# Efficient utilisation of biomass resources in smart district heating networks via sector coupling

Stefan Retschitzegger, Joachim Kelz, Xhoi Zhupani, Ingo Leusbrock - AEE Institute for Sustainable Technologies
Florian Samm, Julia Vopava-Wrienz - Technical University of Leoben

## Introduction

The transformation of energy systems toward 100 % renewable sources is a major challenge, especially in inner-alpine regions with complex infrastructure and seasonal variability. One such region is Murau in Austria, which has pursued a forward-looking energy vision and now generates multiple times its electricity demand from renewables such as hydropower, biomass, wind, and solar. However, these surplus faces grid capacity limits, leading to curtailments and constraining further expansion of renewables. District heating networks can play a major role in addressing this challenge via sector coupling. In this process digital modelling and flexible operation strategies of DH networks are essential tools to mitigate grid constraints and support a fully renewable regional energy system.

## Energy production in Murau

- The region Murau generates about 417 GWh of electricity per year, while consumption in the district is only about 120 GWh per year. Hence, Murau produces multiple times its electricity demand, only from renewables such as hydropower, biomass, wind, and solar.
- On peak days from spring to fall, up to 100 MW are exported (residual load) from Murau to the high-level grid in Austria (Figure 1). This surplus faces grid capacity limits, leading to curtailments and constraining further expansion of renewable electricity production.
- Only in winter (December and January) electricity must be imported from the high-level grid to the region Murau to a minor extent.

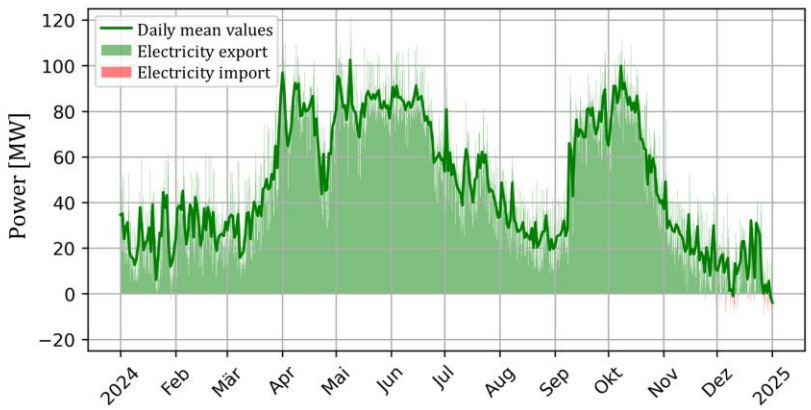


*Figure 1: Residual load in the electricity grid in the Murau district in 2024 (Source: Technical University of Leoben)*

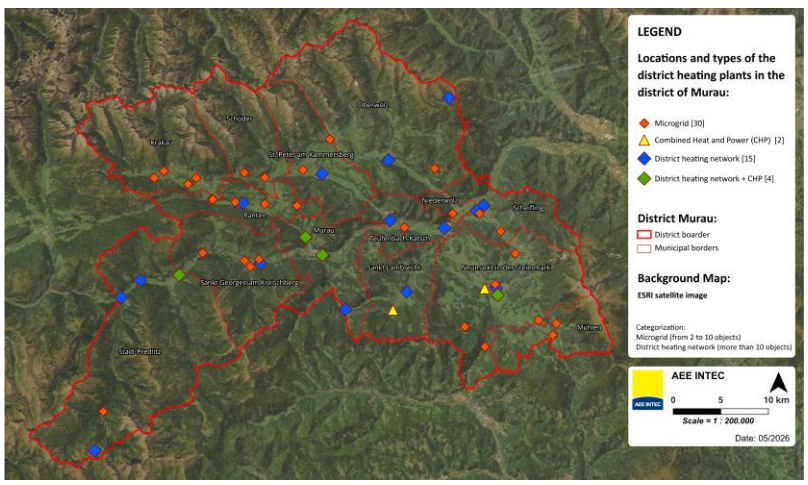


*Figure 2: District heating systems in Murau (Source: AEE INTEC)*

- In the region of Murau, 51 DH networks are currently in operation with biomass as the main energy source (Figure 2). The total capacity of biomass-based boilers and CHP units amounts to 52 $MW_{th}$. Fossil fuel boilers are typically available in each DH system, but they are only serving as backup-systems or for peak loads.
- Currently, only one DH system in Murau uses a P2H unit for heat generation. This and the large number of DH networks signifies the potential for utilizing renewable excess electricity in DH networks via heat pumps or Power-to-Heat units.

