Opportunities and Benefits of Pinch Analysis in the Praxis

DecarbCH Lunch Seminar

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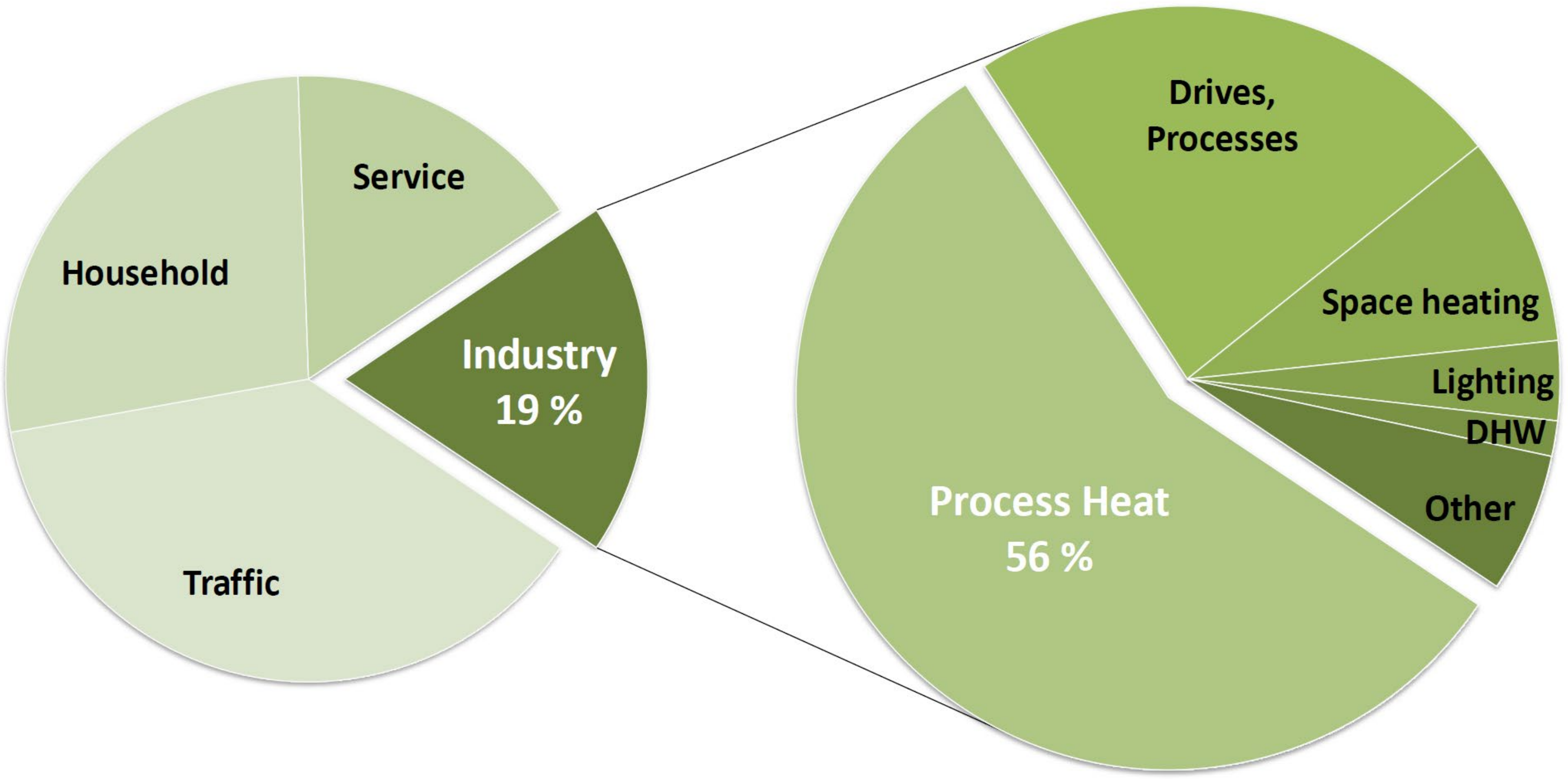
Agenda

- Brief introduction to Process Integration and Pinch Analysis
- Benefits, results and workflow of a Pinch Analysis
- SFOE support, Process Integration Center and PinCH software
- Case studies and overall energy savings potential
- Latest research and role of Process Integration in DeCarbCH

Energy use in Swiss industry

Approximately **19%** of Switzerland's total energy use is for industry. More than half is for **process heat**.



Source: Swiss Federal Office of Energy SFOE (2019)

Challenges in industrial energy optimization

- How energy efficient is the industrial process?
- What is the energy demand if the process was already fully optimized?
- How can a heat pump, CHP system, solar energy system, etc. be properly integrated?
- Where is the economic optimum for the investment and operating costs?
- How can this optimum be achieved?

Process Integration using Pinch Analysis provides the answers!

