Net-Zero through CCS: Energy system integration in a Swiss valley

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Motivation

Under the *Aktionsplan Green Deal*, the canton of Graubünden aims to achieve **net-zero by 2050**. Hard-to-abate industries like cement and waste incineration majorly drive emissions in the Rheintal valley. Such urban-industrial clusters are **emission hotspots but** also offer **unique synergies**. Reaching net-zero requires **integrated solutions** connecting industries and urban settlements.

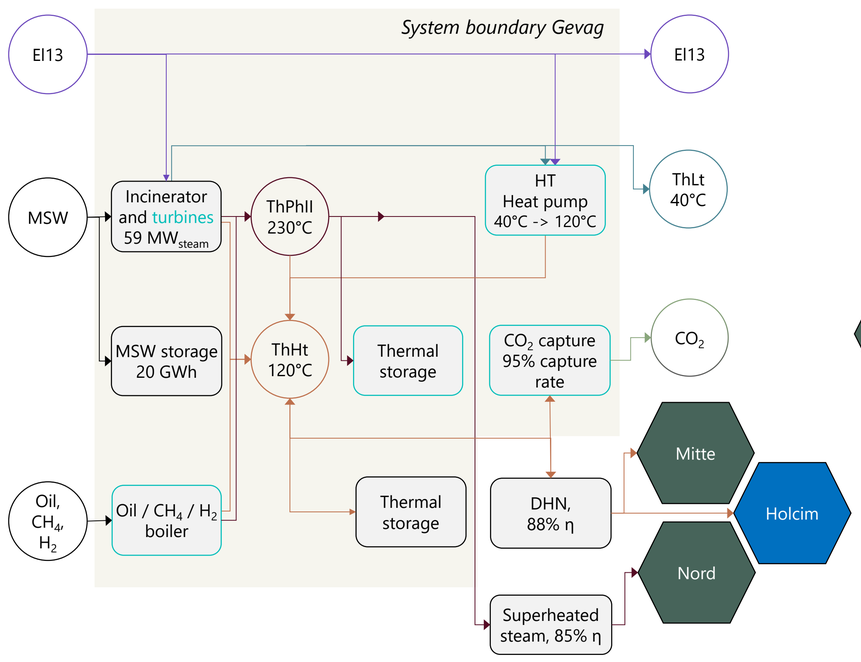
Switzerland: **4** t_{CO2}/capita
Rheintal: **11** t_{CO2}/capita

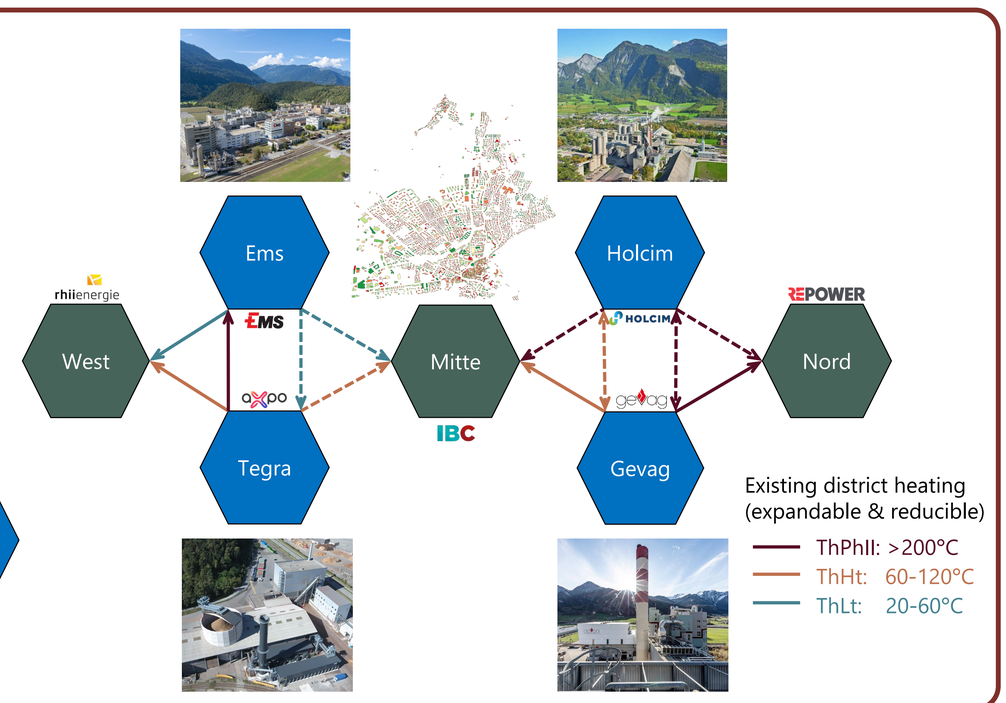
Research Questions

1. How can net-zero be achieved in Rheintal at minimal system cost?
2. How can we utilize synergies and interdependencies between different sectors within a regional energy landscape to achieve net-zero targets?
3. What are the roles of carbon capture and storage (CCS) and district heating network (DHN) in achieving net-zero targets for an urban-industrial cluster?

