

HYBRID PIT THERMAL ENERGY STORAGE FOR SOLAR HEAT AND SURPLUS ELECTRICITY

SYSTEM INTEGRATION, OPERATIONAL STRATEGIES, AND ECONOMIC PERSPECTIVES

ISEC 2026

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Solid Solar Energy Systems

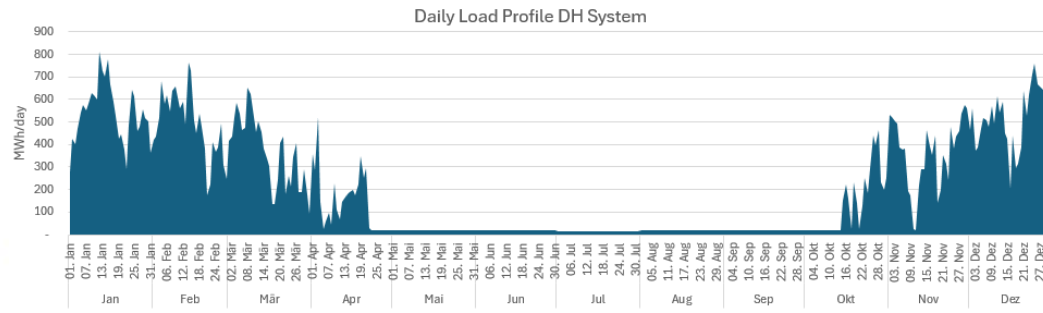
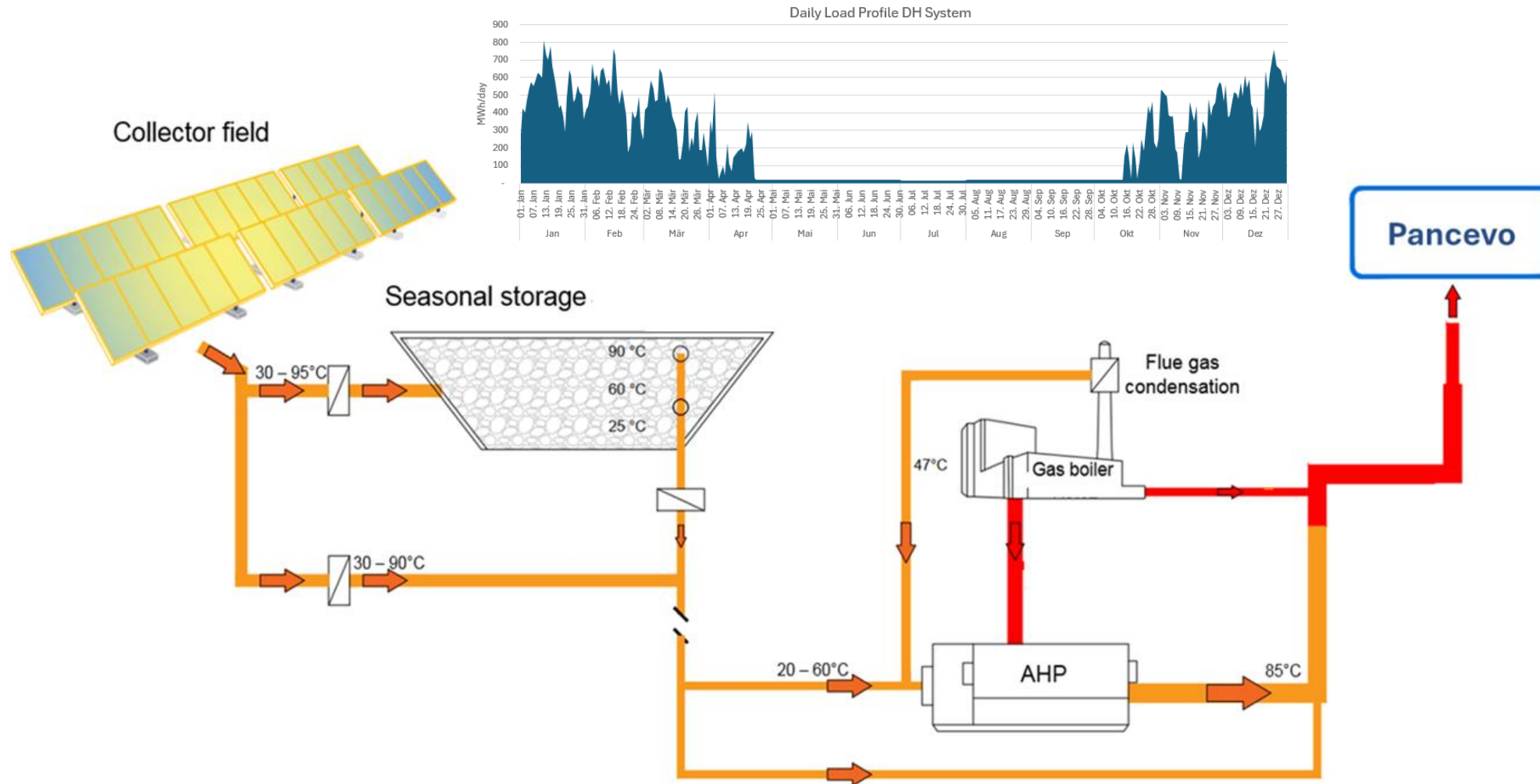