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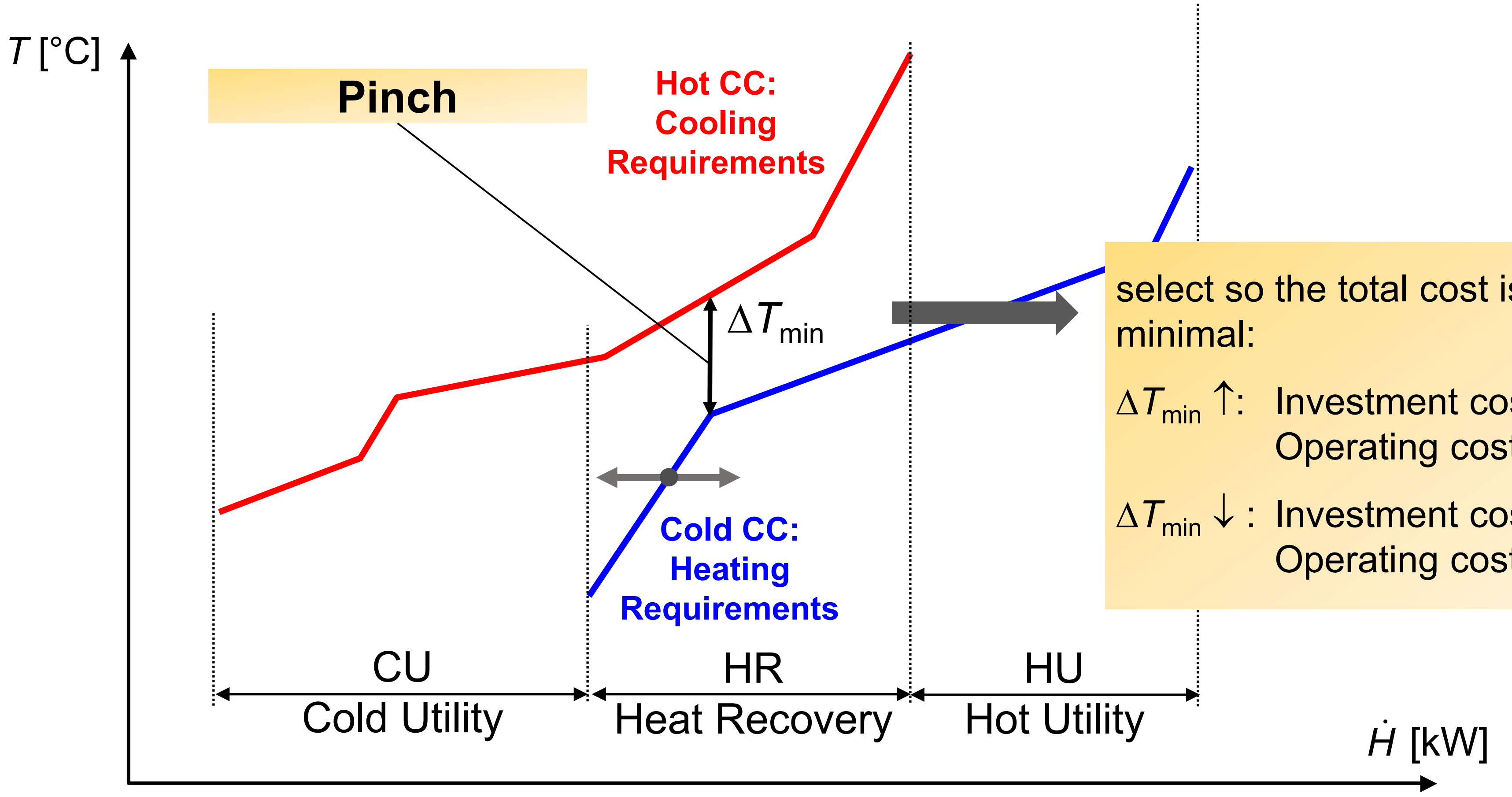
What is energetic Process Integration?

- **Another perspective** on industrial production and infrastructure processes
- **System orientated method** to determine the optimal energy input and plant design under the condition of minimal cost (investment and operation)
- «Energy optimization based on a **systematic approach** instead of Trial-and-Error.»

Pinch Analysis (PA): Most important **tool** for energetic Process Integration (PI)

Principle of Pinch Analysis: the Composite Curves

A process is abstracted into "streams" that have heating requirements (cold streams) or cooling requirements (hot streams) → the **Composite Curves** are the basis of PA.



select so the total cost is minimal:

ΔT_{min} ↑: Investment costs ↓
Operating costs ↑

ΔT_{min} ↓ : Investment costs ↑
Operating costs ↓

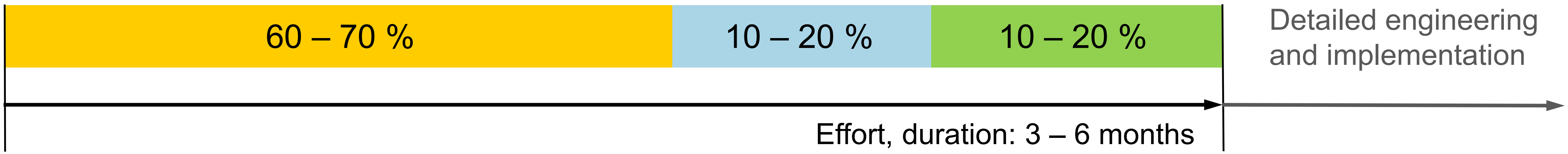
Benefits of Pinch Analysis

- Holistic optimization of
  - plant design
  - energy efficiency
  - utility systems
  - investment and operating costs (Capex/Opex)
- Comprehensive cost/benefit analysis and strategic planning of measures
- Reduction of the energy demand typically 10–40%

Results from a Pinch Analysis

- Determination of the absolute energy savings potential (retrofit and new plants)
- Optimized heat recovery and utility systems (steam, cold, renewables integration, etc.)
- Catalog of measures with technical and economic assessment

Workflow of a Pinch Analysis



- Analysis of present situation, data extraction, energy modelling, definition of process requirements
- Conducting of pinch analysis with software PinCH
- Elaboration of measures (efficiency, utilities, renewables, etc.), economic evaluation, prioritization

- A **suitable software tool** is necessary for the efficient completion of a Pinch Analysis project.
- The **definition of the process requirements** has the most far-reaching influence on the HR potential.
- Excel-based tools to **simplify the energy modelling** of unit operations are available («E-Modules»).