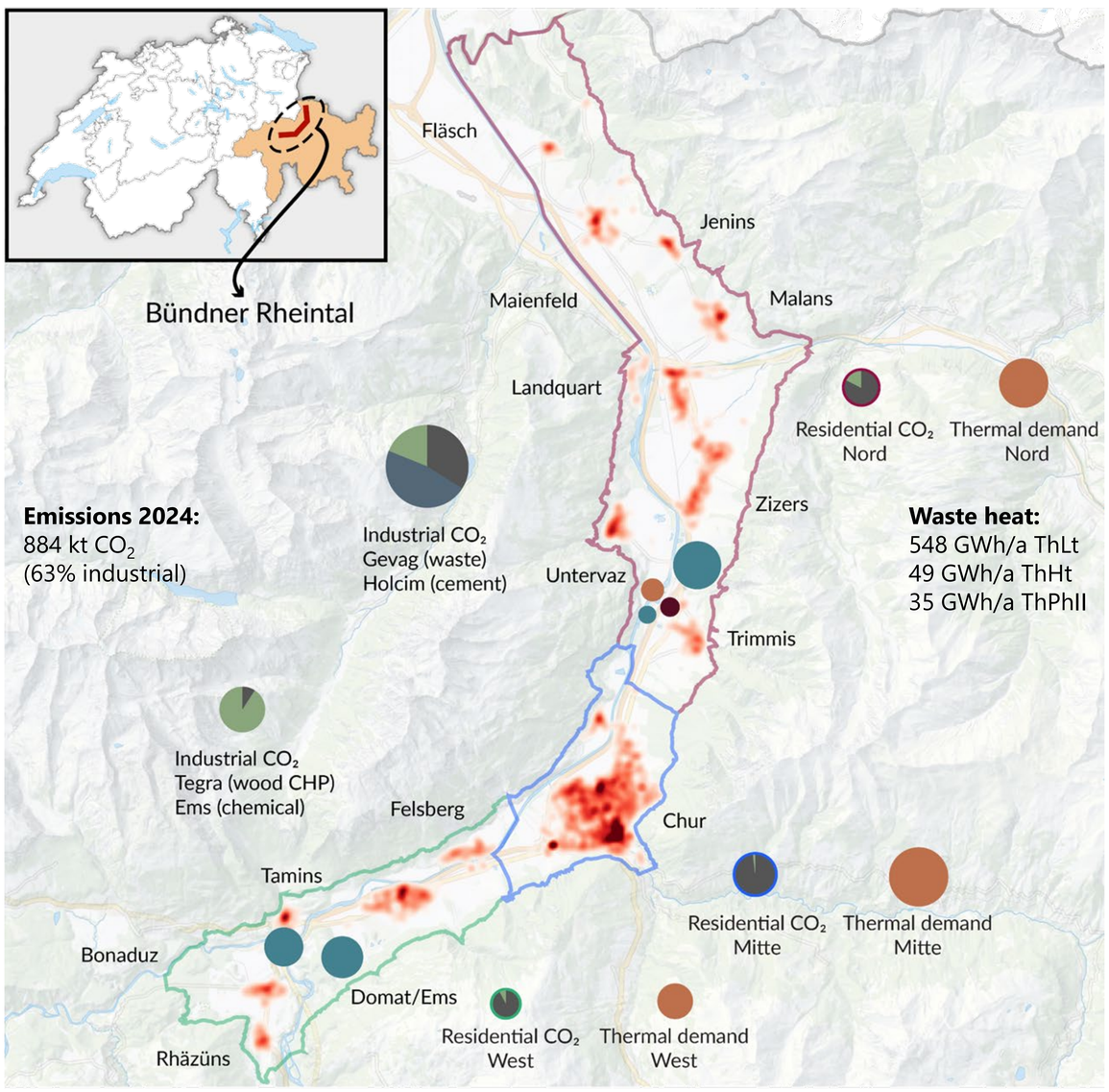
Methodology

- Sector-coupled MILP optimization with cost minimization (ehubX)
- Hourly resolution with 7 energy hubs (3 urban, 4 industrial)
- Detailed regional energy system analysis with real-world data from stakeholders
- Urban demands: bottom-up approach using CESAR-P based on EnergyPlus
- Reference 2024 → validated with stakeholders
- Two snapshot 2050 scenarios
  - Progressive (2050-pro): rapid transition, EU H_2 backbone
  - Restrictive (2050-res): slower transition, limited H_2 imports