Why?



- High upfront investments
- Complex planning and permitting processes
- Regulatory uncertainty
- Integration challenges
- Dependence on policy support and subsidies
- Lack of experience and standardization

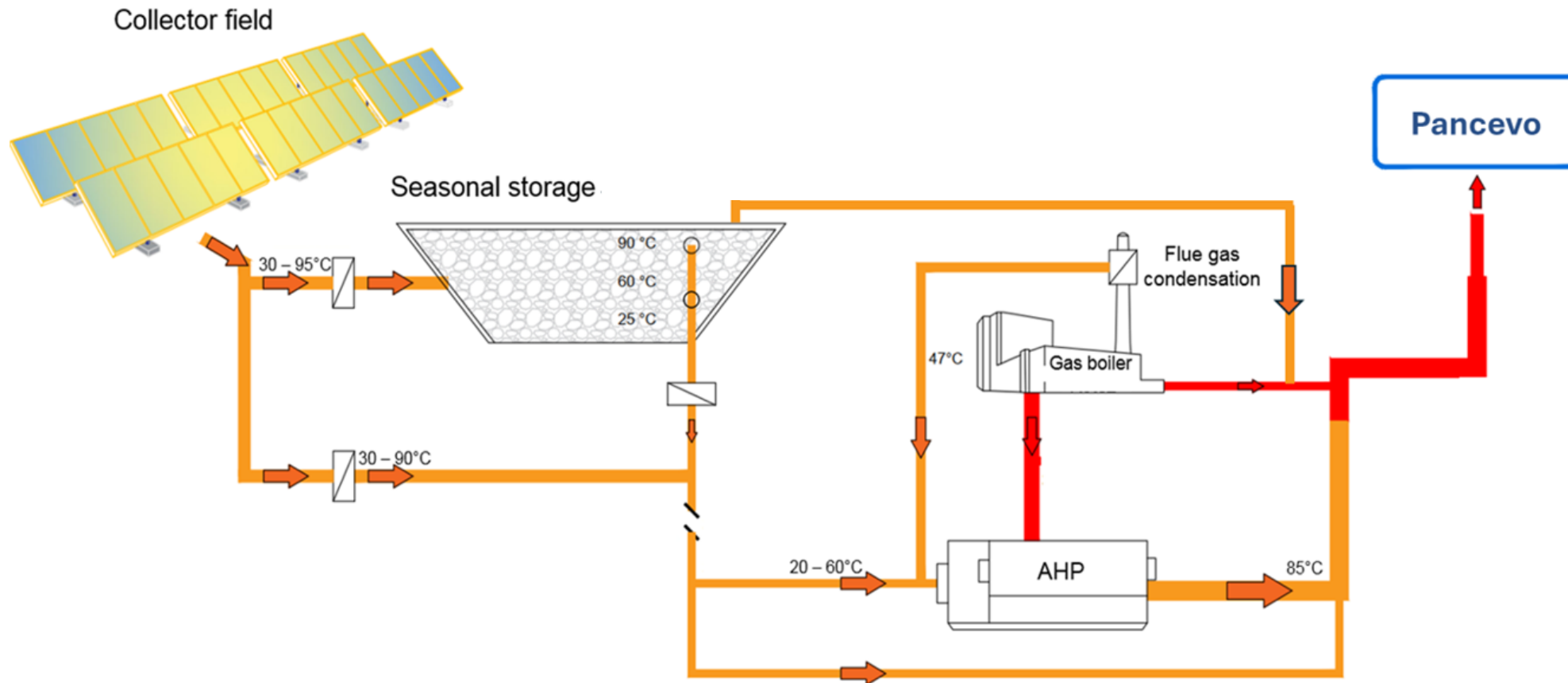
System Concept



What do investors expect

- **Stable and predictable cash flows** over long project lifetimes
- **Attractive return on investment (IRR)** with manageable risk
- **Low operational risk** and proven, reliable technologies
