LENI Systems

Strategy for the identification of optimal exploitation schemes of geothermal systems

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1. Context

Shallow and deep geothermal resources can be used to produce different energy services, such as district heating, electricity and cooling. Some of these services vary throughout the year. To provide them, different conversion technologies can be used. In order to identify the **most efficient and economical possibilities for geothermal system exploitation**, all the different system components have to be modeled and their interactions considered.

2. Objectives

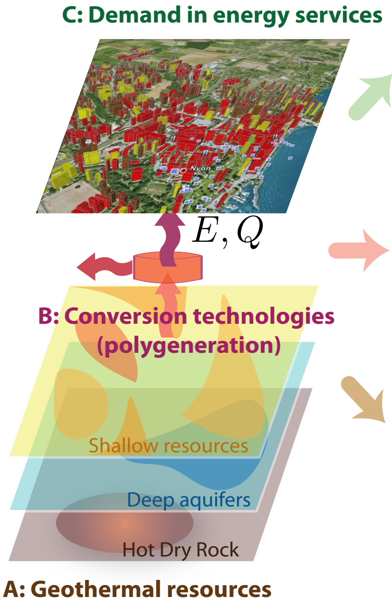
Main objective of the research is to establish a **systemic methodology** to help decisions makers in **identifying the optimal exploitation schemes**. Typical questions to be answered are:

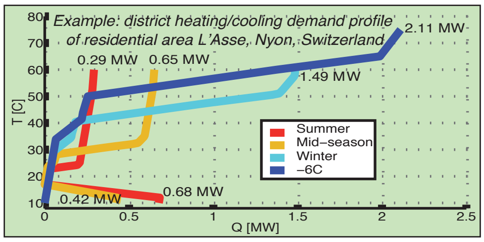
- Which type of geothermal resources have to be exploited and how?
- What is the potential for heat seasonal storage in aquifers?
- How do we target simultaneously economical profitability, thermodynamic efficiency and minimal environmental impacts?

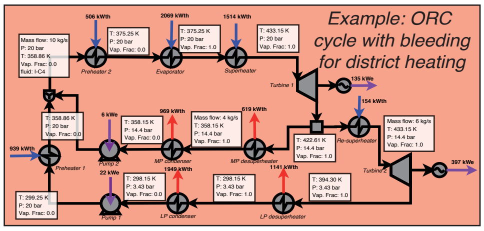
3. Methodology

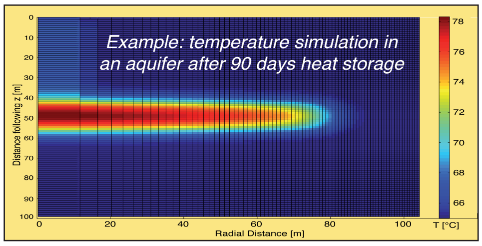
Overall system is considered, divided in 3 subsystems:

1. potential **resources** that have been identified as exploitable by geologists at a given location
2. potential **technologies** to convert geothermal energy in useful energy services
3. varying **demand** in multiple energy services at the location









GIS-based software for identification of energy needs in urban areas

Multi-period profiles:
- Fixed district heating
- Fixed district cooling
- Variable electricity

Superstructure:
- Flash systems
- Binary cycles
- Heat pumps

Flowsheeting software:
- Operating conditions
- Thermodynamic states
- Heat loads

Exploitation modes:
- Heat injection
- Heat extraction
- Heat storage

Computed parameters:
- Temperature level
- Heat available

3.1. System modeling

Each subsystem is first modeled and simulated separately:

1. **exploitation conditions** of different geothermal resources
2. superstructure of conversion technologies with given **operating conditions**
3. demand profiles for given **periods**

3.2. Process integration

Overall system is integrated using process integration techniques:

- based on **pinch** analysis (hot and cold heat streams identification)
- allows for **heat exchange synthesis** and optimal selection of:
  1. geothermal resources to be exploited
  2. technologies to be used and their optimal size

3.3. Performance indicators calculation

Performance of the configuration obtained by simulation and integration is calculated, for each period and on an average basis:

1. **economic** indicators.: investment and operating costs, annual profit
2. **thermodynamic** indicators: energy, exergy and electrical efficiencies

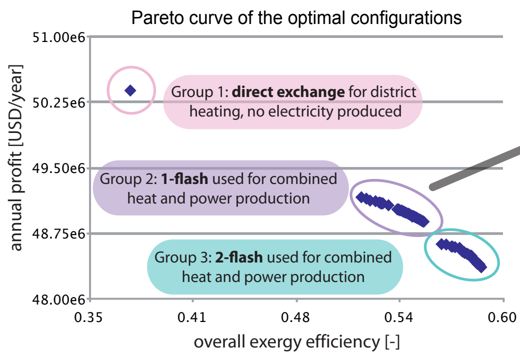
» *further used as objective functions in optimization problem*

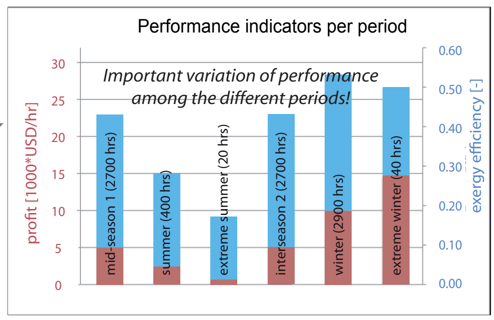
4. Preliminary results

Use of genetic evolutionary multi-objective algorithm to calculate **trade-offs** and optimal configurations in a Pareto curve.

Example scenario with decision variables for optimization:

Decision variable	Range
Hot Dry Rock 180°C	yes/no
Deep Aquifer 90°C	yes/no
Shallow Aquifer 12°C	yes/no
Flash system	none/single/double
flash drums pressure	2-10 bars
dT cond.	1-5 °C





5. Perspectives

1. Thermo-economic comparison of **process design** options
2. Integration of summer **residual heat storage** in the process integration part for usage in winter, using the multi-period approach
3. Extension of performance calculation to the environmental impacts by integration of **Life Cycle Assessment**
4. Validation of the methodology by application to **case studies**

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