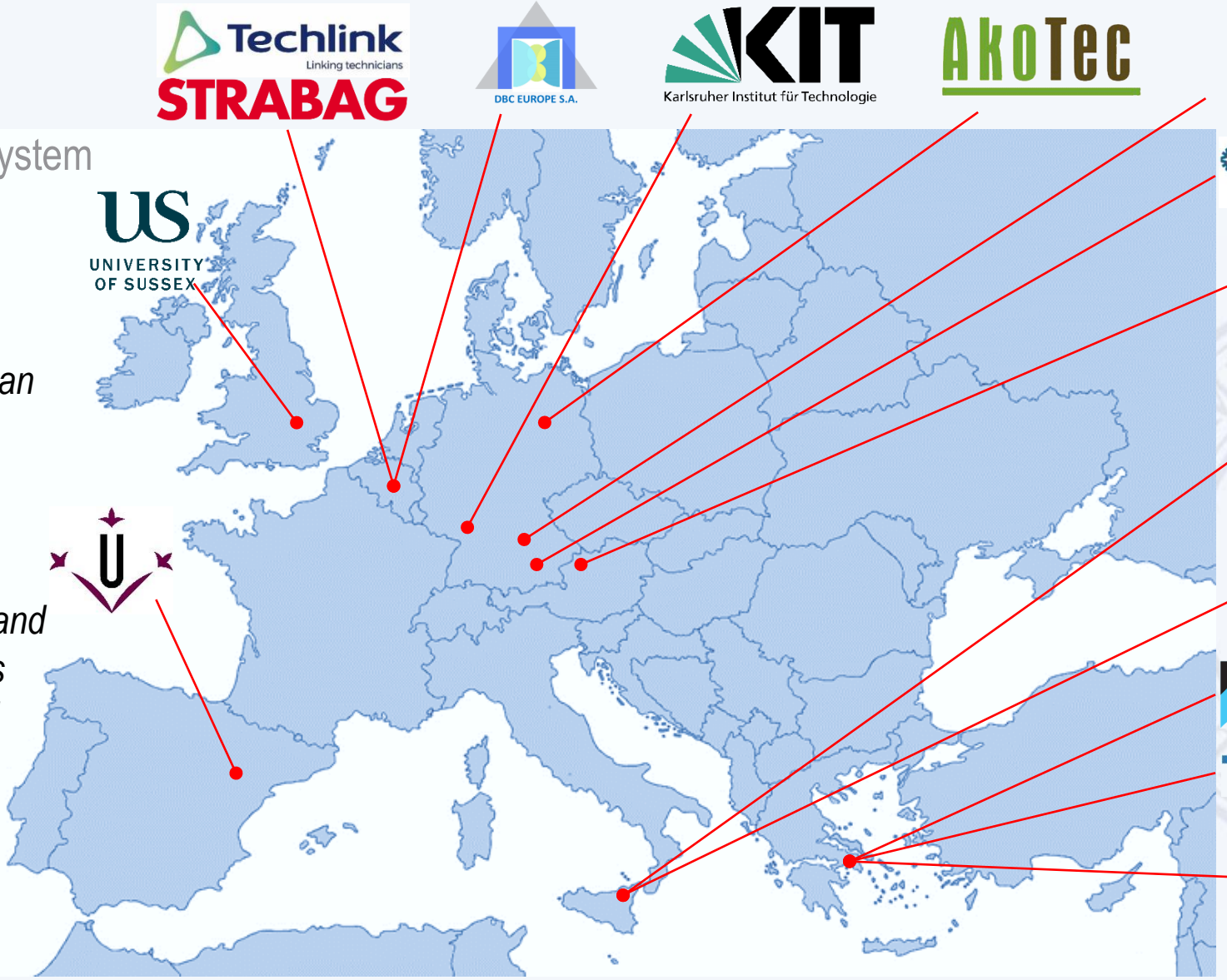
IV

Solar **Biomass** **Reversible system**

Term: 01 May 2019 – 30 April 2023

“The SolBio-Rev project will develop an innovative renewable energy system based on a novel and creative heat pump-based configuration, for the production of heating, cooling and electricity according to the daily and seasonal energy demand of buildings in different european climatic zones.”