- **Clear and stable regulatory framework** (no policy surprises)
- **Long-term contracts** (e.g. heat off-take agreements)
- **Scalability and replicability** of the project concept
- **Protection against market volatility** (e.g. hedging, diversification of revenues)

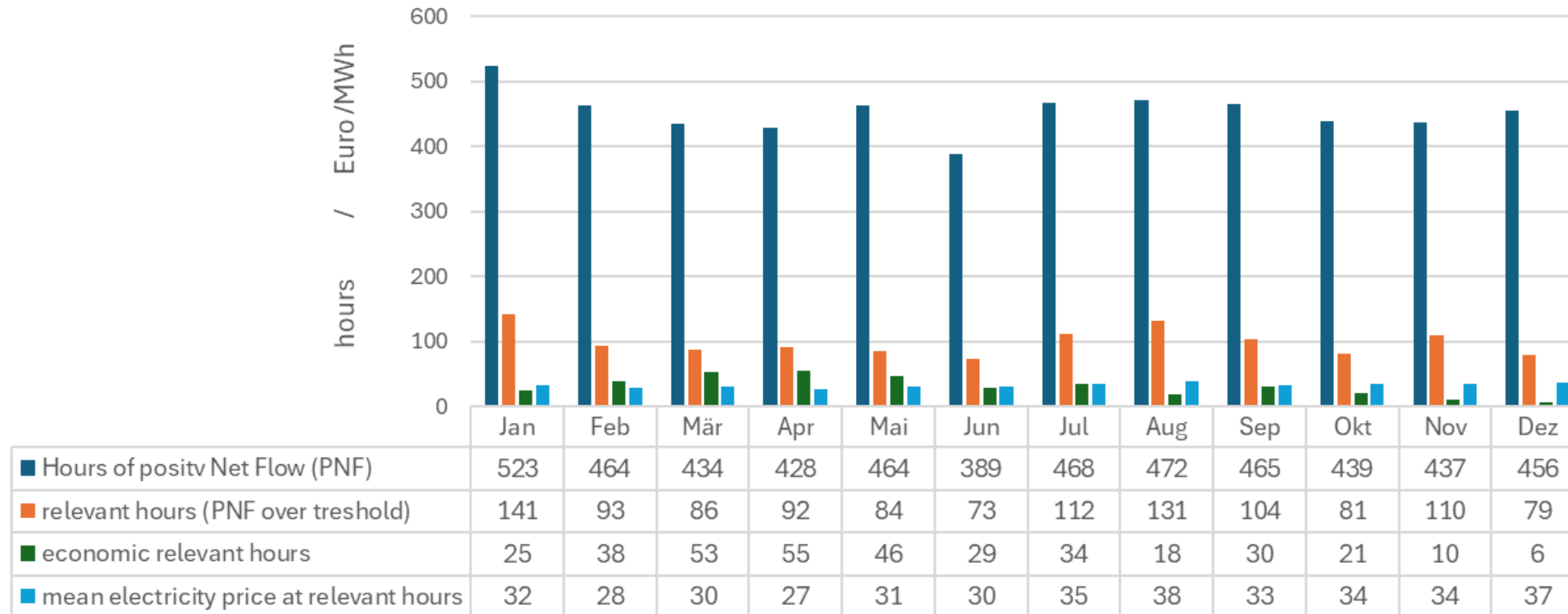
System Concept



Defining E-Boiler Operation

Limited data availability → surplus electricity is approximated using IGCC (International Grid Control Cooperation) data

