LEUPHANA
UNIVERSITÄT LÜNEBURG

Klimaneutraler Campus

Leuphana Universität Lüneburg

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IBP Schulkongress – Workshop Energieeffizienz

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FHW

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

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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)

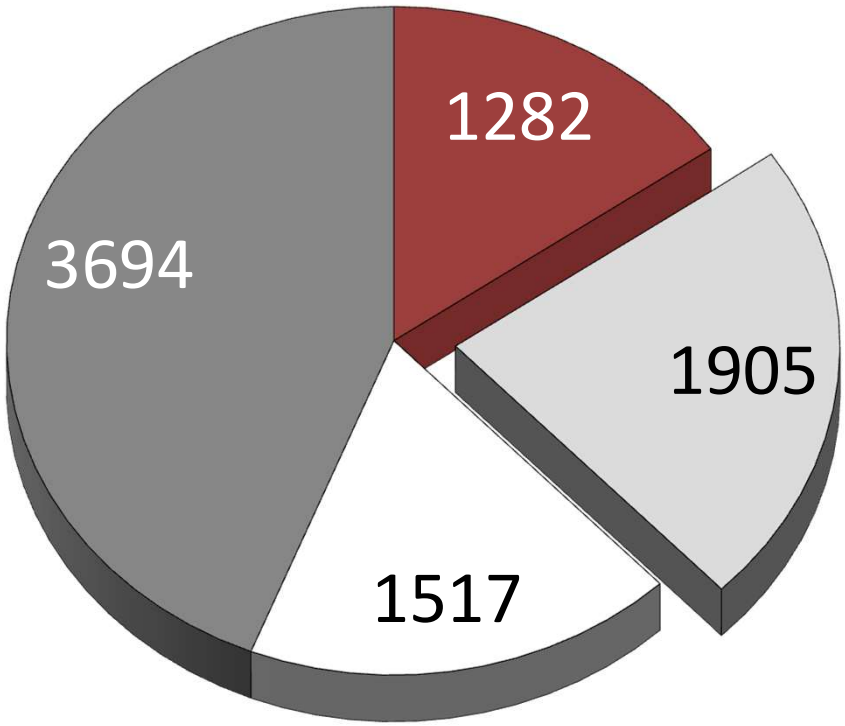
Sustainability Implementation: Milestones at the Leuphana University

Year	
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 ca
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?

