LEUPHANA
UNIVERSITÄT LÜNEBURG

Klimaneutraler Campus
Leuphana Universität Lüneburg
-
Energiekonzept und Umsetzung

Oliver Opel

27. September 2017

Europa fördert Niedersachsen

EUROPÄISCHE UNION
Europäischer Fonds für regionale Entwicklung

Gefördert durch:
Bundesministerium für Wirtschaft und Technologie
aufgrund eines Beschlusses des Deutschen Bundestages

Medium-sized town: 72.500 people
Close to Gorleben, projected
Nuclear Waste disposal site

50 % renewable electricity (100 % by 2021)
25 % renewable heat (7 % with industry)
4 local heating networks

- CHP / Vessels
- Biomethane / natural gas
- ~20 % bioenergy land use in the region

University:
9500 students
1100 Staff members
The Campus has 50 % share
of one local heating network

Sustainability Implementation: Milestones at the Leuphana University

Year	
1996	**Foundation of the interdisciplinary department „Environmental Science“** Paradigma: 50 % natural and 50 % social sciences
1997	Joining the “University Network for Sustainability”, COPERNIKUS Campus
1999	Founding of the senate commission “Agenda 21”
1999	Project “Agenda 21 and University of Lueneburg” (1999 - 2001)
2000	**Implementation of the EMAS management and reporting scheme** Staff (1 Pers. 50%), guidelines, 2 year reporting cycle (ISO 14001)
2001	Research and development project “Sustainable University“ (2004 - 2007)

Sustainability Implementation: Milestones at the Leuphana University

Year	
2003	Conversion to a foundation under public law: **More freedom in decision-making**, also relevant for building and energy management
2005	Bestowal of the UNESCO Chair “Higher Education for Sustainable Development”
2006	Decision of the senate for a **„humanis-tic, sustainable and action-oriented“** university for the 21st century
2007	**Definition of the goal: climate neutral university**
2007	First overall sustainability report “Steps to the future”
2008	Emphasis on sustainability research as one of four initiatives
2010	**Foundation of the Faculty Sustainability**

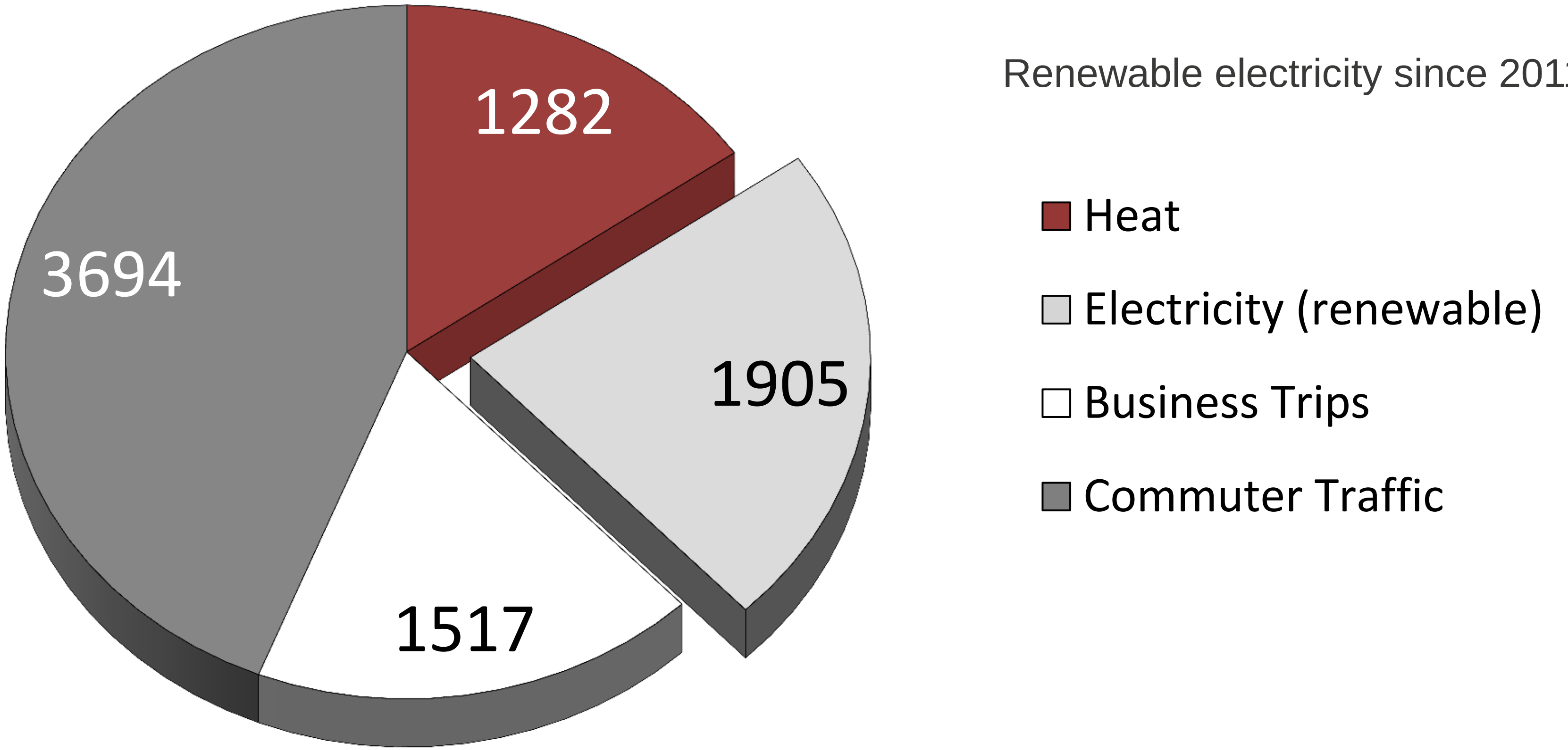
Emissions: Zero Carbon?