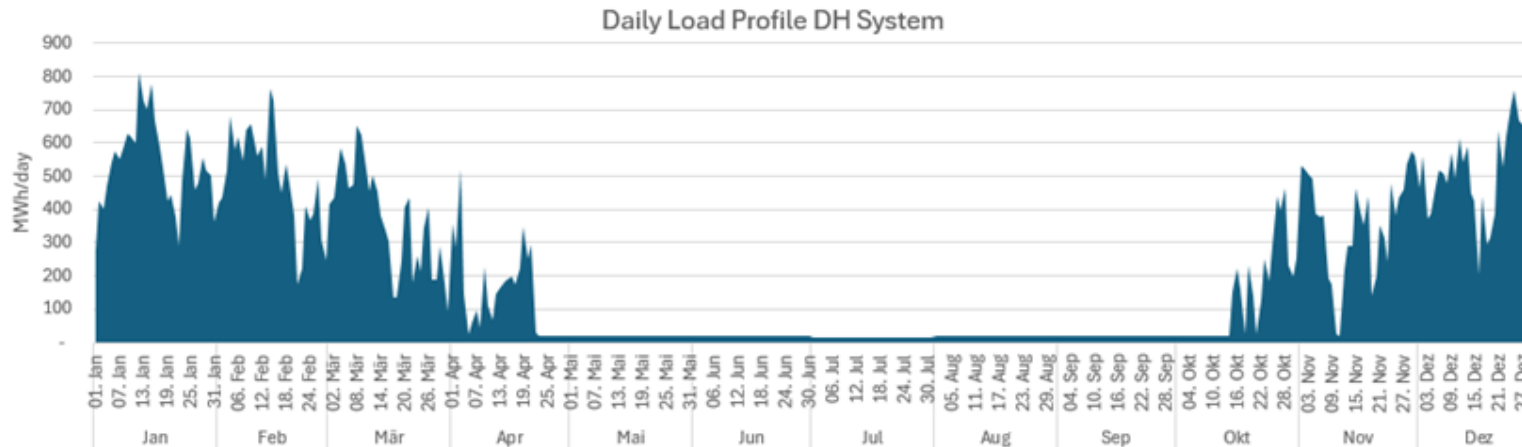
Source: [Engaged Balancing Energy and Imbalance Settlement Price – Elektromreža Srbije](#)



Manual Frequency Restoration Reserve (mFRR) Balancing capacity is assumed to be offered on the daily market in 4-hour blocks, allowing flexible participation depending on seasonal system conditions.

Source: [Ancillary services – Elektromreža Srbije](#)