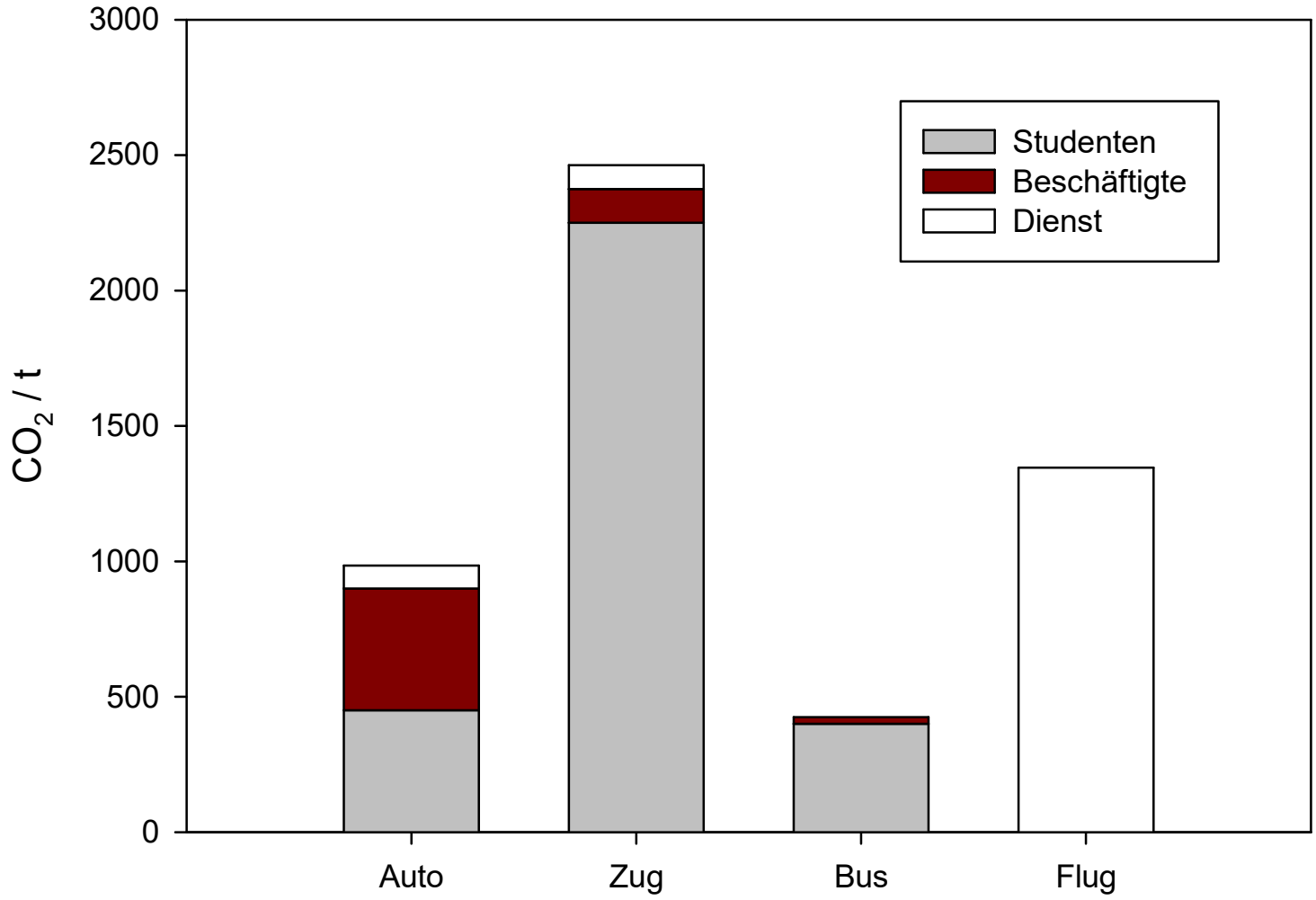


Leuphana University, t CO_2
6 GWh/a th.; 2.5 GWh/a el.
1100 Staff members
9500 Students

