Advanced energetics

Short summary

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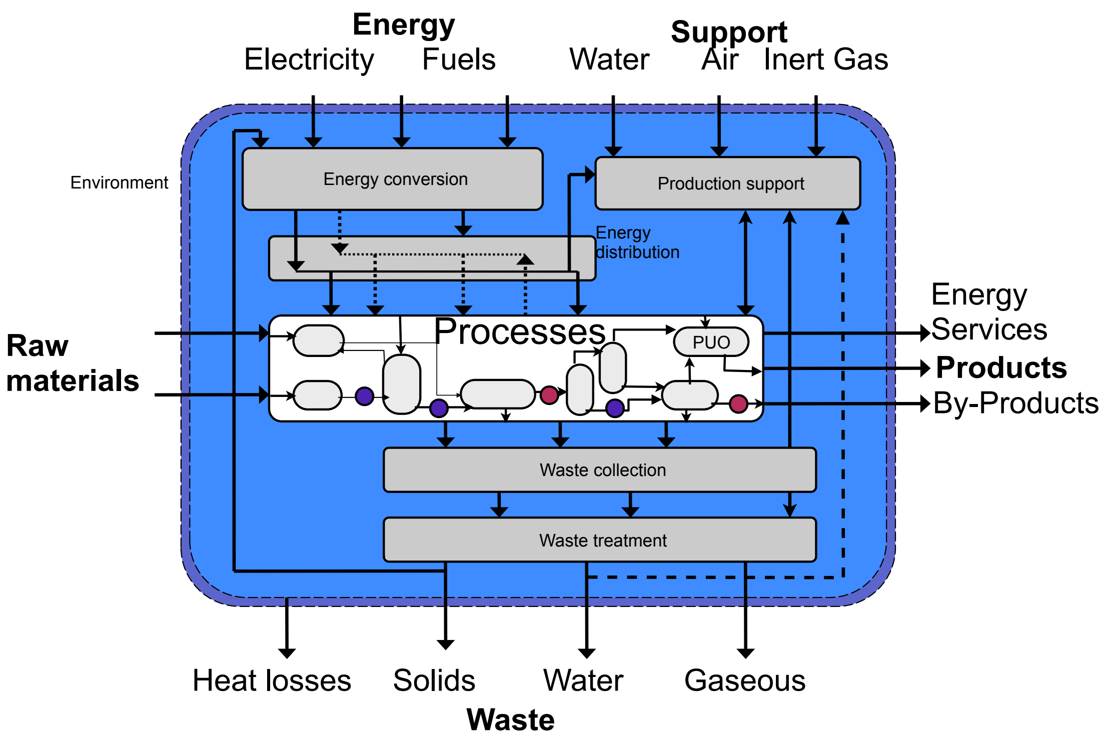
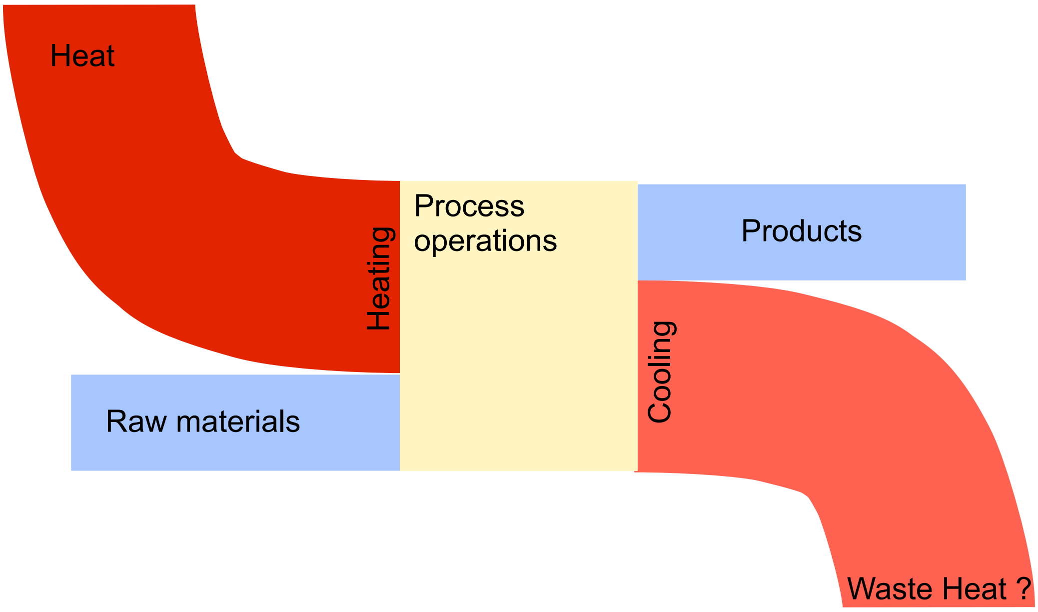
Process system analysis