Defining Scenarios and Parametric Analysis

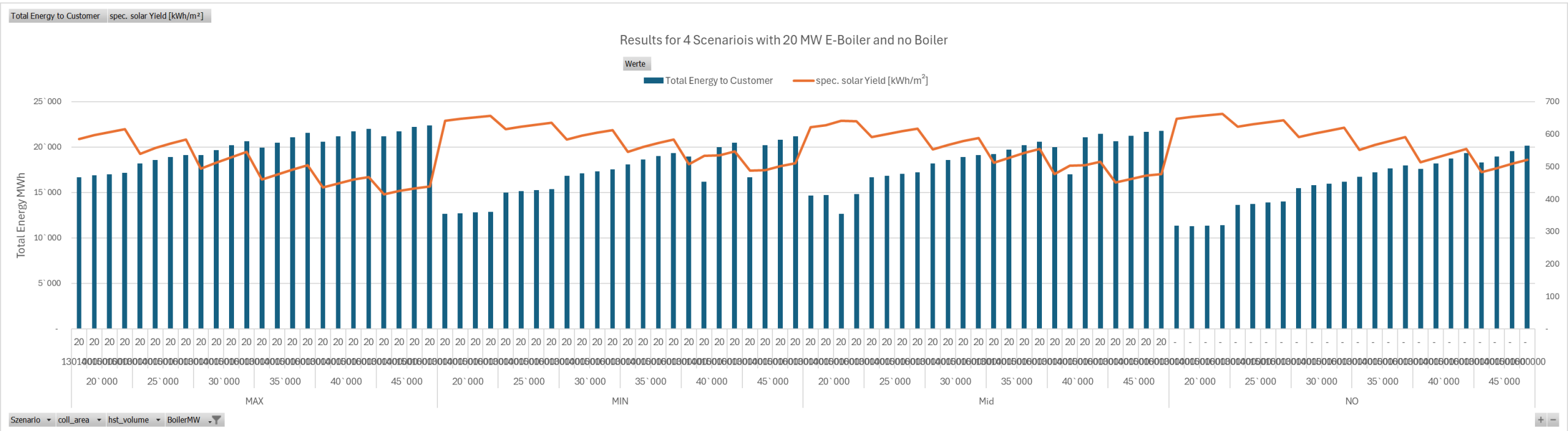


Collector area	Storage volume	Boiler Capacity
20000	130000	10
25000	140000	20
30000	150000	
35000	160000	
40000		
45000		

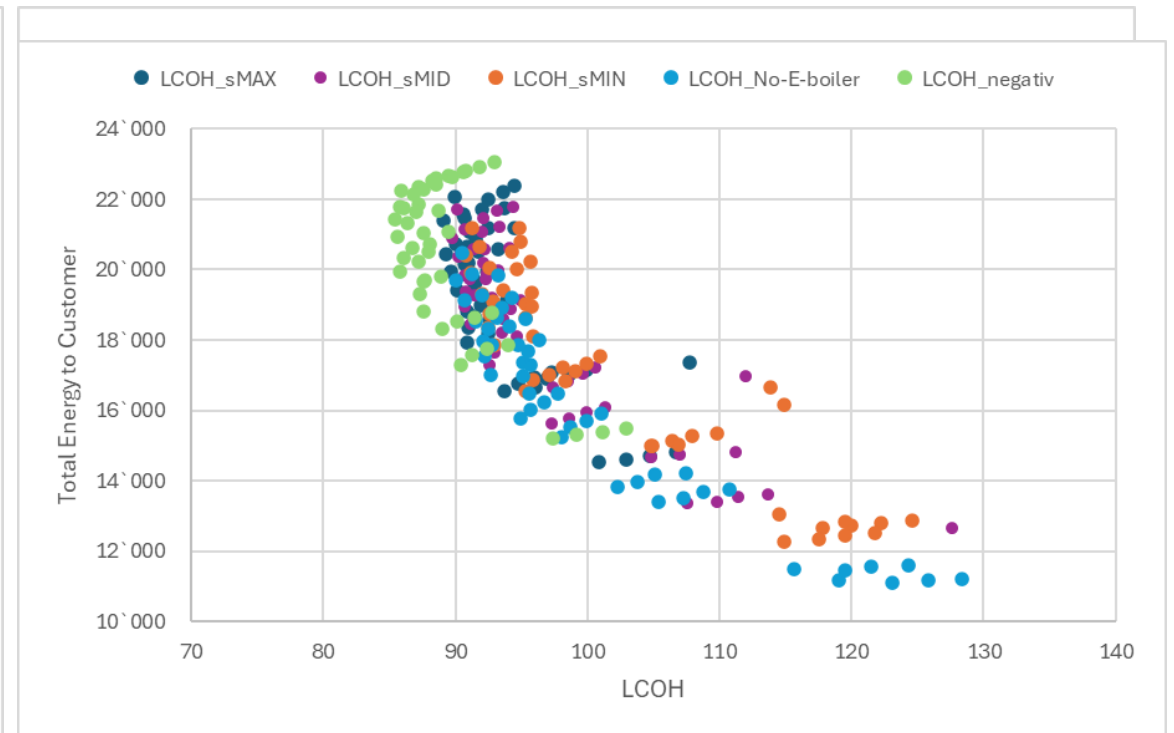