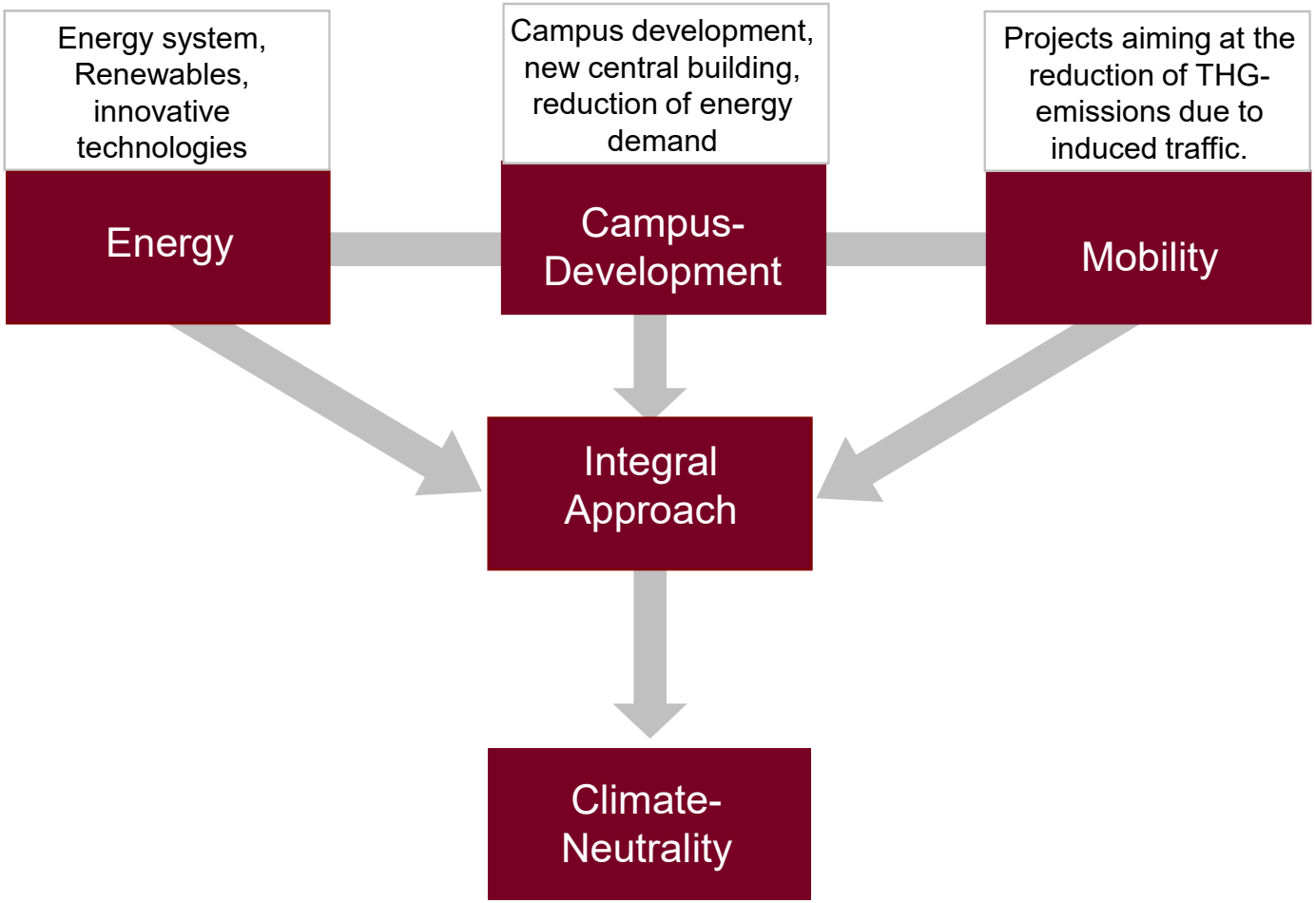
Renewable electricity since 2011

- Heat
- Electricity (renewable)
- Business Trips
- Commuter Traffic

Emissions 2010: How to achieve Zero Carbon?