Support from the Swiss Federal Office of Energy (SFOE)

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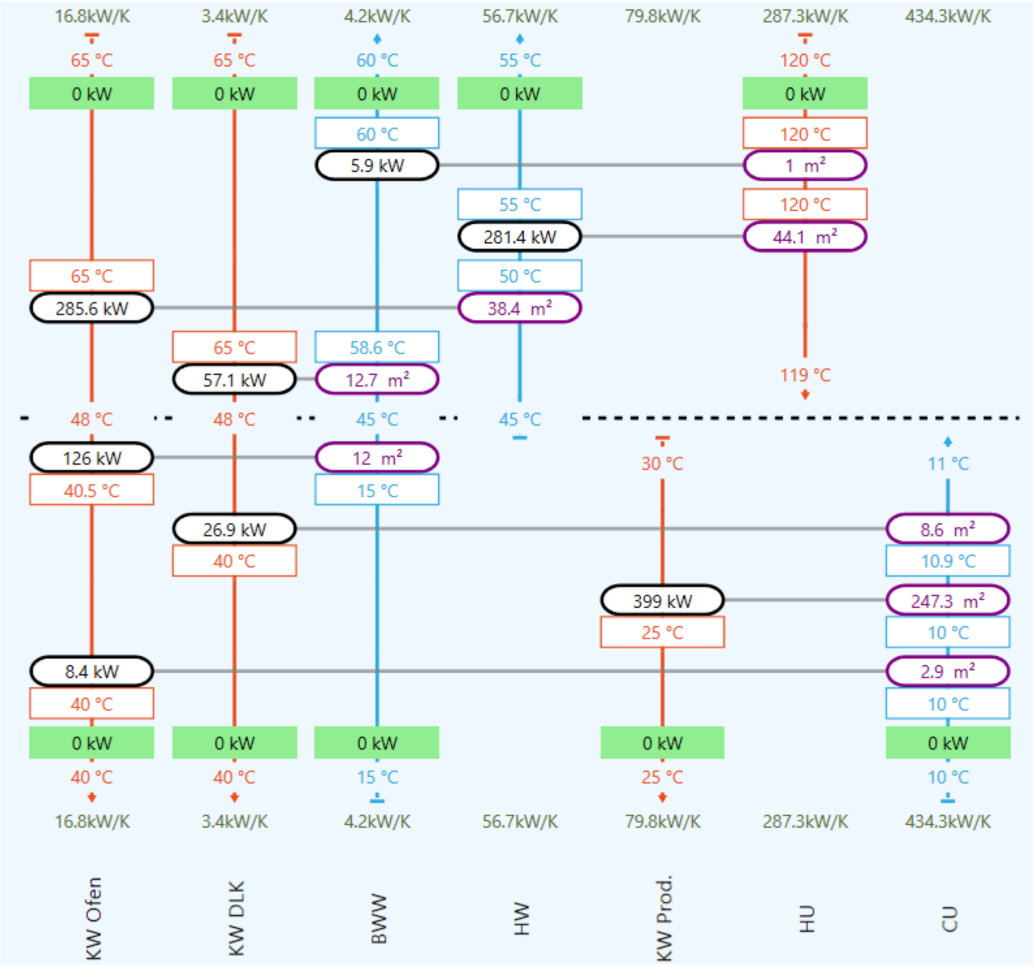
The SFOE supports financially two phases of a Pinch Analysis (PA):

- **Rough Pinch Analysis**:
  - rough quantification of saving potentials
  - identification of possible measures
  - recommendation detailed PA yes/no
- **Detailed Pinch Analysis**:
  - development of measures (efficiency, energy supply, renewables, etc.)
  - technical and economic evaluation
  - recommendations for strategic planning of implementation etc.

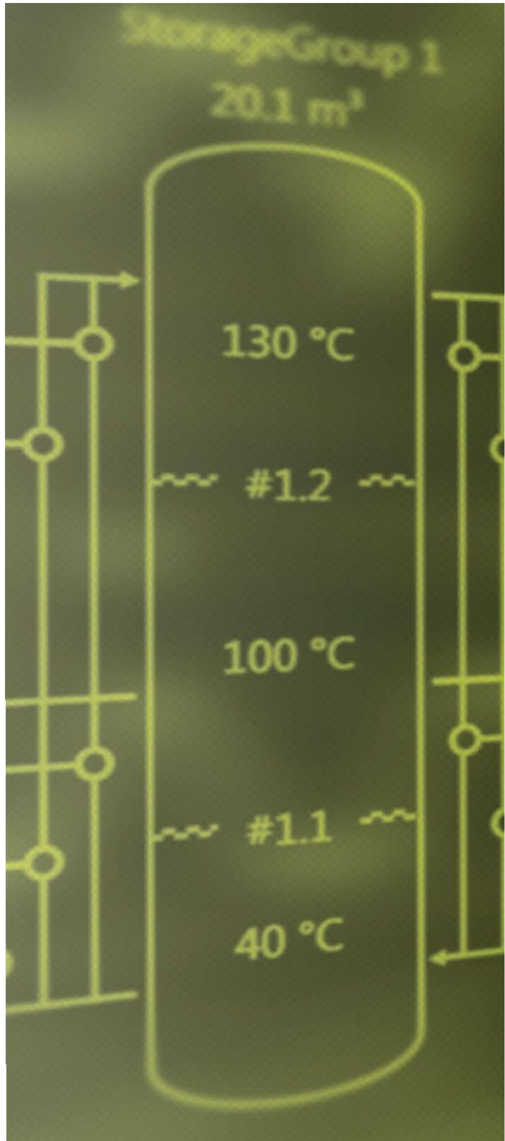


Heat Exchanger Network (HEN) metal processing company (PinCH 3.2)