CO_2-Reduction	Timeframe	Action
3.5 t	per year	New lighting system in the gym
22 t	per year	Photovoltaics on the roof of the gym
1500 g	per kWh food	Green Canteen (organic, vegetarian food)
?		Climate-neutral mail (GoGreen)
?	per year	New efficient lighting system in the library
22 t	per year	Refurbished local heating network (2010)
?	per year	Use of biogas for heating of the Volgershall campu
3.3 t	per year	Photovoltaics on the roof of building 9
19.5 t	per year	Optimization of the lighting scheme in the library
21 t	per year	Optimization of the cleaning scheme in the library
90 t	WS 06/07	„dont waste energy“ campaign
6.6 t	WS 04/05	„Energy Trophy“ campaign
10 t	per year	Heat savings between christmas and new year
4.4 t	WS 01	Campaign in one building
21 t	per year	Technical optimization in building 14

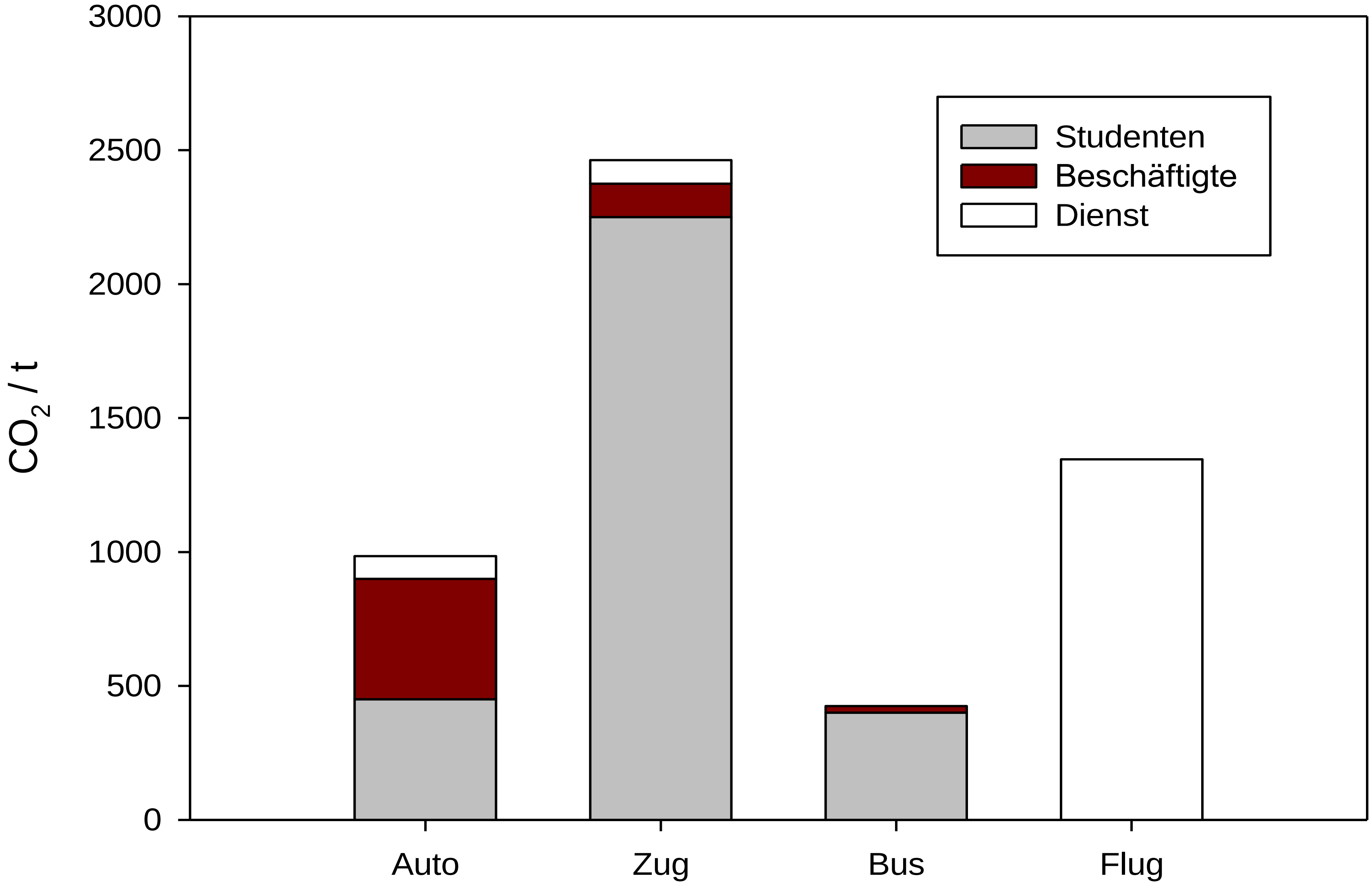
Emissions 2010: How to achieve Zero Carbon?

Leuphana University, t CO_2
6 GWh/a th.; 2.5 GWh/a el.
1100 Staff members
9500 Students