Integral, campus-wide planning and goal setting



The attics were insulated and converted for useable space / other optimizations

- 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

- 56.148 m² before
- 9.480 m² attics conversion

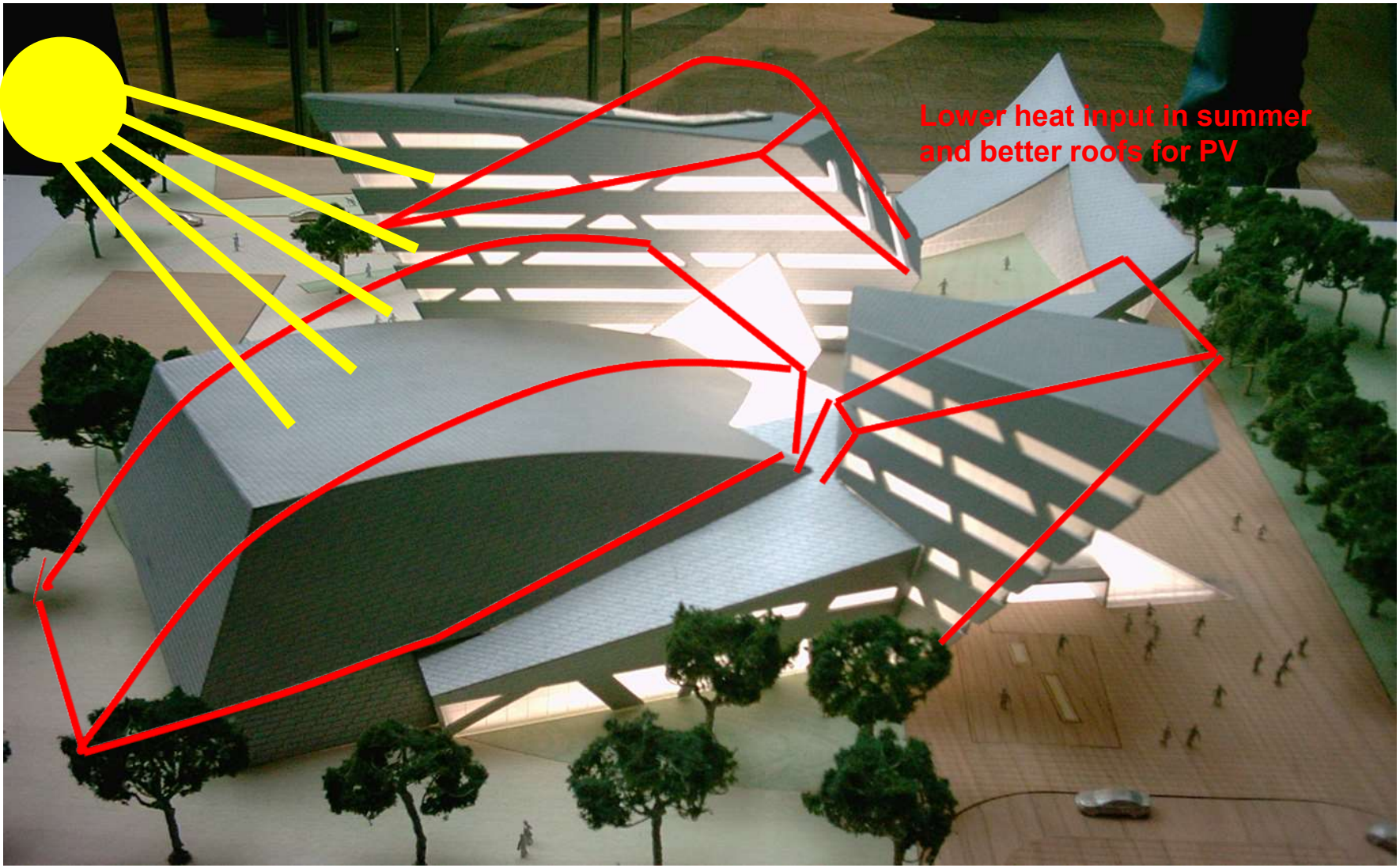
COFELY
GDF SUEZ

The attics were insulated and converted for useable space / other optimizations

	Gebäude			Primärenergiesubstitution	Quartier	
	beheizte Fläche	Primärenergieverbrauch		Eingespeister und selbstgenutzer Strom aus zentralen PV-Anlagen	Primärenergieverbrauch	
	m^2	MWh/a	kWh/m^2a	MWh/a	MWh/a	kWh/m^2a
Ausgangszustand	77.813,4	11.389,9	146,4	0,0	11.389,9	146,4
Ziel (Antrag)	82.352,2	-1.918,5	-23,3	142,8	-2.061,3	-25,0
gemessen Jahr 1	83.028,3	3.267,8	39,4	0,0	3.267,8	39,4
gemessen Jahr 2	83.028,3	1.118,1	13,5	0,0	1.118,1	13,5

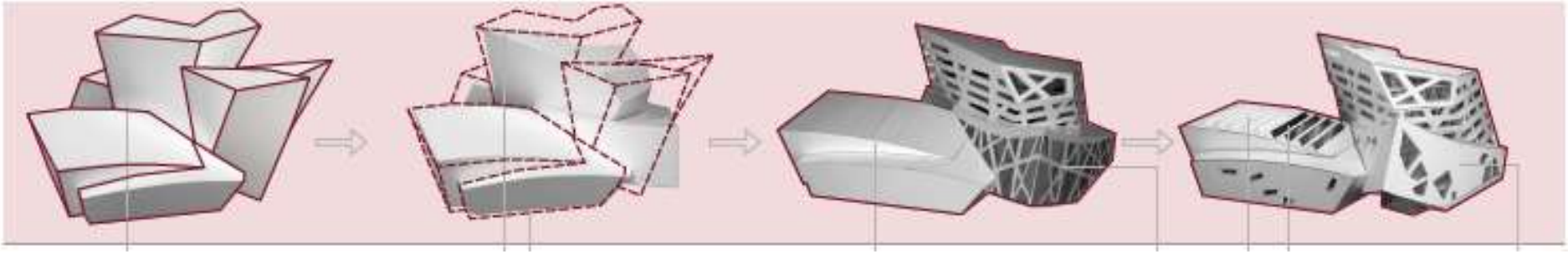
Student Seminars in Lueneburg and New York defined needs and visions…