## Sector coupling in a district heating system

- Sector coupling options are evaluated in detail at 4 demonstration DH systems in Murau. The methods applied and first results are presented for the DH system in Lachtal.
- Key data for the DH system Lachtal
  - Biomass boiler: 1.0 $MW_{th}$
  - Oil boiler: 1.0 $MW_{th}$
  - Thermal storage: 40 m3
  - Heat generation: 2.1 GWh/a

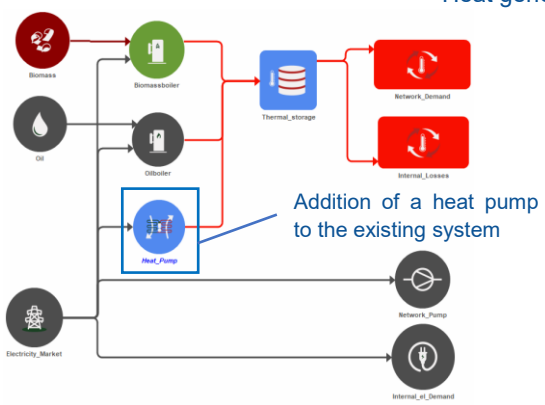


*Figure 3: Digital model of the energy production in Lachtal (Source: AEE INTEC)*

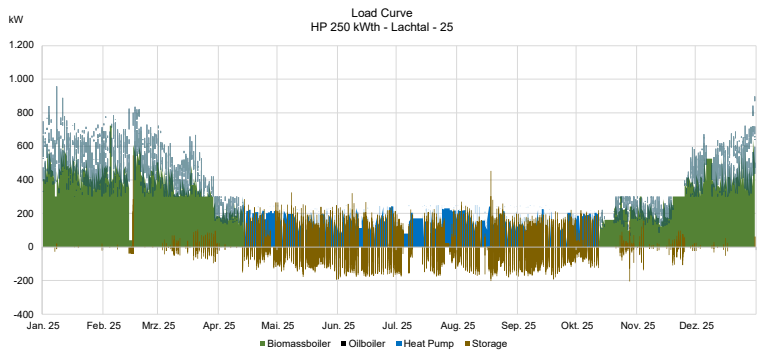


*Figure 4: Time-resolved heat production for a full year (2025). Scenario with 250 $kW_{th}$ heat pump (Source: AEE INTEC)*

- The aim for the DH system Lachtal is to integrate a heat pump, that shall cover the heat demand in summer.
- First, the current system is digitally modelled within energyPRO. Afterwards, possible heat pump integration scenarios are integrated (Figure 3) and evaluated.
- Results:
  - A 250 $kW_{th}$ heat pump is the most suitable system to cover summer heat demand. It will operate from mid-April to mid-October (Figure 4). During this time, the thermal storage is highly necessary, to cover the heat demand (see storage charge and discharge in Figure 4).
  - The problematic part-load operation at very low capacities of the biomass boiler (thermal load below 150 kW) is completely avoided integration of the heat pump. In addition, during biomass boiler maintenance, no oil boiler operation is required as the heat pump is operated during that time.
  - In total, the heat pump supplies 643 MWh per year (~27%), while the biomass boiler supplies 1,720 MWh (~73%).

## Conclusions & Outlook

Sector coupling is a promising approach to increase the flexibility and resource efficiency of biomass-based DH systems. Heat pumps and power-to-heat units can use surplus renewable electricity, reduce biomass demand, avoid inefficient boiler operation at low loads, and limit the need for fossil backup systems. Digital modelling helps identify suitable operating strategies and assess system-level impacts. Future work will focus on the economic evaluation of sector coupling options, considering investment and operating costs, electricity price signals and biomass savings. In addition, the multiplication potential for DH networks across Murau will be assessed.

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**Contact:**
Stefan Retschitzegger
AEE - Institute for Sustainable Technologies
Feldgasse 19, 8200 Gleisdorf (A)
+43 (0) 3112 5886 217
s.retschitzegger@aee.at / www.aee-intec.at