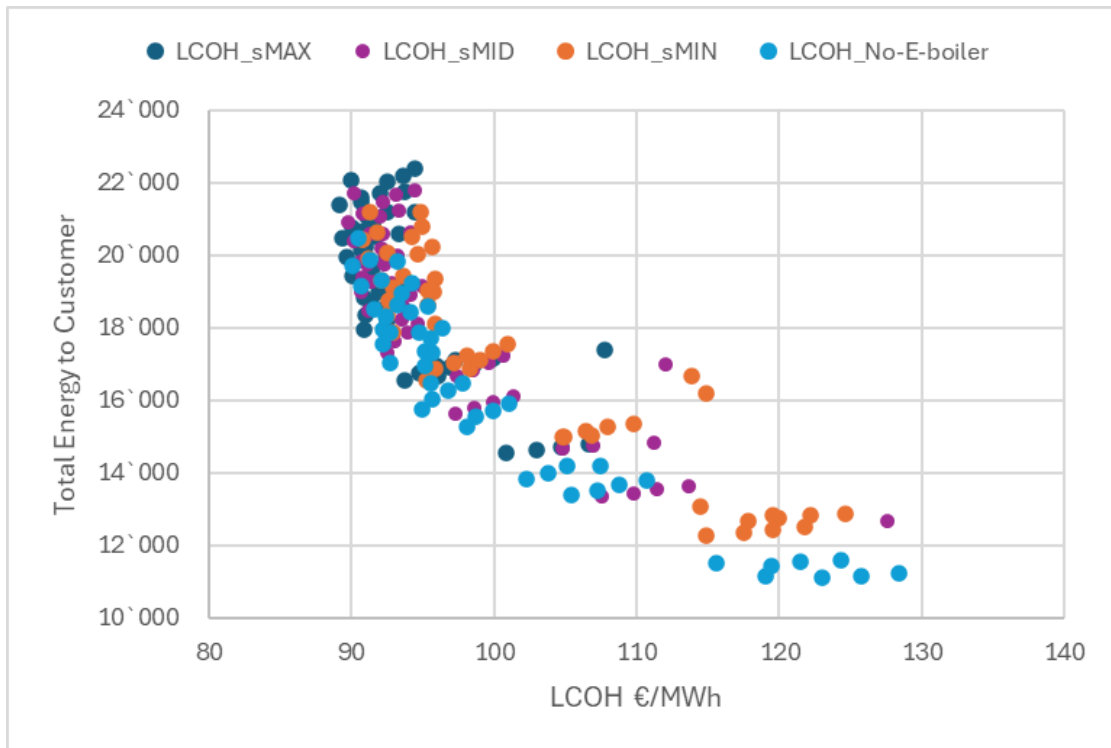
Scenario Max: Offer E-Boiler the whole year for balancing market
 Scenario Mid: E-Boiler Restriction from May to September
 Scenario Min: E-Boiler Restriction from March to October
 Scenario No: No E-Boiler is used