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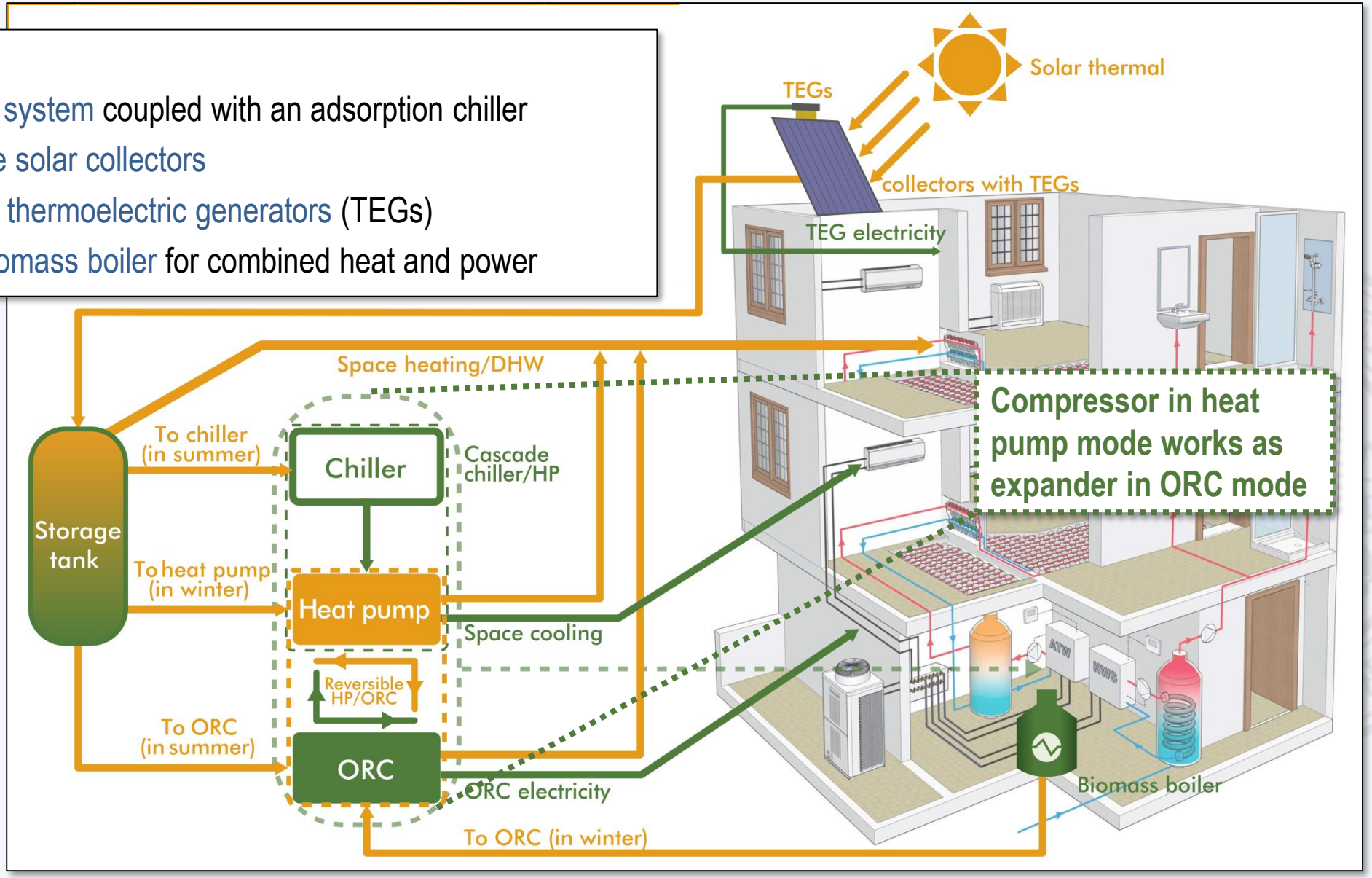
The idea of SolBio-Rev

