Anergy Grid for Enhanced Energy Efficiency of Campus Buildings

ETH Zurich, Switzerland
Campus Science City (Hönggerberg)

A campus grows – built on a sustainable energy concept
Science City is part of „The City of Science“ Zurich

ETH Science City (Hönggerberg)

Univ Irchel

Technopark

ETH Zentrum University

Slide: Prof. G. Schmitt
The Science City Campus, 2010
The Science City Campus, 2025

- Total area = 442‘000 m², effective campus area = 320‘000 m²
- Small units encourage networking
- Max. building height = 544.5 meters above sea level
Sustainable energy concept for the campus

The concept follows a clear strategy
ETH Zurich Energy Strategy

Awareness campaigns

Optimizations of operation (facilities / infrastructure)

New, energy efficient buildings, Reconstructions/retrofittings

Energy concept „ETH Science City“

Energy concept „ETH City Centre“

- Energy use during standby
- Optimal use of heat and light

- Main energy consumers:
  - Chillers, A/C, servers, lightning, etc.

- Minergie, Minergie-P
- Use of waste heat, innovative concepts

- Dynamic geothermal storage
- Concept of „Anergy“
- Reduction of temperature difference for heating and cooling purposes
- Use of heating pumps and renewable energy

Energy concept „ETH Science City“

Ethnic concept „ETH City Centre“

New, energy efficient buildings, Reconstructions/retrofittings

Optimizations of operation (facilities / infrastructure)

Awareness campaigns
Targets of new energy concept

- Safe and **sustainable energy supply** (heating and cooling) for the growing campus.
- **Low emissions**, reduction of CO₂ emissions by 50% in absolute figures despite of ongoing growth (CO₂ emissions include emissions from electricity).
- Focus on **high security of energy supply** (mix of energy sources and redundancies)
- **Focus on life cycle costing**
  High cost efficiency (low life cycle costs)
- **Low usage of primary energy**
  Use of waste heat (→ anergy), reduction of exergy...
Rational

- Buildings with **high energy efficiency have become today’s standard.**
- **To increase the energy efficiency, the focus must be enlarged to the neighbourhood of the building**, the entire area, or the campus in this case – including all of its buildings – to enable the use of a wider energy efficiency potential.
- Not only electrical but **also thermal grids between buildings should be created**. Such thermal grids enable the transfer of waste heat from one building to another in the neighbourhood. These thermal grids with low temperatures (12 to 18 °C) and bi-directional supply
- Buildings which are a part of such an anergy grid draw energy for the operation of a heat pump and/or supply waste heat from the cooling system into the grid.
- In addition to that, these **anergy grids can be supplemented** with seasonal geothermal storage, solar heating systems and natural air cooling systems to keep the anergy use and the anergy supply in balance.
A new way of improving energy efficiency of campus sites
Illustration of the overall grid for Science City

- **Consumers**
- **Distribution network**
- **Extraction/storage**
  - Earth probe field
    - HWO
    - HCL – HPS
    - 400 Probes
    - 128 Probes

- **Distribution cluster**
  - HPP, HPS, HPZ
  - HWO
  - HPL

- **HEZ main heating unit**
  - Discharge of excess energy

- **Ring circuit of approx. 1 km**
  - Warm
  - Cold
  - Freecooling
All buildings on the campus are connected to the anergy network (3 loops)
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The technical background
Project Details

- Project investments: approx. CHF 40 Mio.
- Use of „Anergy-Grid“ (geothermal storage):
  - heating 15 GWh/a
  - cooling 13 GWh/a
- Project duration: 2003 – 2025
  - 1. phase 2012 (completed)
- Size of geothermal storage: 4 Mio m³
- Energy related area: 400'000 m²
- CO₂ reductions: up to 10'000 T/a
Technical Details

- Energy carrier: water
- 5-9 storage fields
  - depending on needs for cooling and heating
  - modular development until 2025.
- Total amount of geothermal probes: approx. 800 (approx. 200m depth)
- Costs per field: approx. 1.5 - 2 Mio.CHF
- Expected COP for heating: approx. 5 - 6
- Expected COP for cooling: approx. >10
Expected temperatures in the dynamic ground storages (Model - year 25 of operation)

- max. inlet temperature (21 °C)
- min. outlet temperature (2 °C)
- min. design temperature (-1.5 °C)
- lower limiting icing temperature (-5 °C)
Expected amount of energy storage in the ground (typical year, after 10 years of operation)
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Current phase of the project
Construction work of the geothermal storage
Construction work of the Anergy Grid
Current (critical) phase of project

- **First buildings connected to the system** in February/March 2012 -> HPZ and HPP, LowEX and Minergie building.

- **First „sub-station“ is in operation** (heating pumps and cooling units)

- Technical **difficulties during commissioning of heating pump – solved.**

- A **monitoring and optimizing working group was formed** (4 people from facilities and 2 external experts)
  - Close monitoring of commissioning process
  - Analysis of performance data of the system
  - Ongoing optimization of the system (e.g. hydraulics and operation of the storages).

- **New lab building will be connected to the system in April 2012** (2nd substation)
Progress of CO$_2$ reduction on the Science City campus

- Business as usual
- Measured data
- Forecast (incl. renovations)
- Forecast (incl. renovations & anergy)
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Teamwork for success
Lessons learned

- The construction of a new infrastructure is a process that takes years and decades to complete.
- The campus owner ETH Zurich needs the motivation and dedication to support the project over a long period of time, until the set goals have been reached.
- The transparent internal communication and the support of the university management are vital for such a project.
- It is also important to divide the entire projects into several fractions, build it step by step and communicate the success of each step.
Project partners involved

- ETH Zurich
  - ETH real estate management
  - ETH facility services
  - ETH SSHE
- External (Engineering and Consulting)
  - Amstein und Walthert AG
  - Lauber IWISA AG
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Outlook
We may have to much energy... 

Data modelling shows that the anergy grid may store enough energy to provide excess heat to the ETH Zurich neighbourhood. Making the grid even more attractive...
„A campus has much more potential to improve energy efficiency by connecting the buildings in a grid than is the sum of all energy efficiency potentials of individual buildings“