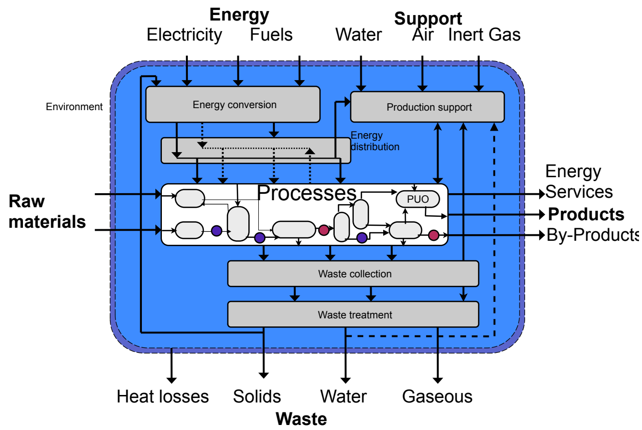
Understand the role of energy (and water) in the industrial processes

Energy usage



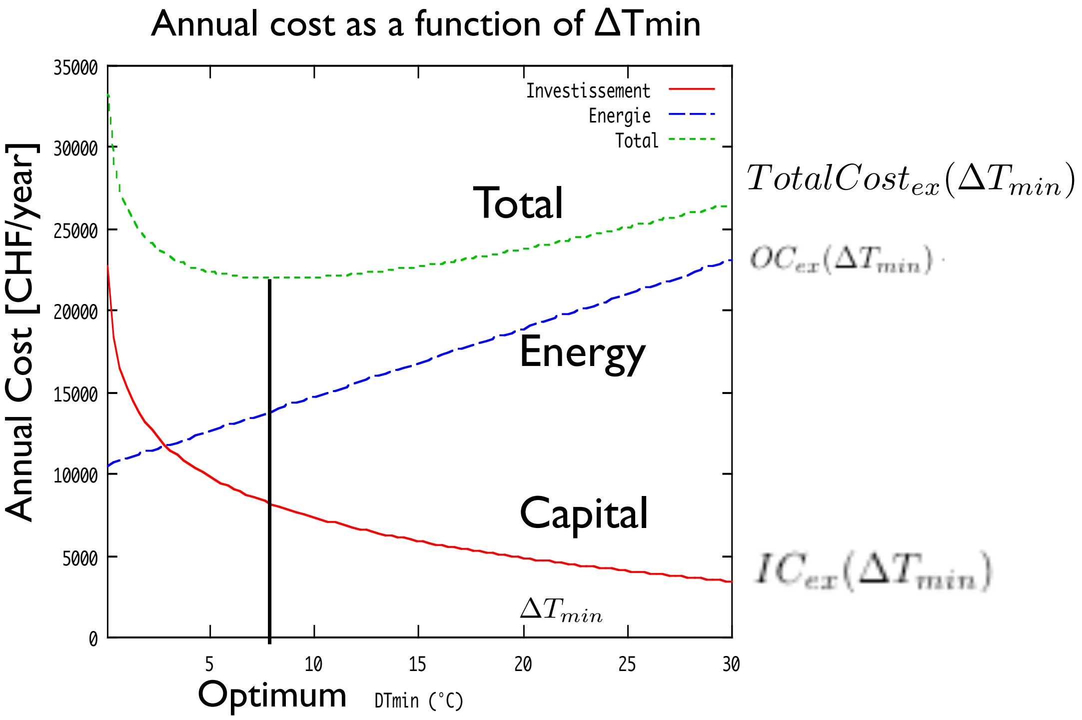
Process system analysis: understanding the role of energy

- **Energy system**
  - Energy conversion
  - Energy distribution
  - **Heat transfer**
    - **Heating**
    - **Cooling**
- **Process system**
  - Raw material conversion
  - **Heat transfer requirement**
    - ***streams to be heated***
    - ***streams to be cooled***
  - Unit operation
  - Products + Waste