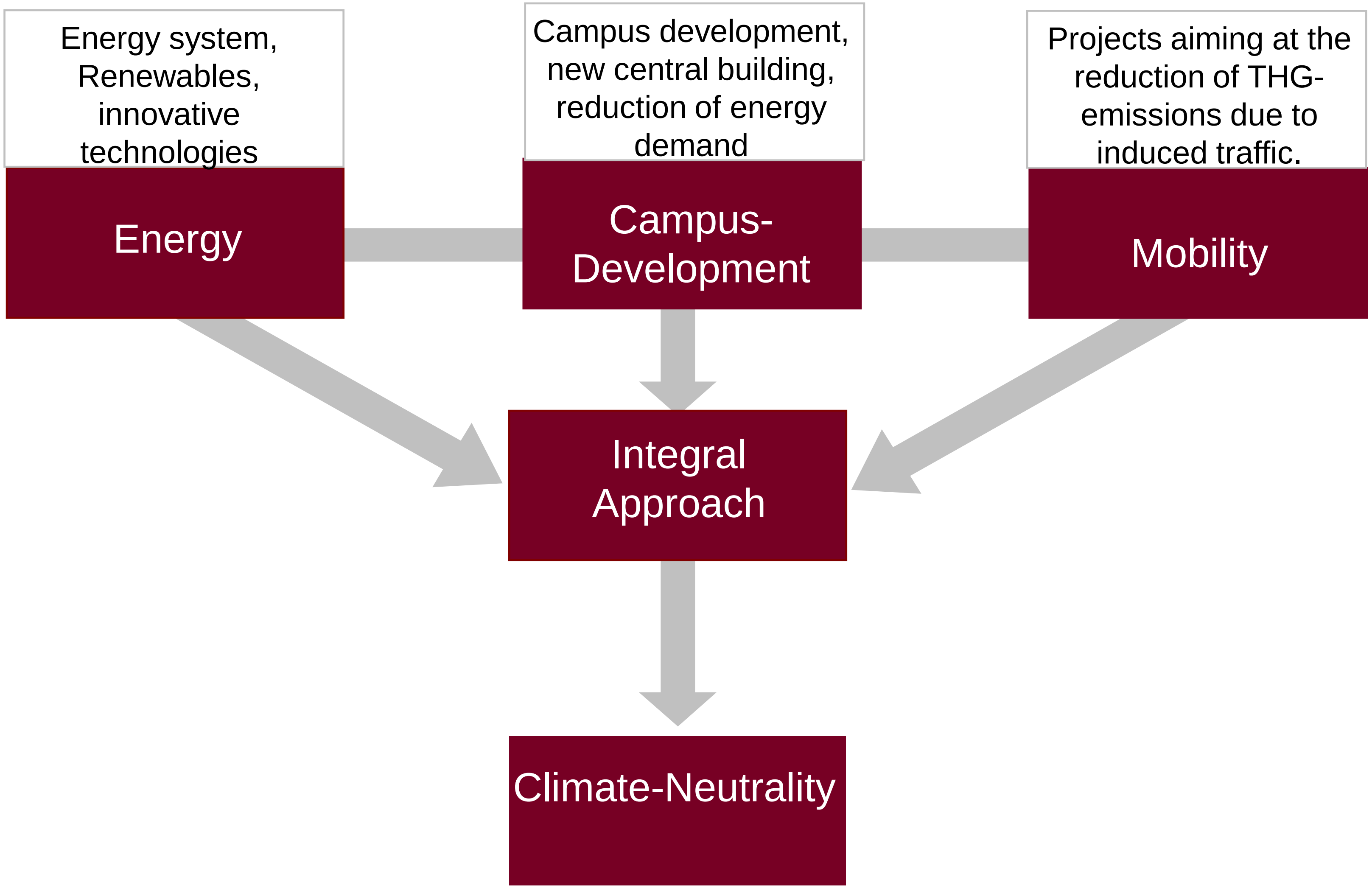
Renewable electricity since 2011



Emissions 2010: How to achieve Zero Carbon?



Integral, campus-wide planning and goal setting



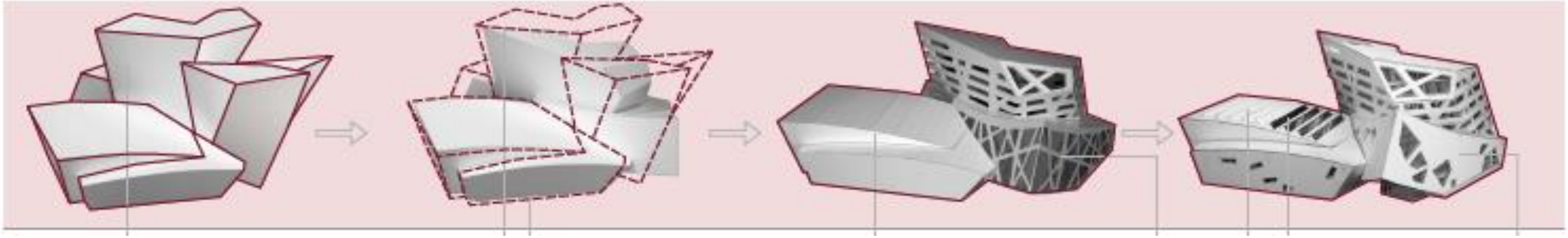
The buildings on the campus were renewed and insulated (roofs)

- Roofs were used for PV (east/west/south)
- 650 kWp PV (total 720 kWp), 95 % used in university electricity network (~600 MWh, 25 % of the demand)

- 40% savings heat / electricity:
- and insulated for more useable space
- renewed heating network
- new pumps, optimisation of the heating systems
- LED-lighting
- building automation
- energy management

COFELY
GDF SUEZ

The design of the new building was improved in student seminars at an early stage (2007).



Draft A/V-Ratio „Solar“ facade design less windows

The building (17.400 m²) offers:

- 6 Seminar rooms, 200 bureaus, 14 meeting rooms,
- Open-space as well as group meeting rooms for students
- A cafeteria
- A machine hall
- And a large auditorium (1.200 seats) with retreatable tribune

that can be connected to the entrance hall and foyer for large events
(up to 2.500 people) concerts exhibitions
(even 2 or 3 events in parallel are possible)