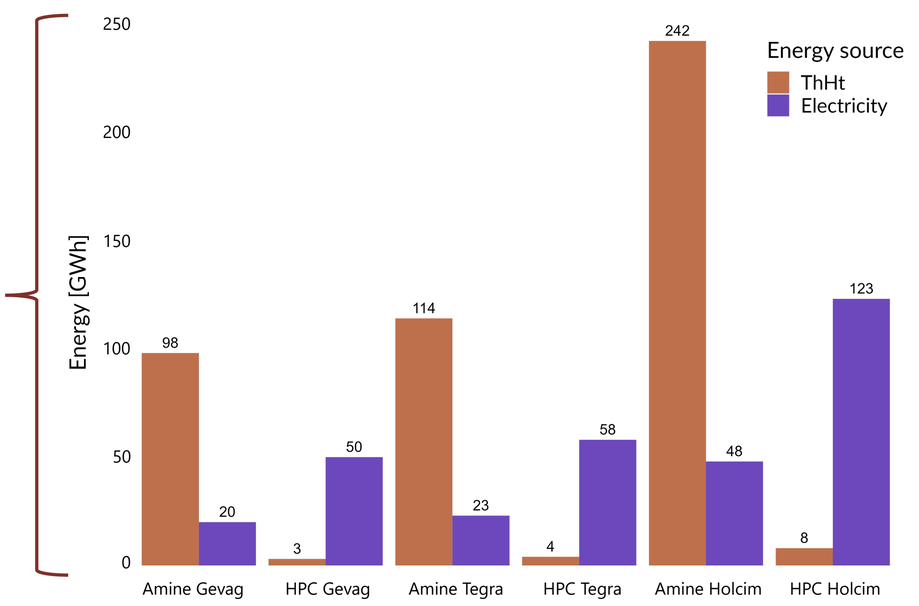
Waste heat and emissions in Rheintal today



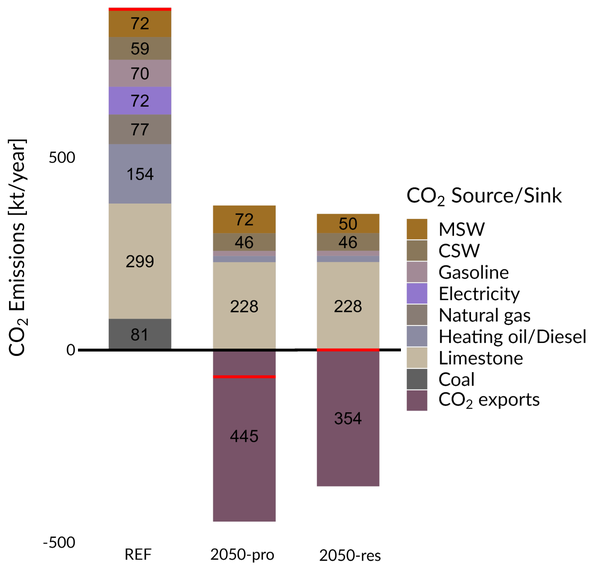
Technological solutions in the future system

2 technologies for point-source post combustion CO_2 capture:

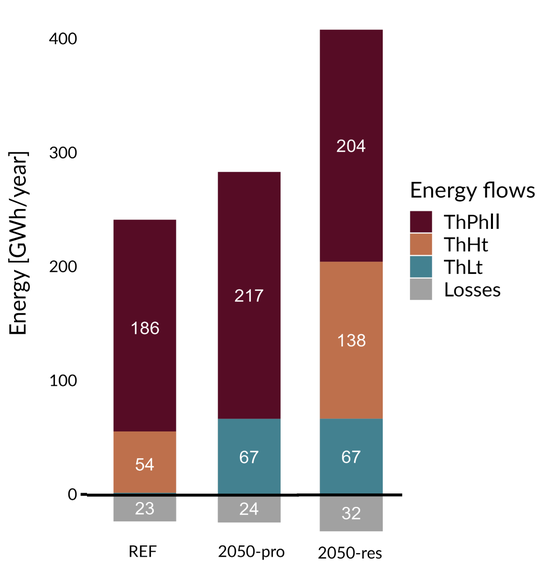
- Amine washing, primarily requires high temperature heat
- Hot Potassium Carbonate, primarily requires electricity



Fossil and geogenic CO_2 balance



Energy flows in Rheintal DHNs



- 2050 net-zero target in Rheintal is only achievable with **carbon capture** and **district heating networks**, complemented by electrification and building retrofits.
- System costs reduce through efficiency gains, local resources, and lower fossil imports.

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Link to the full article

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