Variation of solar collector area, storage volume and E-Boiler Capacity
 -> 48 Simulations for each scenario

Preliminary Results

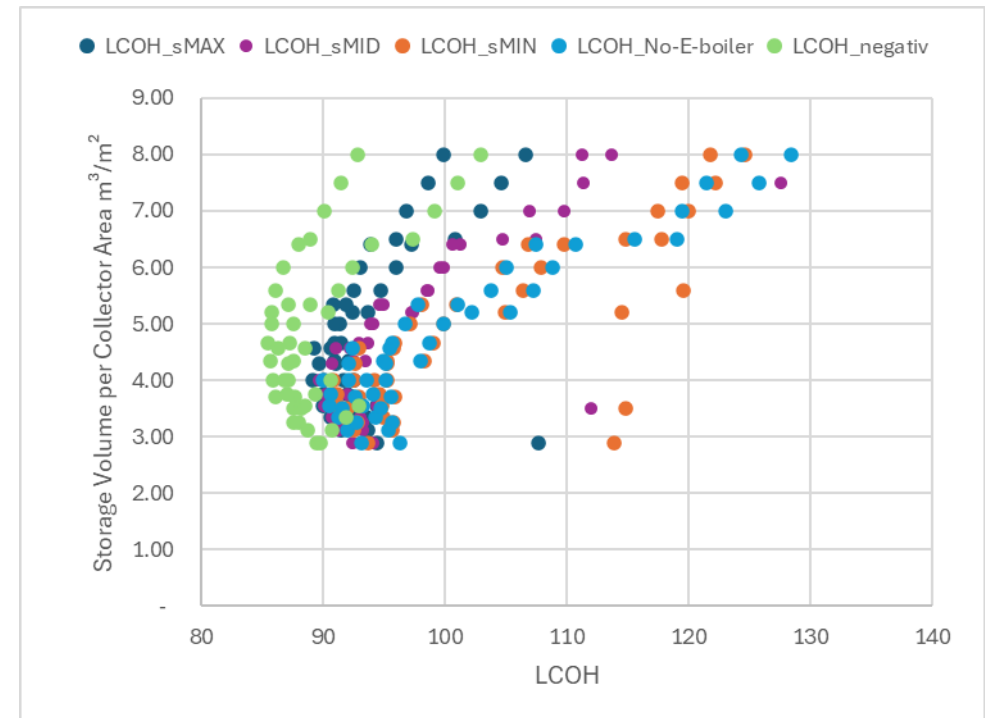
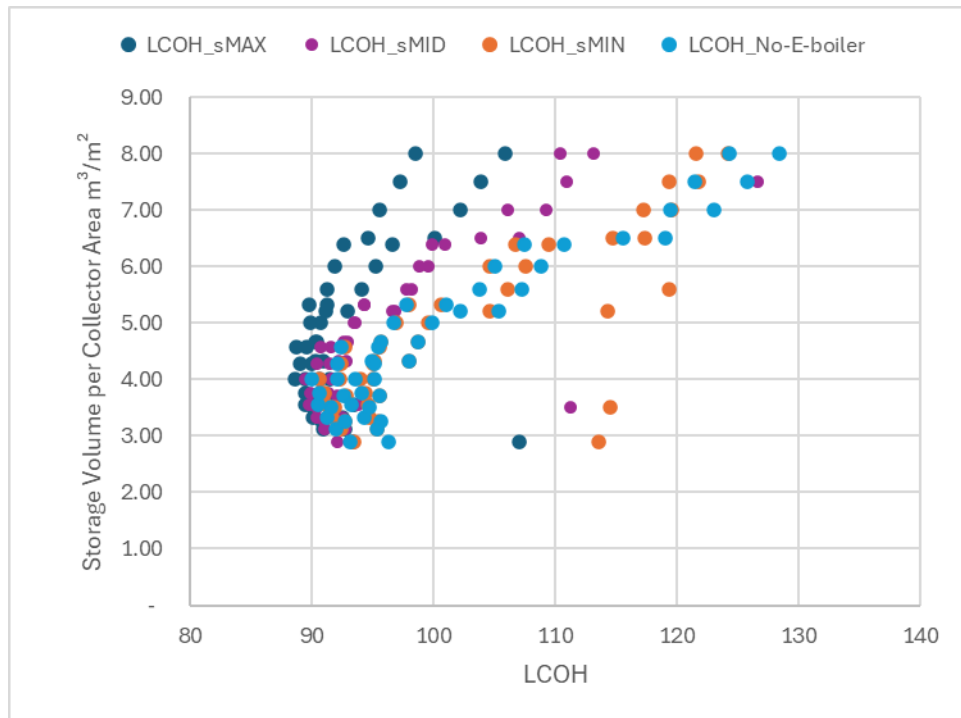


Preliminary Results



•With negative prices

Preliminary Results



The takeaway

- Power-to-heat via balancing can significantly improve project economics
 - Balancing markets are highly uncertain, particularly in emerging markets like Serbia
 - A robust business case must remain viable even without power-to-heat revenues in the long term
 - Negative electricity prices increase the importance of optimal system sizing
- > Market conditions affect not only system operation, but also optimal system sizing

Still to do...

- Still open
 - More detailed sensitivity analysis of key assumptions
 - Inclusion of additional economic KPIs (e.g. IRR, NPV)
 - Improved representation of long-term market developments
- Next steps
 - Development of an extended system concept including a heat pump for P2H
 - Integration of PV generation into the system design
 - Further optimization of hybrid system configurations



Demonstrating large pit thermal energy storages and improving their components, processes, and procedures for an accelerated realisation of 100% sustainable district heating networks in Europe.

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Accelerating the Uptake of Large Thermal Energy Storages

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IEA ES Task 39

Large Thermal Energy Storages for District Heating

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IEA Technology Collaboration Programme

A SUN THAT NEVER SETS

TAKE ACTION TODAY
FOR A BETTER
TOMORROW

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