SFOE Process Integration/PinCH Center at HSLU

- PinCH software development, maintenance and user support
- Consulting for industrial companies and engineering firms in the area of process integration and pinch analysis
- Continuing education courses, customized company training courses and individual coaching

www.pinch.ch

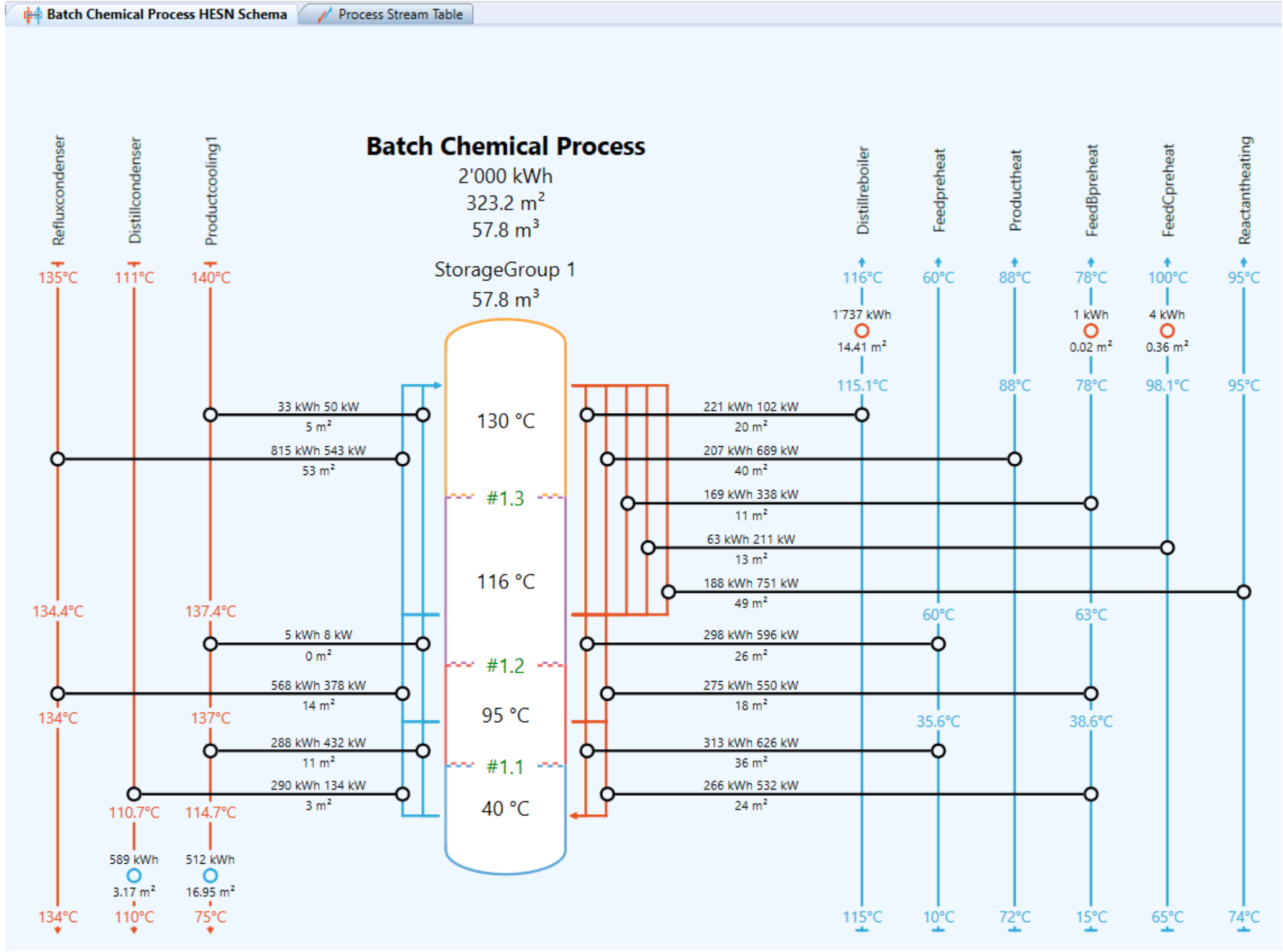


PinCH software

- A user-friendly software for the practical application of pinch analysis
- Guides the engineer step by step through the optimization
- Enables the rapid evaluation of different designs and scenarios

The development of PinCH is supported by the SFOE (EnergieSchweiz, Industrie und Dienstleistungen)