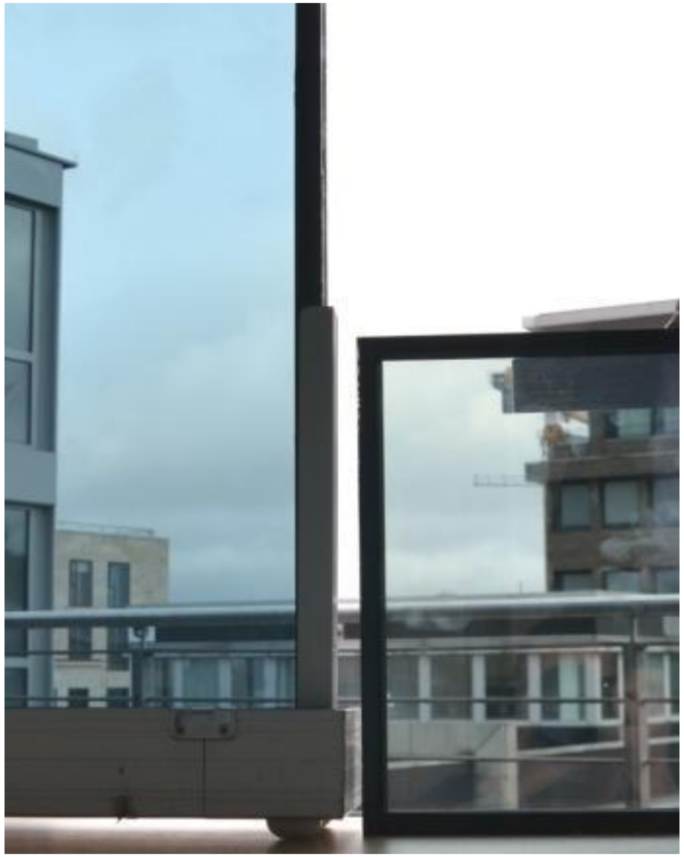
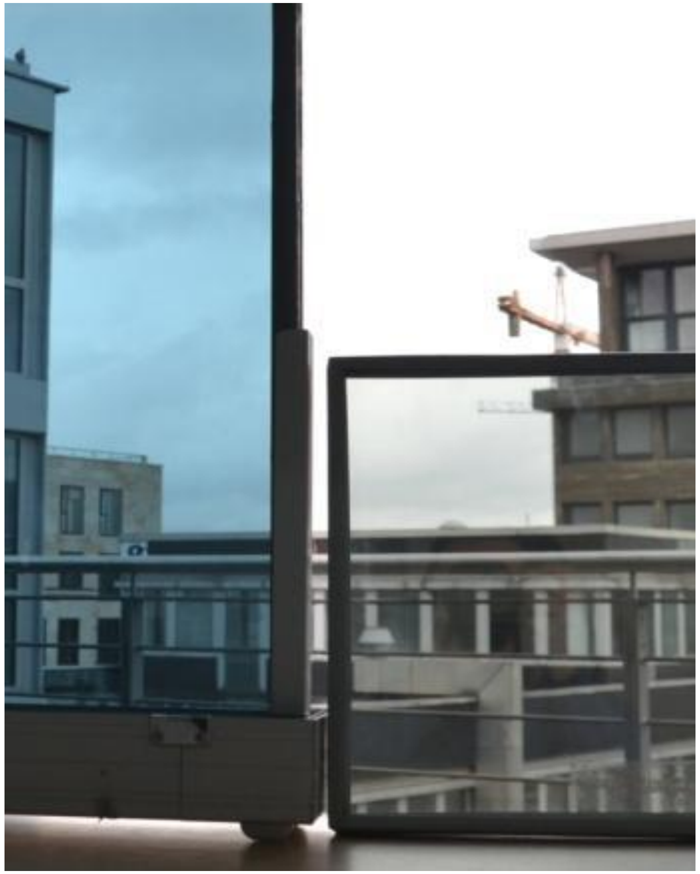
Solar facade design: High solar gains in winter

Lower heat demand!

Low solar gains in summer due to shadowing

Lower cooling demand!

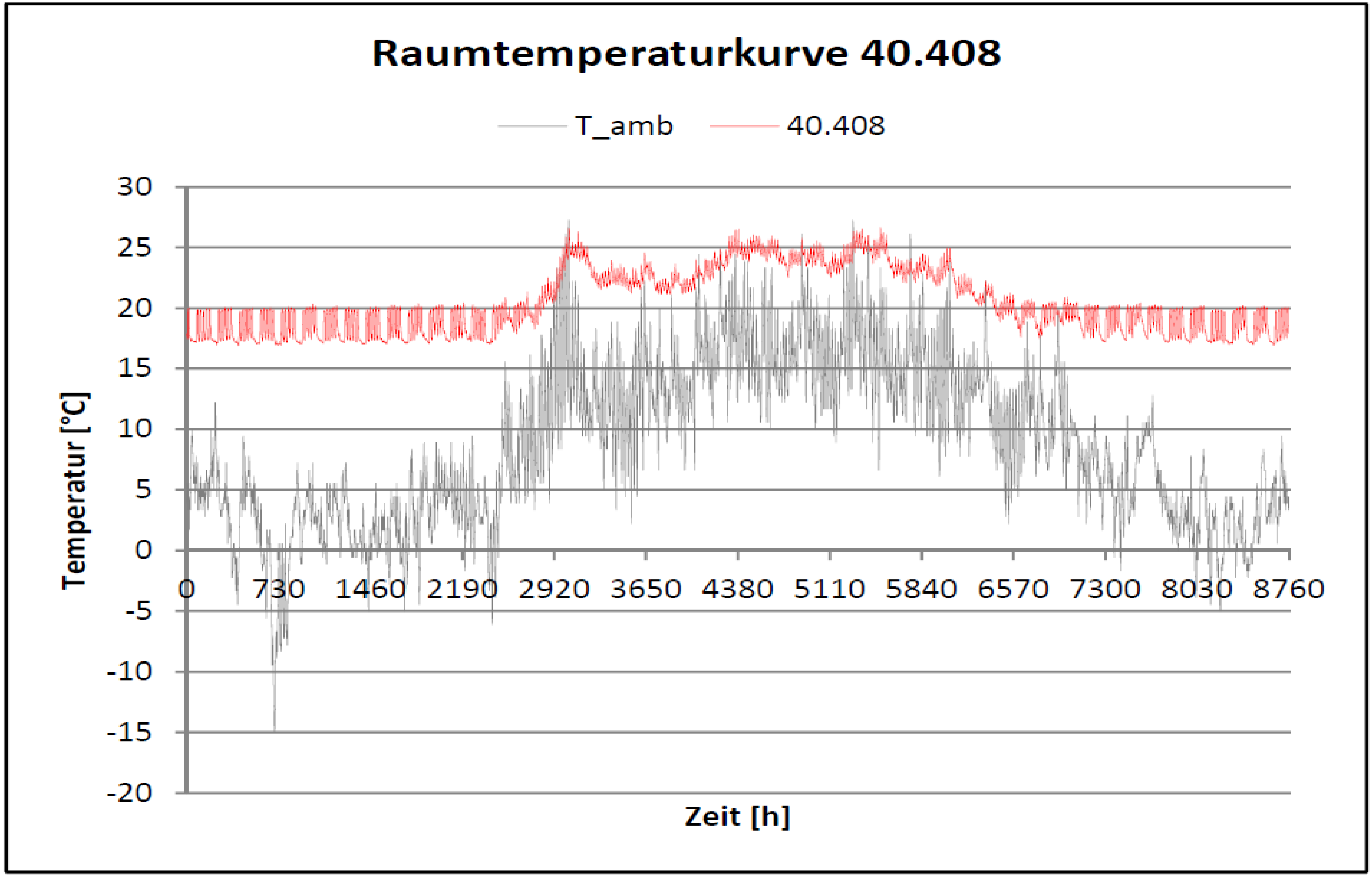
The switchable glazing „E-Control“ (electrochrom) has big advantages
It will be used in the south-east and south-west facades

