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

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:

<table>
<thead>
<tr>
<th>Decision variable</th>
<th>Range</th>
<th>Group 1: direct exchange for district heating, no electricity produced</th>
<th>Group 2: 1-flash used for combined heat and power production</th>
<th>Group 3: 2-flash used for combined heat and power production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Dry Rock 180°C</td>
<td>yes/no</td>
<td>51.00e6</td>
<td>50.25e6</td>
<td>49.50e6</td>
</tr>
<tr>
<td>Deep Aquifer 90°C</td>
<td>yes/no</td>
<td>49.50e6</td>
<td>48.76e6</td>
<td>48.00e6</td>
</tr>
<tr>
<td>Shallow Aquifer 12°C</td>
<td>yes/no</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash system</td>
<td>none/single/double</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash drums pressure</td>
<td>2-10 bars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dT cond.</td>
<td>1-5 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Acknowledgements: Competence Center Environment and Sustainability for the funding of this research, Prof. Aurèle Parriaux and Dr. Laurent Tacher of the Laboratory of Engineering and Environmental Geology of EPFL for their collaboration and advises on geological issues, Mr. Michael Hoban and Mr. Cédric Dorsaz for their contribution to this research in the frame of their studies.