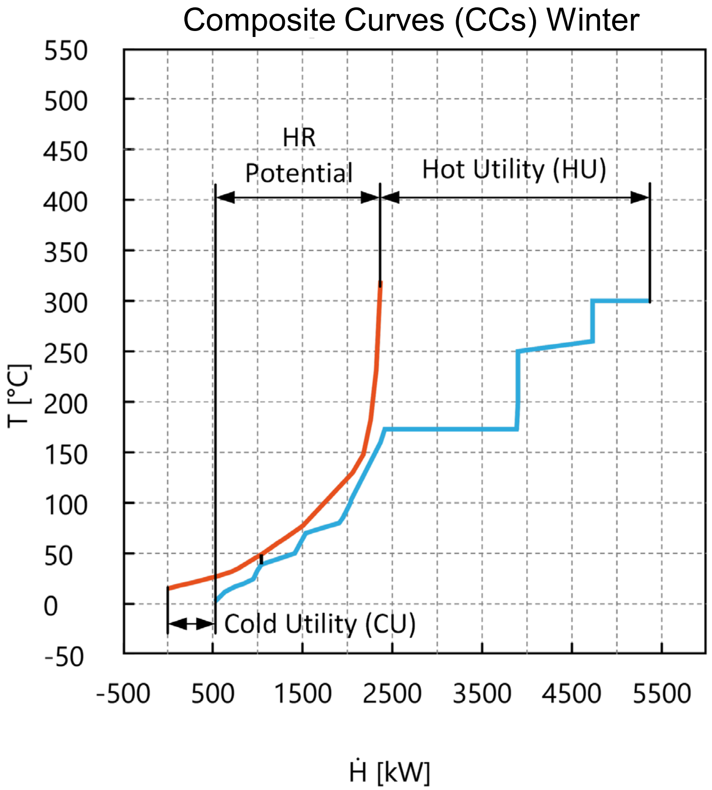
www.pinch.ch



Heat Exchanger and Storage Network (HESN) of batch chemical process (PinCH 3.2)

Example 1: Textile finishing

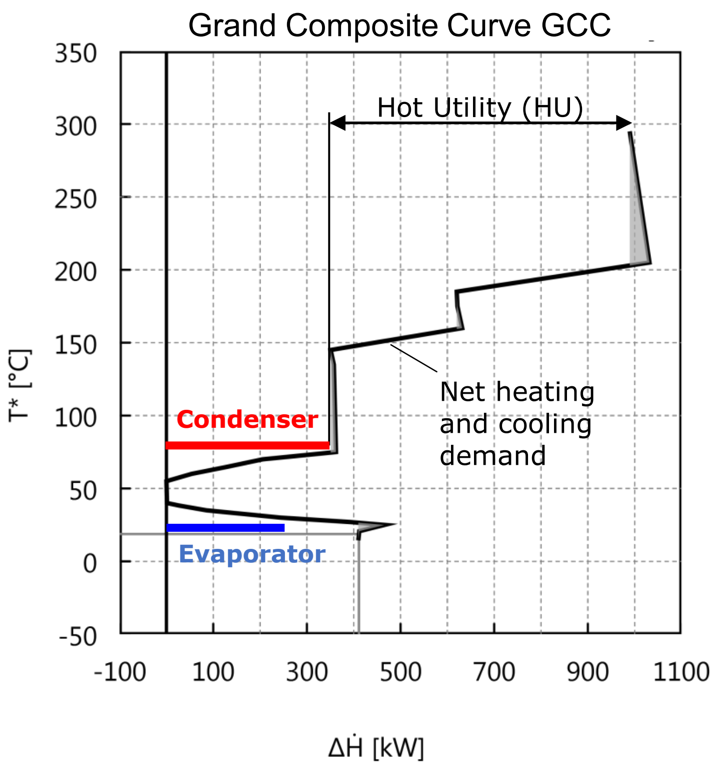
Identifying heat recovery potential of production processes and infrastructure systems:



- Pinch analysis with 55 energy streams (typical situation in Swiss Industry)
- Heat recovery potential: winter 1‘800 kW, summer 1‘300 kW

Example 2: Paint shop

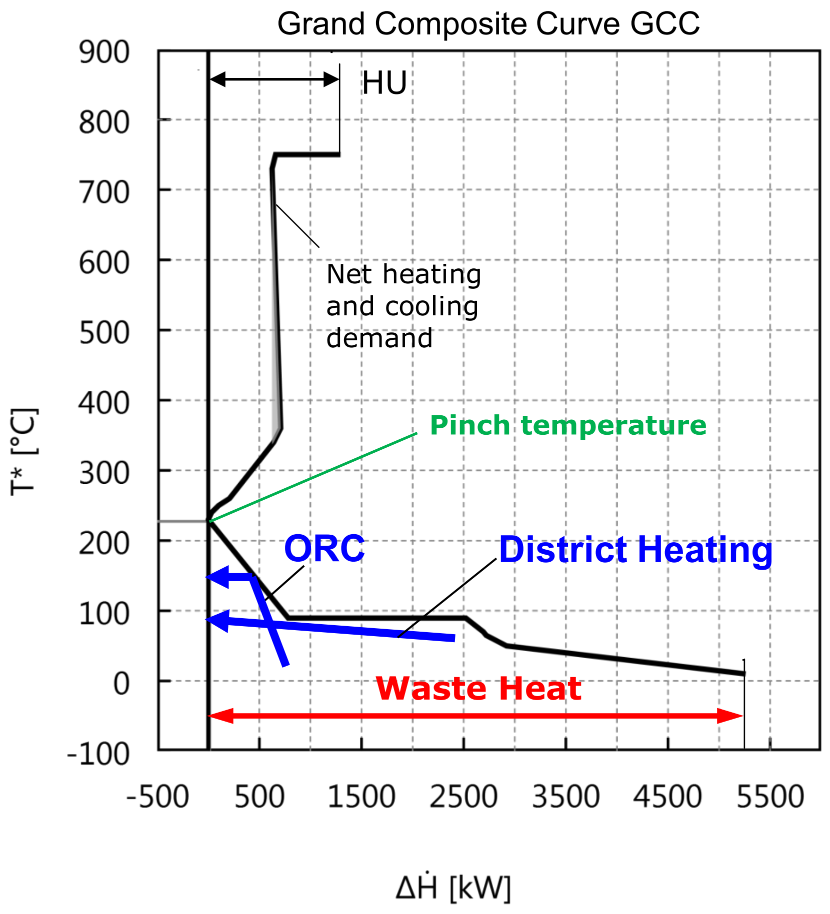
Pinch analysis is key to ensure the correct integration of a heat pump:



- Reduction in natural gas demand ca. 1.3 GWh/a (-30%)
- Payback approx. 5.5 years (for infrastructure acceptable)

Example 3: Mineral processing

Pinch analysis is the only feasible method in the praxis to identify and characterize waste and excess heat:



Comparison of an ORC plant vs. district heating: Expansion of district heating was implemented.