… that lead to first drafts and models:



A summer school in Lueneburg took care about solar design and energy demands and supply!

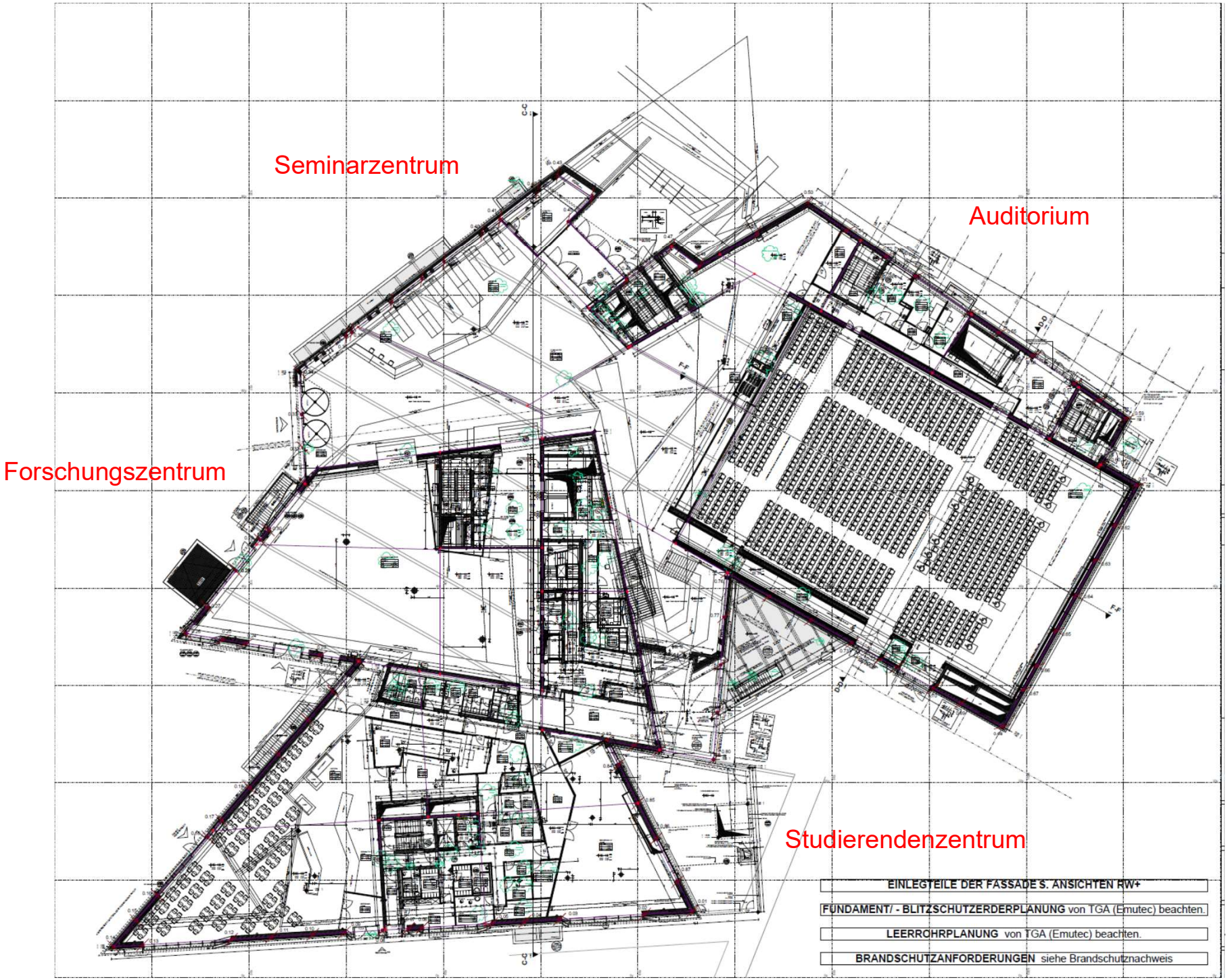
The design of the new building was improved in student seminars at an early stage (2007).