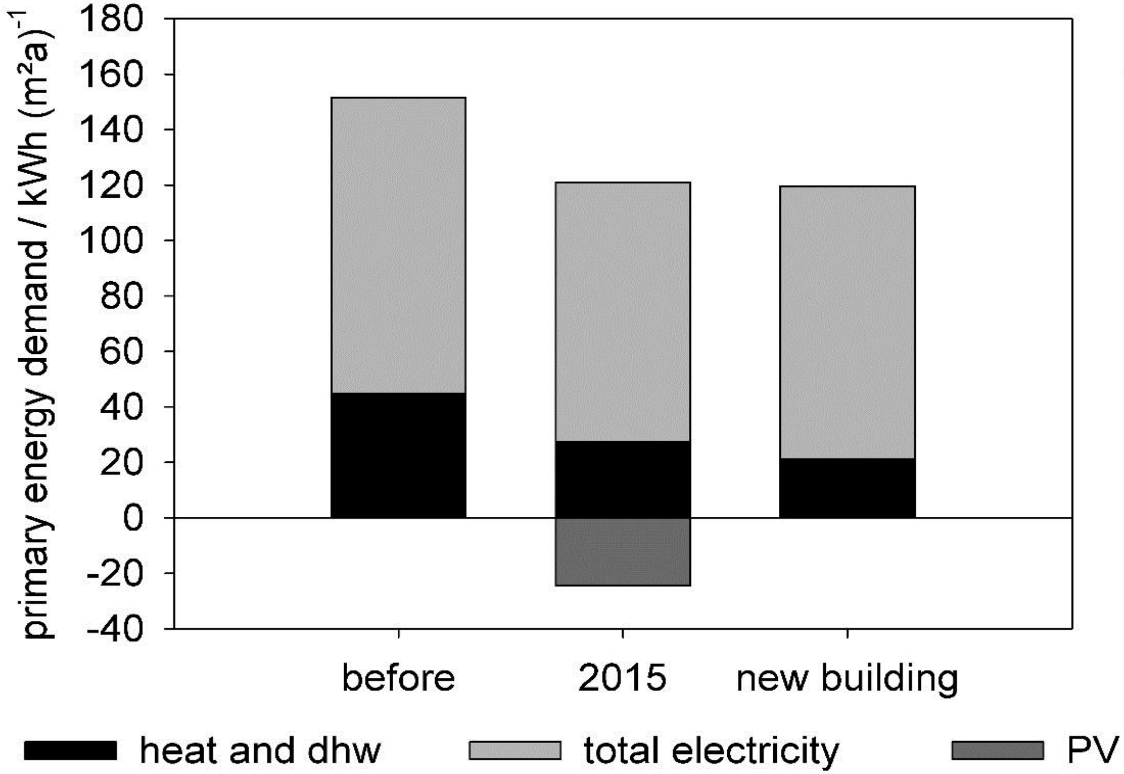
- - 50% cooling demand in summer compared to sunshade glazing
- + 50% solar gains in winter whilst providing good insulation (Triple glazed)
- savings in total > 160 MWh/a ~ 10 % of the end energy consumption
- (no active cooling and mechanical ventilation needed in facade-sided rooms)
- fits the presence- and daylight-controlled LED-lighting-system