Example 4: Batch process in chemical industry

Demonstration in the PinCH Software

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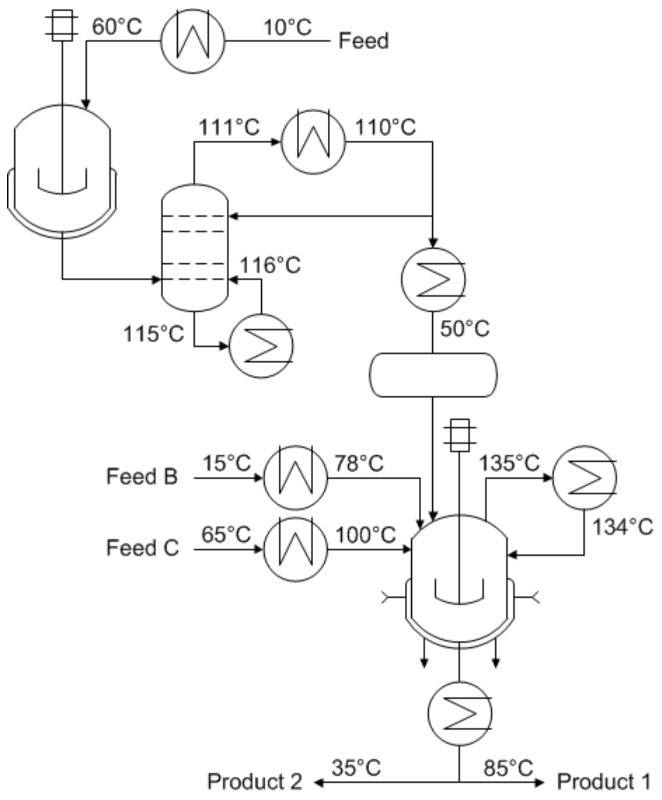
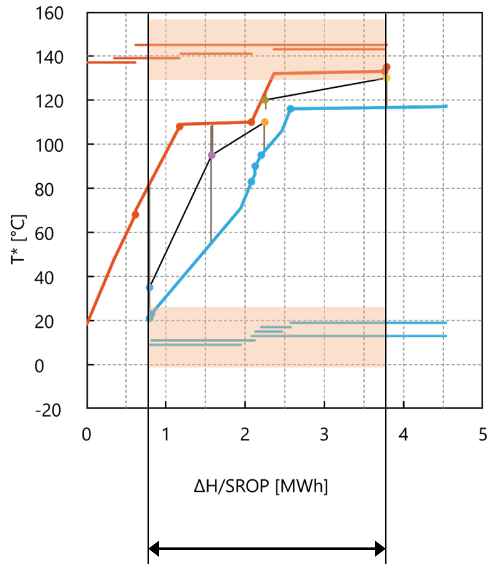
Batch plant

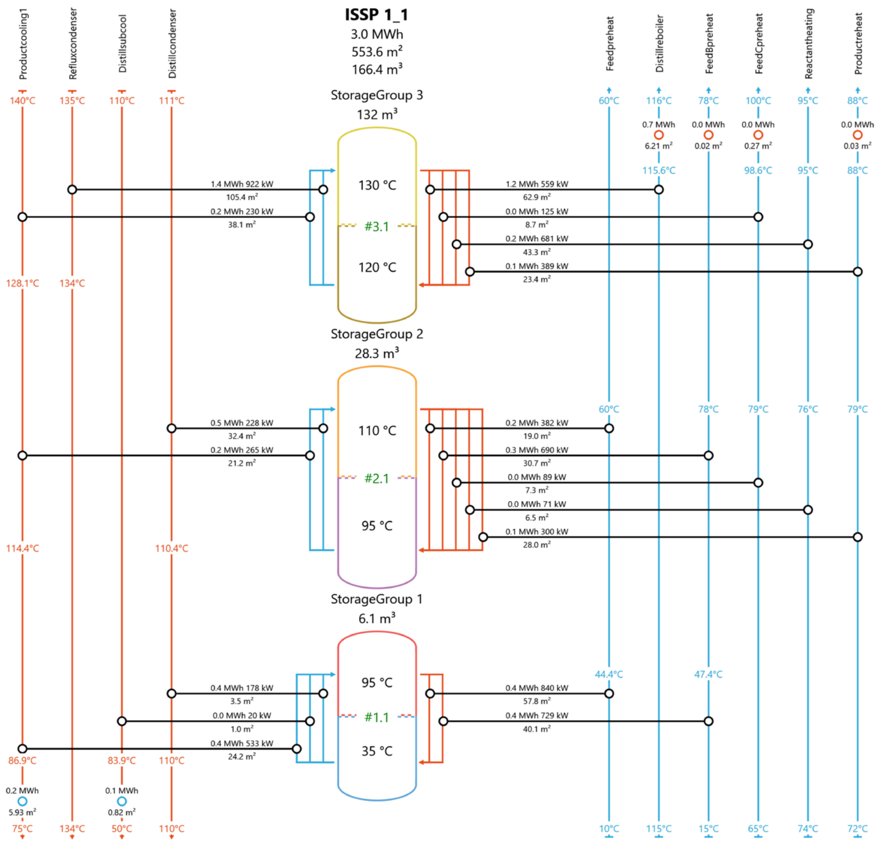


Indirect Sources and Sinks Profiles (ISSP)



