Identification and Quantification of Excess Heat using Pinch Analysis

Competence Center Thermal Energy Systems and Process Engineering,
Lucerne University of Applied Sciences and Arts, Switzerland

Donald Olsen

Energy Future 2023 in Industry
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Swiss Energy Perspectives 2050+

- **Hydrogen production** at run-of-river sites (7 PJ)
- **1.5 million** heat pumps (today 0.3 million)
- **Wind and geothermal energy** with attractive generation profile
- **3.6 million** battery-powered cars
- **38.6 TWh** from hydropower (renewable net production)
- **34 TWh** from PV systems, 40% of production (today 2 TWh)
- **Biomass** for process heat
- **Expansion of heat grids** in urban areas
- **Cement and chemical plants** with CCS (2.9 Mt CO₂ pa)
- **Well insulated** buildings with low heating demands
- **High levels of efficiency** in industrial processes
- **Waste incineration with CCS** (3.6 Mt CO₂ pa)
- **Negative emission technologies**: storage in Switzerland (3 Mt CO₂ pa)

Prognos et al., Energy Perspectives 2050+
Energy use in Swiss industry

Approximately 20% of Switzerland's total energy use is for industry. More than half is for process heat.

Process Integration is key to decarbonizing industry

Process Integration is by far the most effective method to save energy and reduce CO₂ emissions in industry. **Pinch Analysis** is the most mature tool for energetic Process Integration.

SFOE Project “Evaluation of Pinch Analysis projects in Swiss Industry”\(^{(1)}\):

- 78 evaluated projects, covering 11% of total industrial energy consumption
- Median of thermal energy savings 22%
- Median of net savings per reduced tonne of CO₂ 310 CHF\(^{(2)}\)

\(^{(1)}\) until 2021, i.e. before drastic increase of energy prices
\(^{(2)}\) economic EEMs, for all EEMs 275 CHF/t CO₂
DeCarbCH
Swiss Federal Office of Energy Project (SWEET Call Funding)

The DeCarbCH project addresses the challenge of **decarbonization of heating and cooling** in Switzerland within three decades and it prepares the grounds for negative CO2 emissions.

Facilitate, speed up and de-risk implementation of renewables for heating and cooling in i) **residential** sector and ii) **service and the industry sector**

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### Questions

- How to realize large-scale thermal grids?
- How to realize weekly and monthly energy storage?
- How to initiate and accelerate change?
- How to...

### Solutions

- **Model-based/theoret. analysis**
  - The right combinations of technologies in the right place (guidance, archetype solutions)
- **Show that it works:** Developing, piloting and demonstrating (techn.) solutions
- **The right legal measures and involvement of actors, ensuring acceptance**
DeCarbCH
Pinch Analysis Projects Database

- Determining industrial energy demand profiles (quantity, quality, temporal), based on real data analyzed using PI techniques
- > 170 Pinch Analyses conducted and saved in a database
- The comprehensive database of evaluated Pinch Analysis projects include:
  - Process information, stream tables, scheduling information, economic data
  - Composite Curves, Grand Composite Curves
  - Potential and implemented energy efficiency measures (EEMs)
  - Utilities consumption
DeCarbCH
Sectorial Energy Demand Profiles

Aggregate individual company profiles of the studied sector and scaling them according to a factor based on total energy consumption or annual production of the sector.

The profiles allow the estimation for potentials of EEMs, renewables integration, etc.

Source: Ong et al. (2022), Construction of Sectorial Thermal Energy Profiles, Proceedings of the 25th PRES Conference, 5-8th Sept, Croatia
**DeCarbCH**

Sectorial Energy Demand Profiles – Chocolate and Meat Subsector

Energy demand profiles for **two sub-sectors** after implementation of EEMs:

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- **Heat recovery potential**: 21 %
- **Heat pump potential**: 50 %

- **Heat recovery potential**: 24 %
- **Heat pump potential**: 69 %
**DeCarbCH**

Exemplar Demand Profiles

Develop **exemplar profiles** for different processes from the sectorial profiles.

Using these profiles to generate energy demand profiles of a company.

Quantify opportunities for optimal integration of EEMs, renewable energy sources, **excess heat use**, etc.

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**Exemplar profiles: Composite Curves (CCs), Grand Composite Curve (GCC) and/or Sources and Sinks Profiles (SSPs)**
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Chocolate Sector Exemplar Profile – Slides removed due to confidentiality.
Annex XV Task 3
Subtask 1: Combination of methods for excess heat identification and quantification

**Question:** How can we combine i.e. process integration studies with more qualitative input from questionnaires and insights from studies regarding individual industrial branches to calculate excess heat potentials?

**Detailed Pinch Analysis** – Large effort involved to collect and analyse the data.

**Questionnaires** – Have not had good experience since not „core business of customer“ (Data was not indepth enough and incomplete).

Proposal: **Pinch Rough Analysis** as a combination of the two approaches.

Annex XV Task 3
Subtask 1: Combination of methods for excess heat identification and quantification

In Switzerland, pinch analyses are conducted by many engineering firms and industrial companies.

Financial support is provided by the Swiss Federal Office of Energy (SFOE) using two-stages:

**Stage 1:** Pinch Rough Analysis (Pinch „Grobanalyse“)

**Stage 2:** Detailed Pinch Analysis

In Switzerland, over 30 pinch rough analyses are performed annually.
Annex XV Task 3
Systematic Workflow of a Rough Pinch Analysis

Intensive 2-4 meetings with the key operational and engineering staff.
- Tour process on-site
- Define system boundaries
- Clarify which processes exist and understand their operation
- Gather process data and build data basis (no comprehensive measurement program)

Determination of the present state mass and energy use as well as associated costs.

Completion of pinch rough analysis to clarify and document possible operational improvements, heat recovery measures and excess heat potential.

Typical Effort is ca. 80 – 150 h.
Annex XV Task 3
Benefits of a Rough Pinch Analysis

**Process understanding:**
- Site layout and equipment structure
- Interconnections between different processes
- Basic schemas of key processes
- Operating cases
- Existing energy efficiency measures already in place

**Identification and rough quantification of key heating and cooling demands and their availability:**
- Schedule
- Temperature levels and heat loads roughly established

**Excess heat potential provided directly from the Composite Curves and Grand Composite Curves.**
Summary

- The use of industrial excess heat can enable companies to better pursue their economic and ecological goals and help industry in general to decarbonize their processes.
- The proper identification and quantification of excess heat is an important consideration to better assess and exploit the opportunities suitable for implementation.
- Process integration and its most well-known tool, pinch analysis, provides a practical and effective method to identify the potential and characteristics of the available excess heat.
- In the presentation, sector and exemplar profiles developed based on pinch analysis projects completed in Switzerland in the last years are presented to illustrate the concept of using pinch analysis for excess heat identification and quantification.
Summary cont.

- A proposal of a pinch rough analysis is made to provide an approach to combine methods for quantifying and characterizing excess heat ranging from the two extremes of a detailed pinch analysis to a questionnaire supplemented with a data base approach.

- This proposal was presented and elaborated in detail in the Annex XV Task 3 final report.

- The pinch rough analysis as well as detailed pinch analysis are supported by the Swiss Federal Office of Energy. The rough analysis provides the basis for the decision to do the more comprehensive detailed analysis.
Thank you