Technology overview

- Reversible heat pump/ORC system coupled with an adsorption chiller
- Heat supply by vacuum tube solar collectors
- Excess solar heat utilized in thermoelectric generators (TEGs)
- Additional heat supply by biomass boiler for combined heat and power

Energy sources **solar heat** and **pellets**

Covering an energy share of up to 70 % in various buildings



The idea of SolBio-Rev

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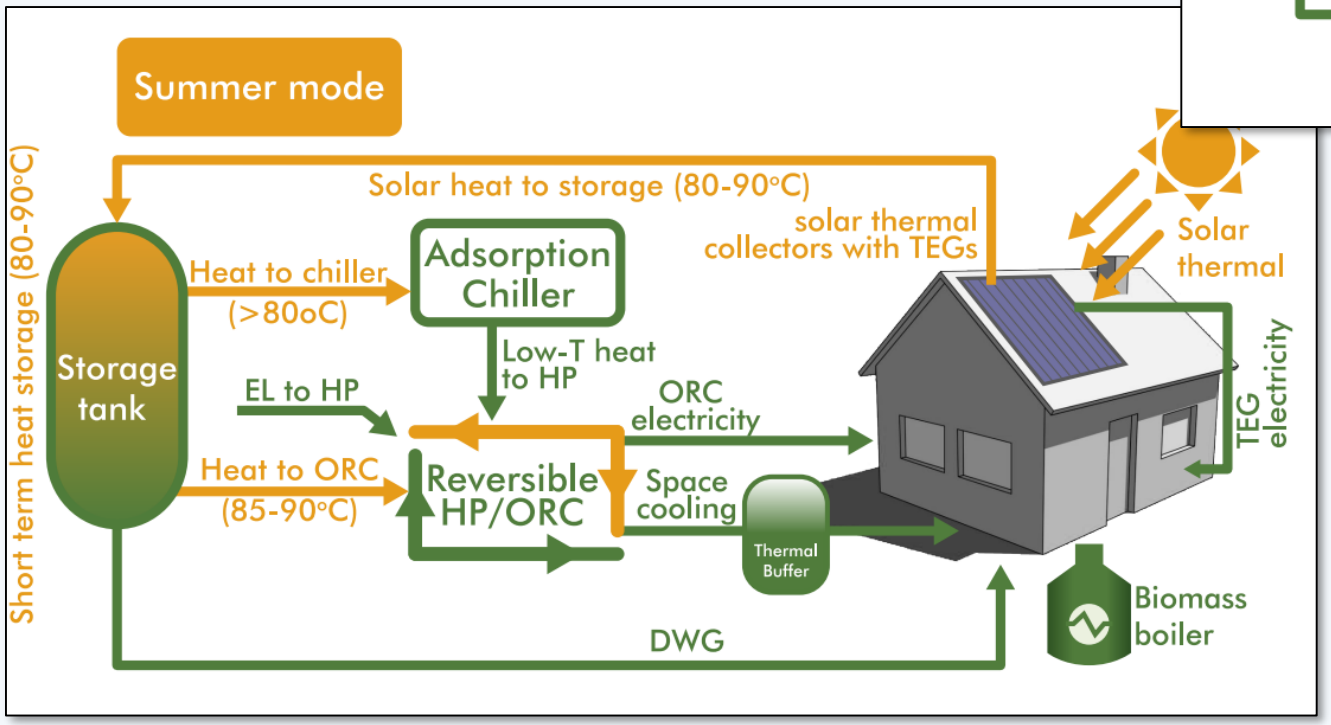
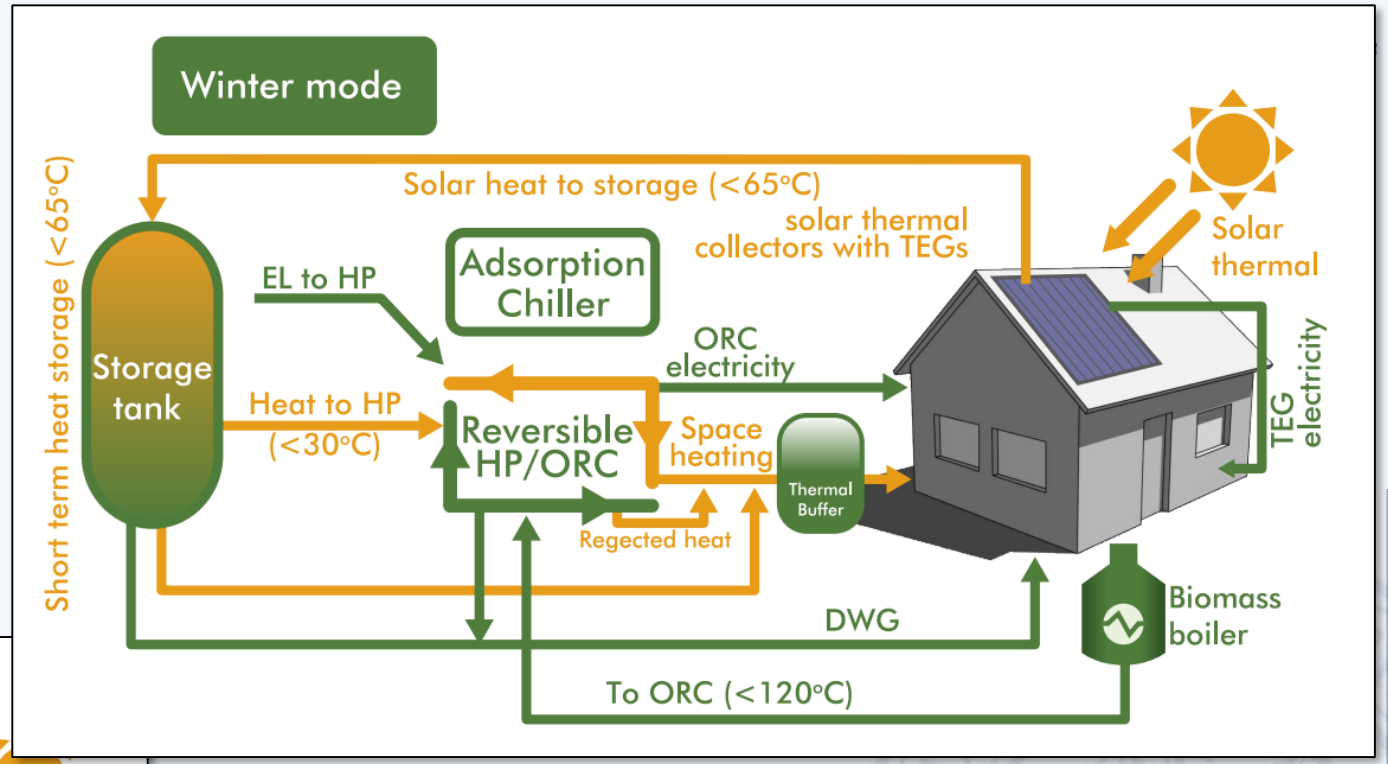
Summer mode