Indirect HR potential (storage)

Storage integration



- Design thermal energy storage system: number, capacity, temperatures, HEN design, profitability, etc.
- Energy savings 3‘000 kWh/batch, static payback 3.6 years

Economic energy efficiency improvement potential using Process Integration

Conservative estimate for the Swiss industry sector:

Energy Savings [1]	min. 3 TWh/a
Reduction CO_2 emissions [2]	0.54 Mio. t CO_2/a
Net savings per reduced tonne CO_2 [3]	385 CHF/t CO_2

[1] only economic energy efficiency measures (EEMs) under today's conditions (investment costs, energy prices, CO_2 levy); saving potential including waste heat use measures (i.e. extended system boundary) at least double.

[2] only economic EEMs, without potential for renewable integration

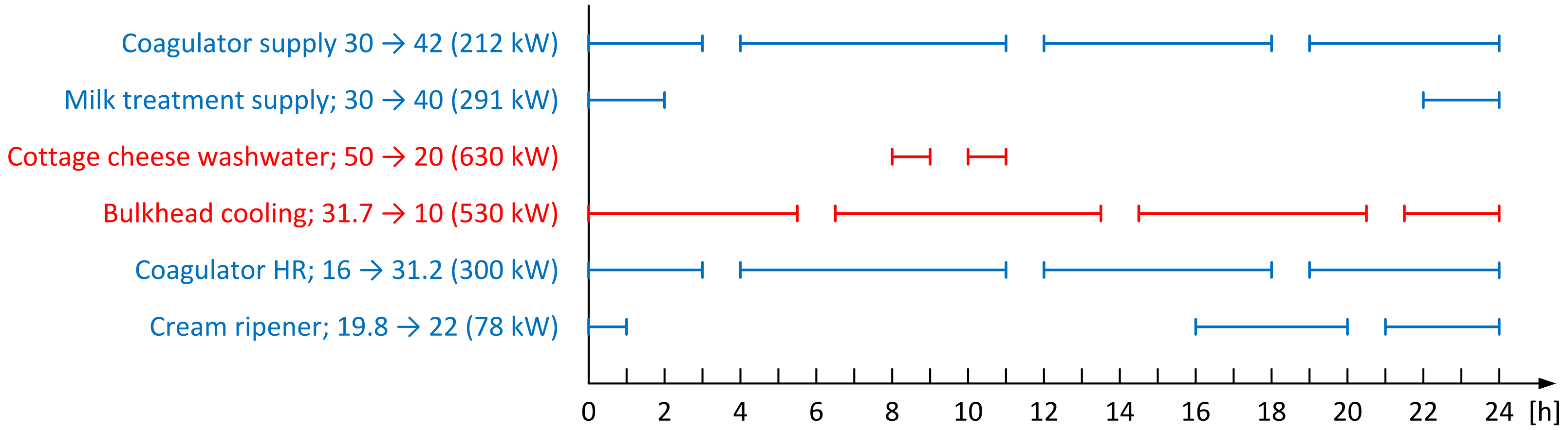
[3] negative CO_2 abatement costs for a mean economic lifetime of 10 years, static calculation

Process Integration is (by far) the most effective method to save energy in industry. With the use of additional methods and tools, Process Integration can also be applied in SMEs, i.e. the potential will be increased markedly in the future.

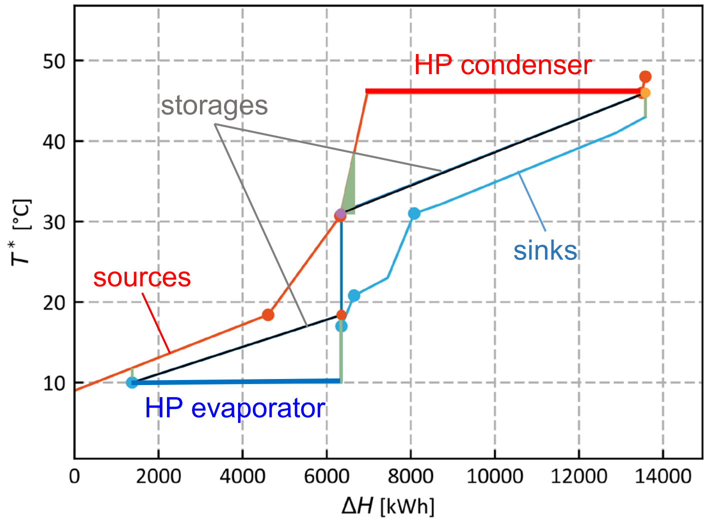
Actual research: Integration of heat pump and storage systems in non-continuous processes

- The vast majority of processes in Swiss industry is non-continuous → heat storage solutions are often the only possible optimization strategy (Indirect Heat Recovery, IHR)
- Development of a practical method for cost-optimal integration of heat pump and storage systems in non-continuous processes
- Workflow extends available practical Pinch Analysis tools (e.g. Indirect Source Sink Profiles, ISSP)

Case study cheese production plant:



ISSP (variant 4 on next slide)



Actual research: Integration of heat pump and storage systems in non-continuous processes

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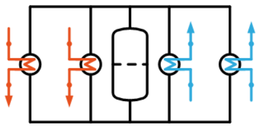
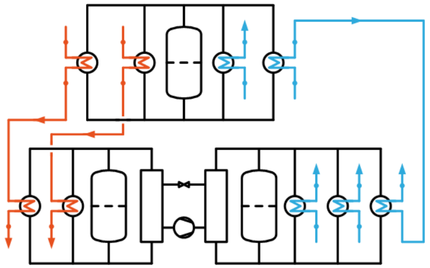
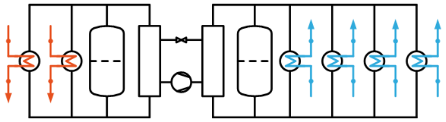
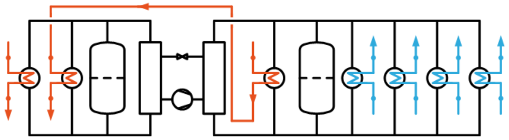
Case study cheese production plant: variant study

	Variant 1: **IHR only**	Variant 2: **IHR + HP split**	Variant 3: **HP only**	Variant 4: **IHR + HP combined**
				
Investment	280 kCHF	767 kCHF	659 kCHF	703 kCHF
Energy Cost Savings	44 kCHF/y	150 kCHF/y	131 kCHF/y	143 kCHF/y
Static Payback	6.4 y	5.1 y	5 y	4.9 y

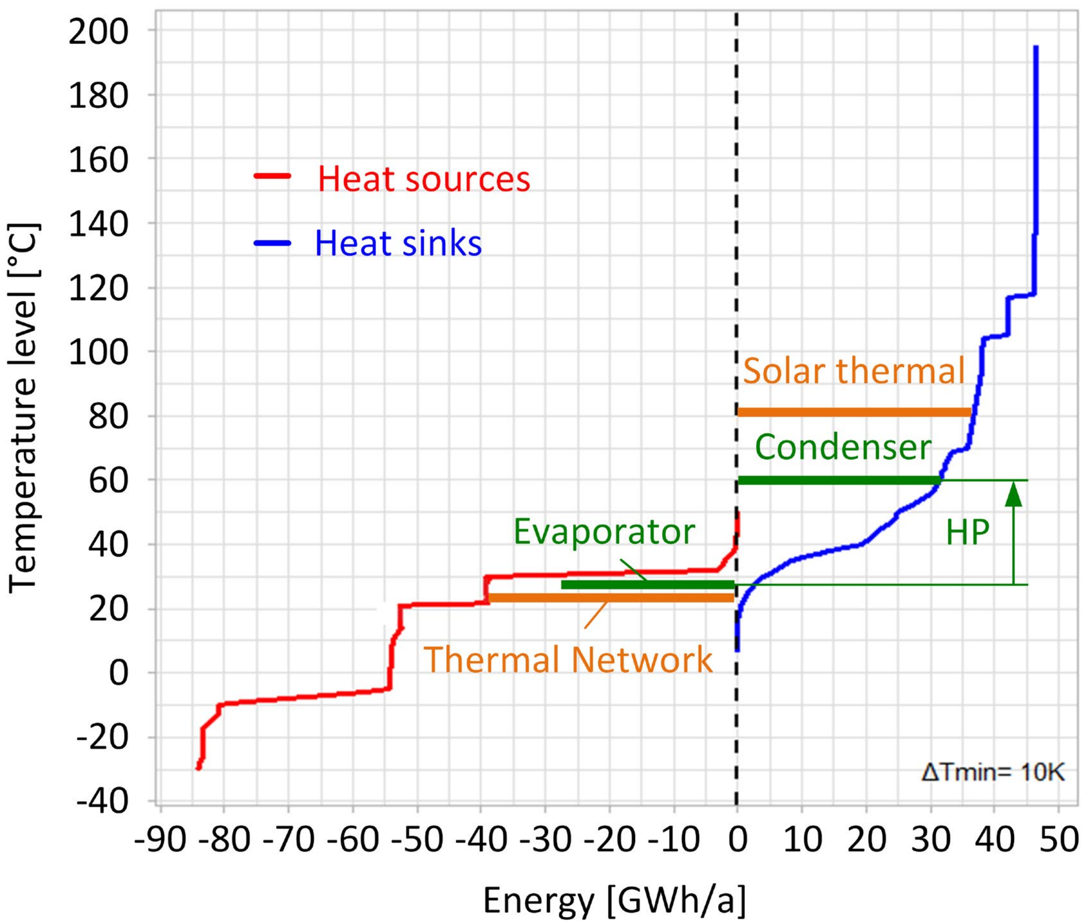
- System design, hydraulics, key component sizes and costs are computed automatically.
- Tradeoff between these systems are the economic efficiency and the complexity of solutions.
- Recommendation: Variant 3 likely is preferred due to less complexity.

Role of Process Integration in DeCarbCH

Process Integration as basis for:

- Determination of energy demand profiles at company level and sector level
- Optimal integration and implementation of
  - energy efficiency measures
  - renewable energy sources
  - fuel substitution
  - Negative Emissions Technologies (NETs)
  - excess heat use (e.g. in thermal grids)
- Development of practical methods and engineering tools as well as of decision-making tools

Energy demand profile for sub-sector «Meat» after implementation of energy efficiency measures



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Thank you for your time!

The pinch method leads to transparency and new perspectives on industrial processes and energy systems.