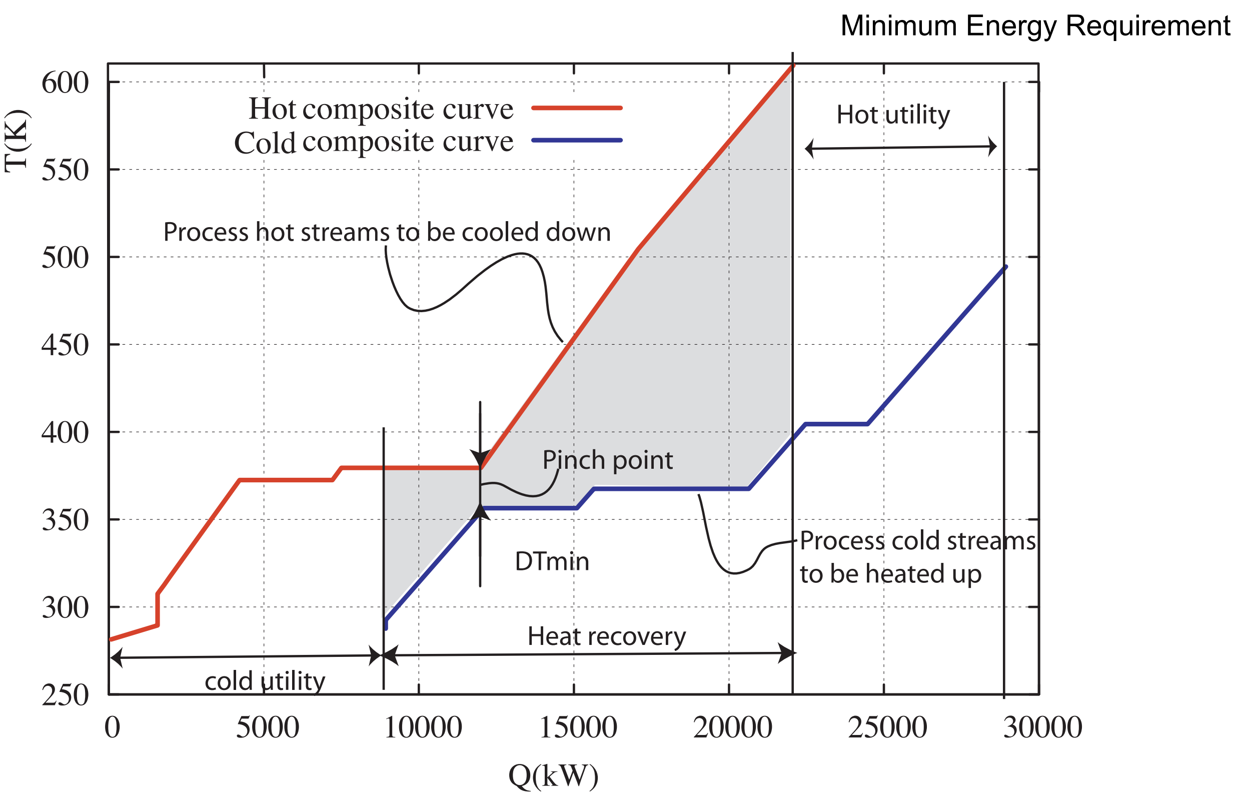


- ONION representation
- Exergy demand analysis

ΔTmin value : optimization problem

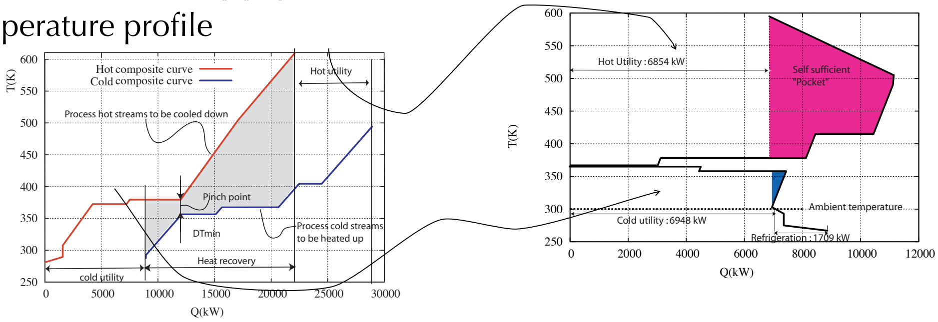


Heat recovery between hot and cold streams



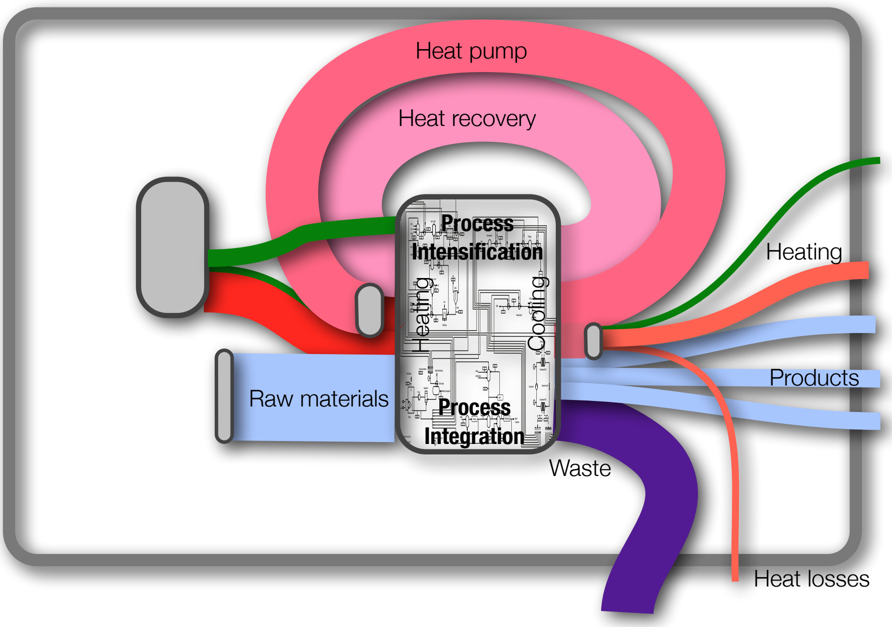
Results of pinch analysis

- **Maximum heat recovery**
  - Target of the heat recovery potential
    - System wide
    - The More in, the More out
    - Pinch point => 3 sub-systems : Sink, Source, Refrigeration
  - Penalising heat exchangers
    - what to modify
    - remaining problem analysis
  - Minimum heat to supply/remove
    - Temperature profile