- Solar heat stored in short term storage
  → Supply of domestic hot water demand
- Priority: space cooling
- Excess heat used for electricity production



Energy flow scheme of the SolBio-Rev system in summer mode



Energy flow scheme of the SolBio-Rev system in winter mode

Winter mode

- Solar heat used for domestic hot water and space heating
- Low temperature heat supplies the heat pump
- In case of no solar energy: biomass boiler for CHP

Summary and Outlook

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Kickoff of SolBio-Rev

- Site preparation
- Comissioning of the prototype system
- Integration with a smart system control

Two prototype systems in Nürnberg an Athens

May 2019 | May 2019 – April 2021 | May 2021 – April 2022 | May 2022 – April 2023

Currently ongoing

- Development of the SolBio-Rev components
  → Biomass boiler with internal heat exchanger and EGR
- Evaluation of different internal heat exchanger designs for the integration in domestic pellets boilers
- Development of a load-depending EGR strategy for optimized emissions and efficiency
- Lab-tests with the developed prototype boiler

- System testing and technology validation
- One year testing to demonstrate advantages

SolBio-Rev advantages

- Enhanced flexibility
- Applicability in a large variety of buildings
- High utilization throughout the year
- Reduction of equipment → compactness

Covering a high share of up to 70% of annual energy needs in a variety of buildings