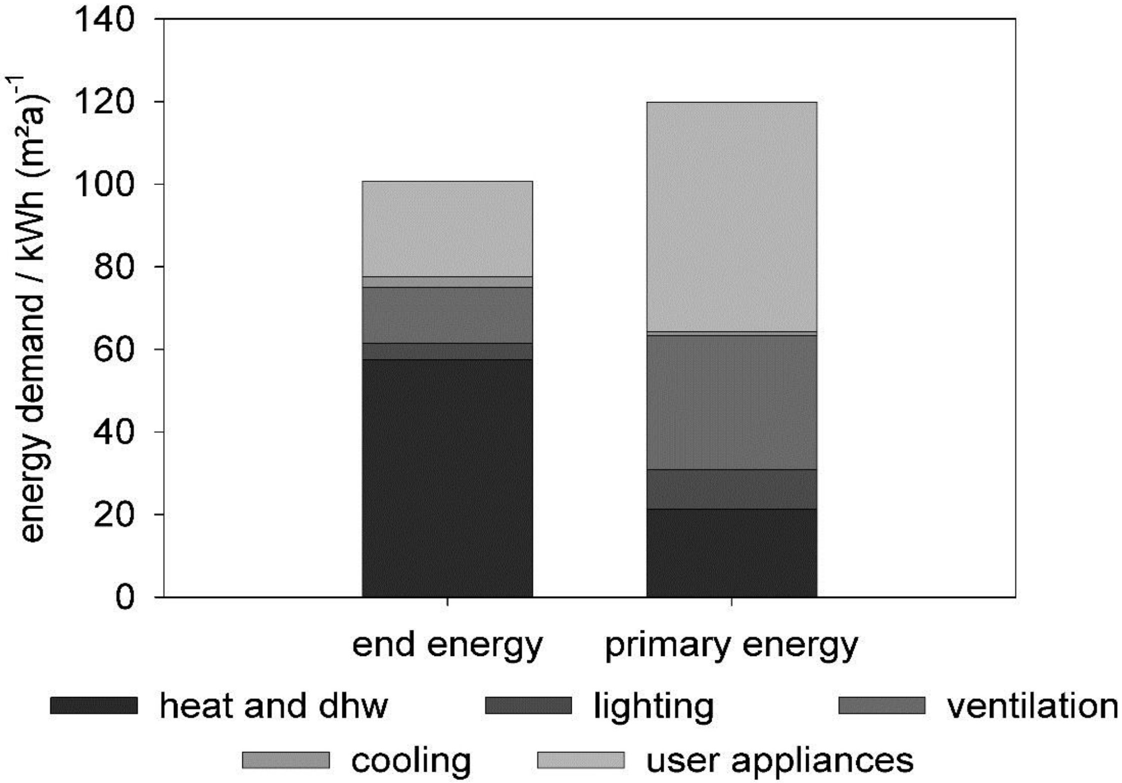
In the model (DOE.2E) it works fine…

We dont know how the users will react – Monitoring will start in 2017.

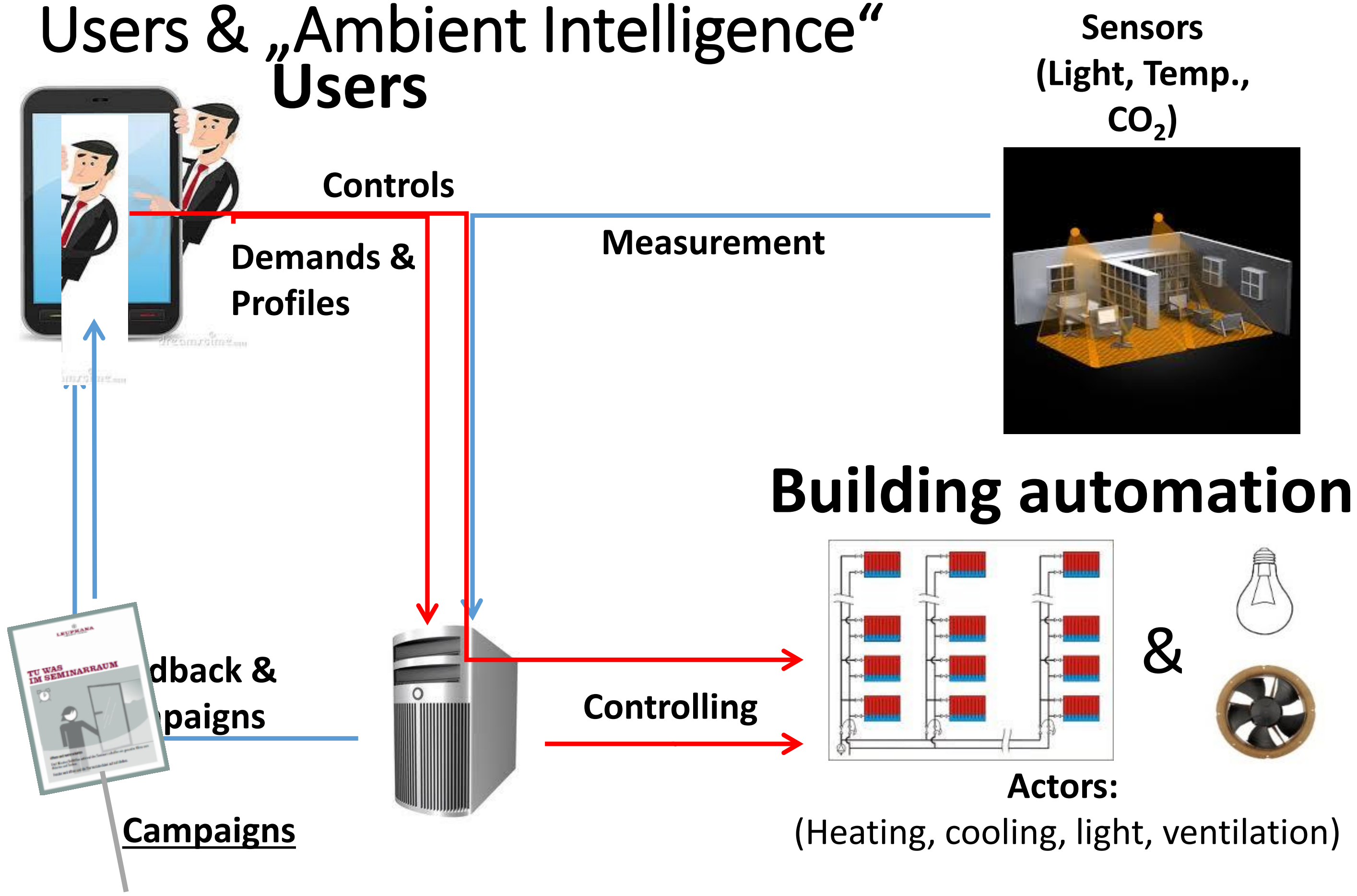


Some numbers… (Measurements, DOE.2E and DIN 18599 modeling)





Users & „Ambient Intelligence“



An energy management system

To help with openable windows, heating and cooling systems – and it will give feedback!