  - Process Modifications for energy efficiency
    - Plus/minus principle

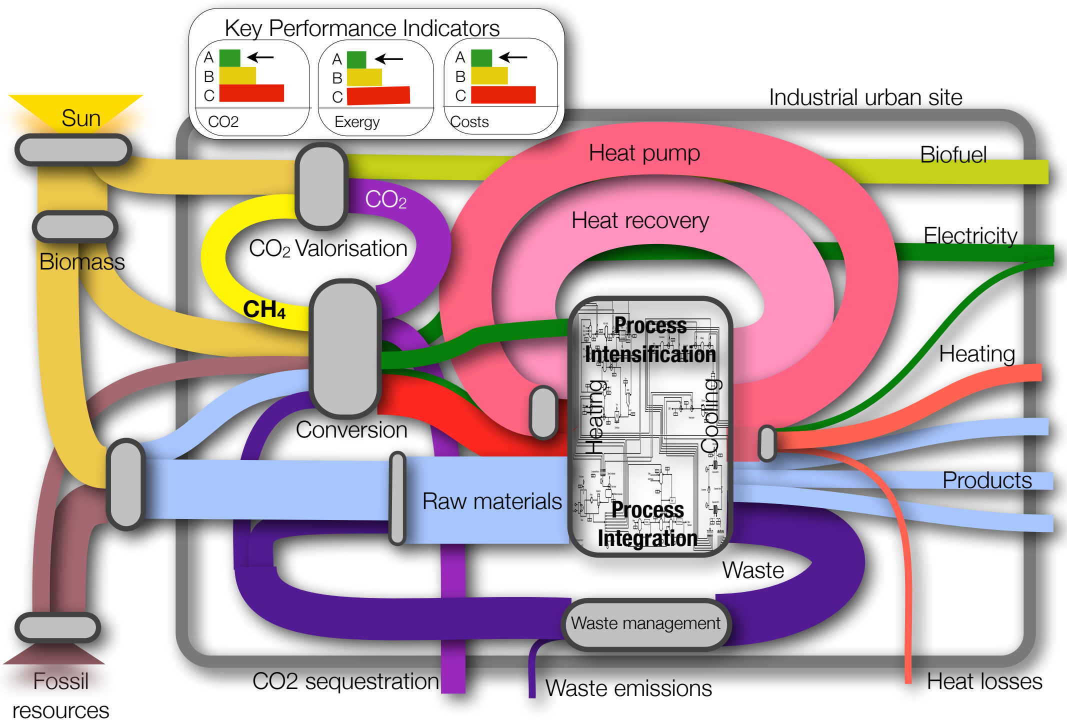
Heat recovery and valorisation



Energy conversion system integration

- **Utility streams**
  - Hot and cold streams => heat cascade
  - Combined heat and power (Electricity)
    - Optimal placement of heat pumps
    - Optimal placement of cogeneration units
  - Flows calculated for minimising the cost
    - Heat cascade constraints => multiple pinch points
    - Operating costs for each stream
    - Investment costs
- **MILP model for energy conversion system integration**
  - interrelated streams
  - balanced heat cascade
  - Y/N decisions
- **Target for all the streams considered**

Energy conversion system integration



Exergy analysis

- **Definition of the process needs**
  - Quality (T) of the heat transfer requirement
  - Definition of the heat transfer requirement
    - isothermal mixing
    - temperature enthalpy profiles
- **Analysis of the energy conversion system**
  - Exergy losses in the conversion process
  - Exergy losses in the system integration
    - Carnot composite
- **Use for the overall system integration**
  - minimise the area between the balanced Carnot composites

Designing heat exchanger network

- **Applying pinch design method**
  - Feasibility rules @ pinch points
  - Heuristic rules
- **Applying Heat Load Distribution**
  - MILP model => heat load from i to j
- **Heat exchanger network improvement**
  - HEN simulation & optimisation
    - EMAT vs HRAT
  - Loops and path
  - Thermo-economic evaluation
- **Practical considerations**
  - Feasibility
  - be pragmatic

Summary of the approach

- **Rational use of Energy/Water**
  - Heat recovery
  - Water (Solvant) recovery
  - Energy conversion
  - Waste management
- **Computer aided guide lines for engineers**
  - Target/synthesis
  - Evaluation
    - Technico-economic
    - Environmental
  - Engineering

Goals of the project

- **Apply the theory on a real scale example**
- **Write a report (is part of the grade)**
  - Clear
  - Concise
  - Guidelines can be found on
    - http://ipese.epfl.ch/Student Projects -> Documents
  - Needed for being accepted at the exam
- **Present and defend the results**

The exam

- **Oral exam (20 min/person)**
  - 3 min poster presentation
  - 17 min questions
- **Poster presentation (individual)**
  - A0 poster (Paysage) in pdf (will be displayed)
  - Free design
  - Summary of the project
    - Methodology applied
    - Major results obtained
  - Should allow to explain the whole project
    - is a support to what you will say
- **Examination goal**
  - Explain the theory and its application
  - Will not discuss the numerical details

Not to forget

- **Fill out doodle for exam scheduling**
  - see on the moodle
- **Project report**
  - How to write a report – on ipese website
  - Report examples: Exercises I to IV
  - Delivery date : **January, 14, 2014**
- **Prepare Poster**
  - Poster is not supposed to be self-explanatory:
    - Keywords (no entire sentences)
    - Graphical explanations
- **Do not forget the lecture specific objectives list**
  - together with the lecture notes

4 Detailed specific goals of the course

The following tables should help you assessing your progress. By filling the bullets you should be able to follow your progress during the lecture.

4.1 Minimum Energy requirement

	Goals
ooooo	Compute the energy bill of an industrial system
ooooo	Explain what is the meaning of the $\Delta Tmin$ and what are the major parameters that define its value
ooooo	Define hot and cold streams for a process integration analysis
ooooo	Compute the energy balance of an industrial system including the application of First Law balances to verify the coherency of the data set.
ooooo	Explain the construction of the hot and cold composite curves
ooooo	Explain the construction and the use of the grand composite curve
ooooo	Compute the maximum energy recovery in an industrial process and compute its minimum energy requirement
ooooo	Explain the major assumptions and how these can be assessed or overcome
ooooo	Estimate the heat recovery heat exchanger network cost and compute the optimal $\Delta Tmin$ value of the plant.
ooooo	Identify and quantify pinch violations in a process
ooooo	Explain the More-in More-out principle
ooooo	Explain the plus-minus principle
ooooo	Identify ways to improve the minimum energy requirement from the analysis of the composite curves