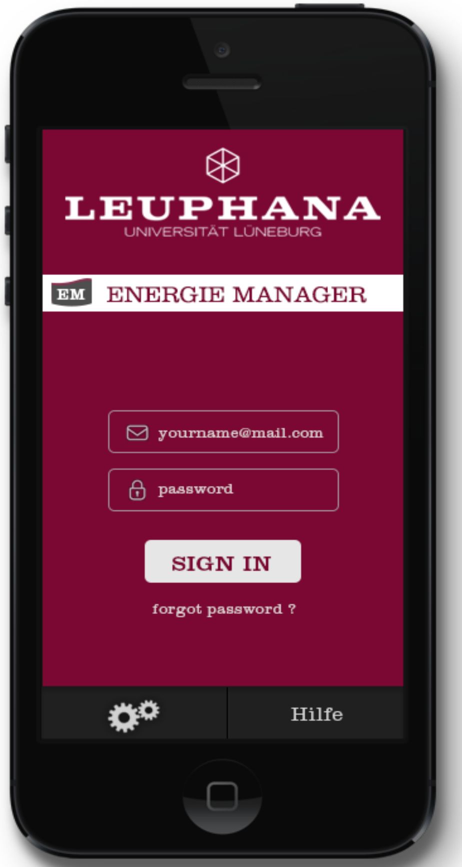
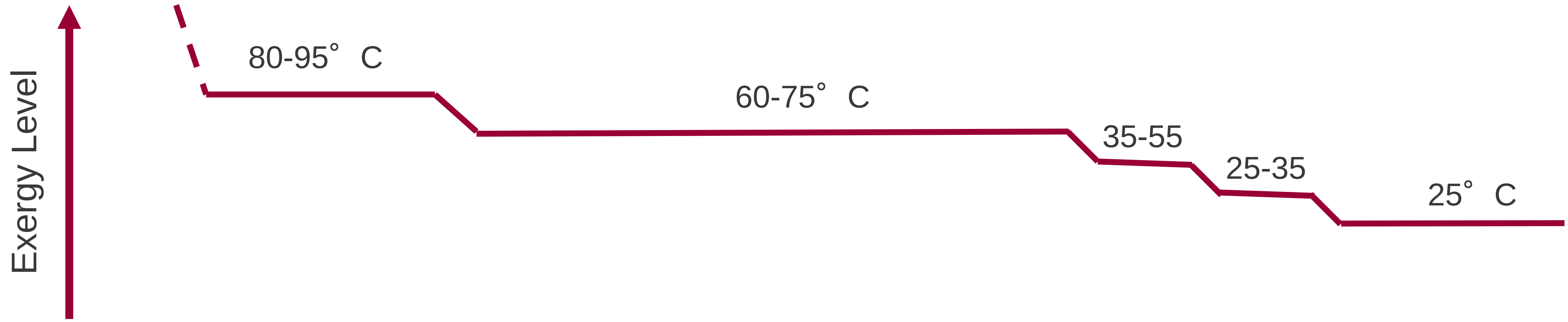


Abb. 1

Abb. 2

Abb. 3

Different temperature levels in the energy system allow for optimal heat use and increase thermal storage efficiency.



Electricity

The exergy-rich and valuable fuel is used primarily for electricity production in CHP-units. The heat demand of the Campus is fully covered by excess heat of the electricity production.

Cooling

Cold is equally regarded as relatively exergy-rich, because electricity is used for cooling. More exergy-efficient cooling is realised by using excess heat or solar energy in absorption chillers.

HT-Heating

Excess heat from the CHP units is of a sufficient temperature level for space heating purposes. In the Campus-systems, different supply temperatures are needed, which can be provided from the HT-side.

Storing of heat

If the heat demand is lower then the excess heat supplied by the CHP-units, for example in summer, heat is stored in an underground aquifer.

Use of stored heat

The stored heat can be used either directly or by means of a heat pump. In the Campus system, direct use is facilitated by means of low-exergy heating systems.

LT-Heating (central building)

The return line from the HT-heating systems still is hot enough to drive low-temperature (low-exergy) heating systems. Especially in the new central building, low-exergy heating is used exclusively.

Return flow

In order to extract as much heat as possible from the underground aquifer storage, a low return line temperature is needed. The cascade shown here helps to minimize return line temperatures and thus maximizes storage efficiency

Exergy efficiency analysis show the advantages of cogeneration + thermal storage due to the minimized use of inefficient peak load heat production

	Exergy eff. η_c	Exergy use
Oil+Gas Boilers	0.03	$0.68 \cdot Q_{Heat}$
Baseload-CHP	0.49	$0.66 \cdot Q_{Heat}$
Power-operated CHP with short time storage	0.63	$0.53 \cdot Q_{Heat}$
CHP with aquifer storage	0.68	$0.52 \cdot Q_{Heat}$

- baseload plant: 60% CHP heat, 40% boiler, 50m³ water storage
- power-operated plant: 90% CHP heat, 10% boiler, 200 m³ water storage
- CHP with aquifer storage: 100% CHP heat, 60% heat recovery, 33% stored heat

η_c (Biogas) = 0.62 (compare combined cycle plant $\eta_{el.}$ = 0.59 and $\eta_{th.}$ = 0.03)
[Lüking 2011]

- **High-Temperature Underground Heat Storage:** Good geology and groundwater chemistry (modeled by PHREEQ) allow storage of ~ 90 °C hot water from biomethane-chp and ~ 1000m² solarthermal

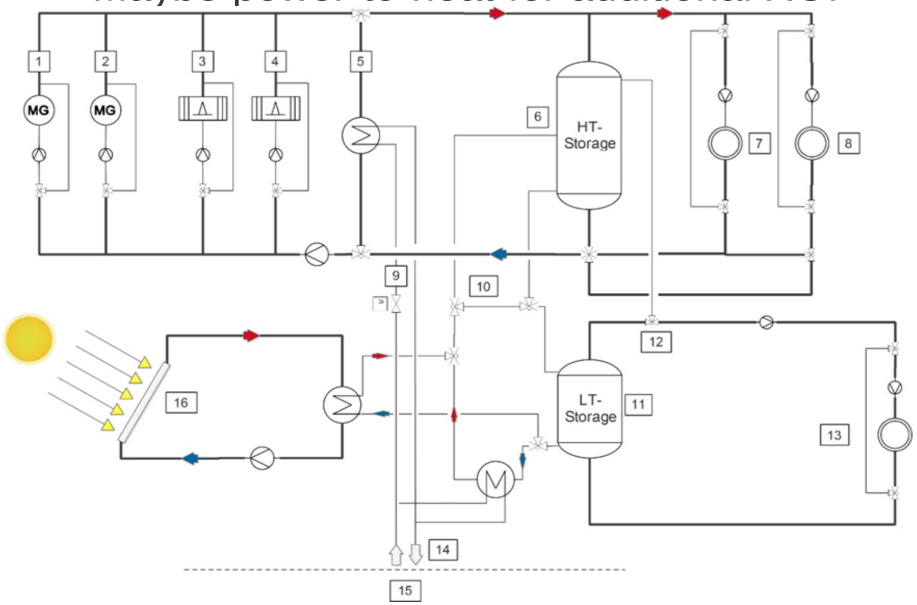
- Total cost ~2 Mio. € (150.000 m³ water-eq.)
- 1/40 of above-ground storage cost
- With 80 % subsidies for the investment:

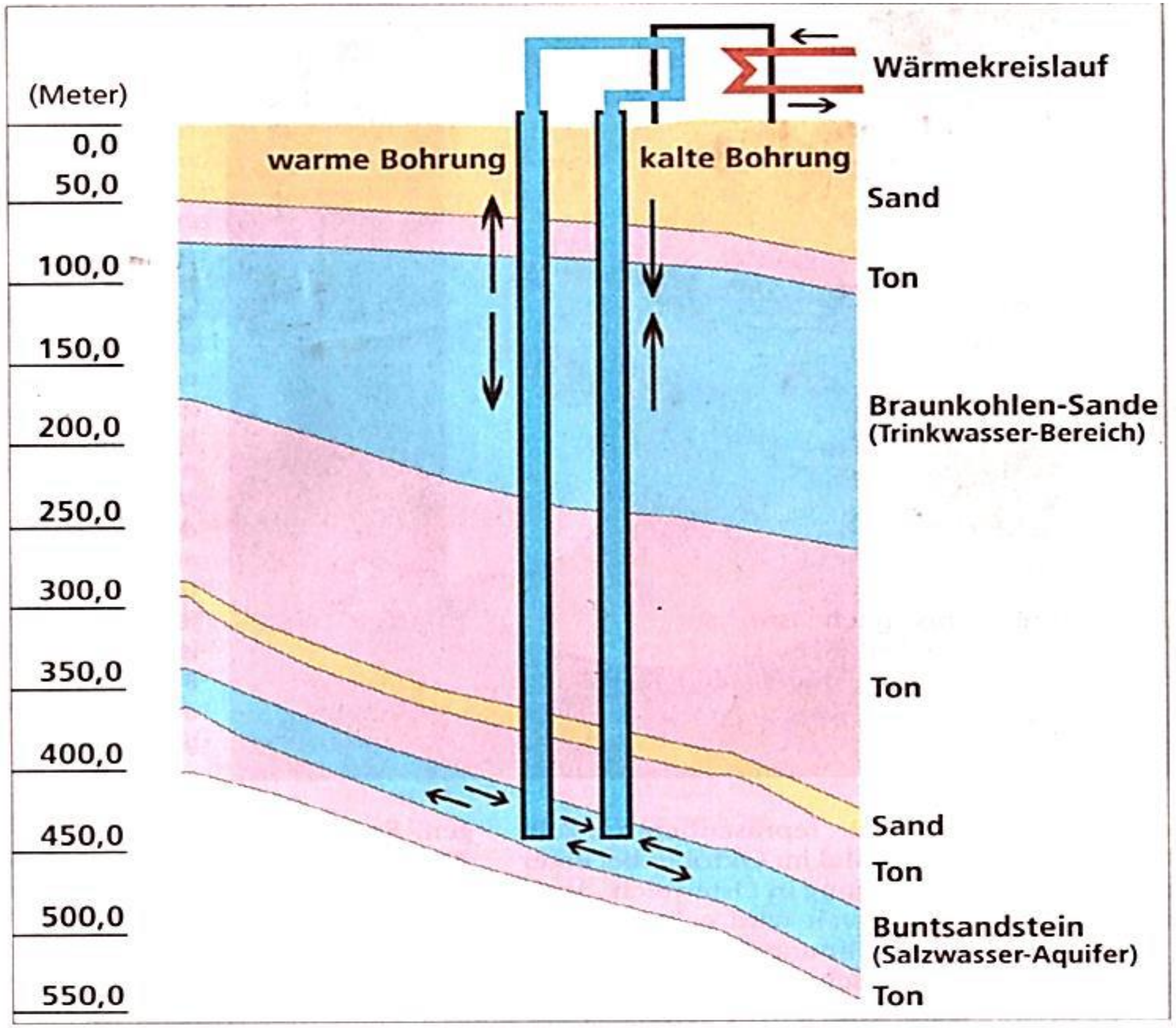
  ROI ~ 5-10 years (50 years lifespan)

  ROI mainly from biomethane subsidies

  Electricity prices otherwise too low

  Maybe power-to-heat for additional ROI





- **Climate-neutral university and Bockelsberg district (district heating network, TRNSYS, DOE.2E and FeFlow models):** Biomethane since 2013, 30 % lower cost due to subsidies (savings will be used for more measures).

	w/o ATES	with ATES	f_{EM}	w/o ATES	with ATES
Biomethane (CHP)	16.6 GWh	23.3 GWh	80 g/kWh	1,328 t	1,864 t
Natural gas (vessels)	3.4 GWh	0.7 GWh	245 g/kWh	833 t	172 t
Electricity production (CHP)	6.4 GWh	9.2 GWh	- 821 g/kWh	- 5,254 t	- 7,553 t
Electricity consumption (campus, renewable)	2.7 GWh	2.7 GWh	5 g/kWh	14 t	14 t
	0.55 GWh PV	0.55 GWh PV	80 g/kWh	44 t	44 t
Cars and business trips				599 t	599 t
other				≈ 800 t	≈ 800 t
Balance				**-1,636 t**	**-4,060 t**

THINKING GREEN
GERMANY SEEKS
SUSTAINABILITY

PAGE 7 | EDUCATION

Dr. Oliver Opel, Prof. Dr.-Ing. Wolfgang Ruck, Dipl.-Ing. Karl F. Werner, Dipl.-Uwiss. Irmhild Brüggen