The building (17.400 m²) offers:

- 18 Seminar rooms, > 110 bureaus for up to 4 people and several 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

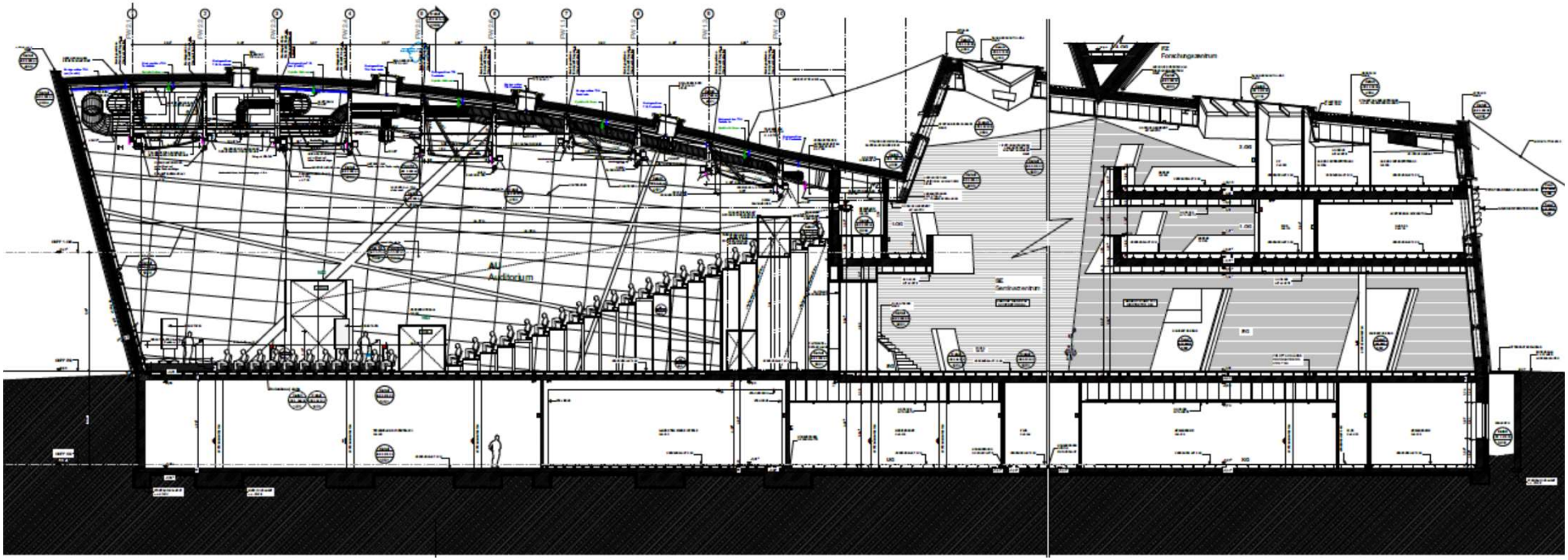
that can be connected to the entrance hall and foyer for large events
(up to 2.500 people) concerts exhibitions
(even 2 or 3 events in parallel are possible)


Seminarzentrum
Auditorium
Forschungszentrum
Studierendenzentrum
EINLEGTEILE DER FASSADE S. ANSICHTEN RW+
FUNDAMENT/ - BLITZSCHUTZERDERPLANUNG von TGA (Emutec) beachten.
LEERROHRPLANUNG von TGA (Emutec) beachten.
BRANDSCHUTZANFORDERUNGEN siehe Brandschutznachweis

Forschungszentrum

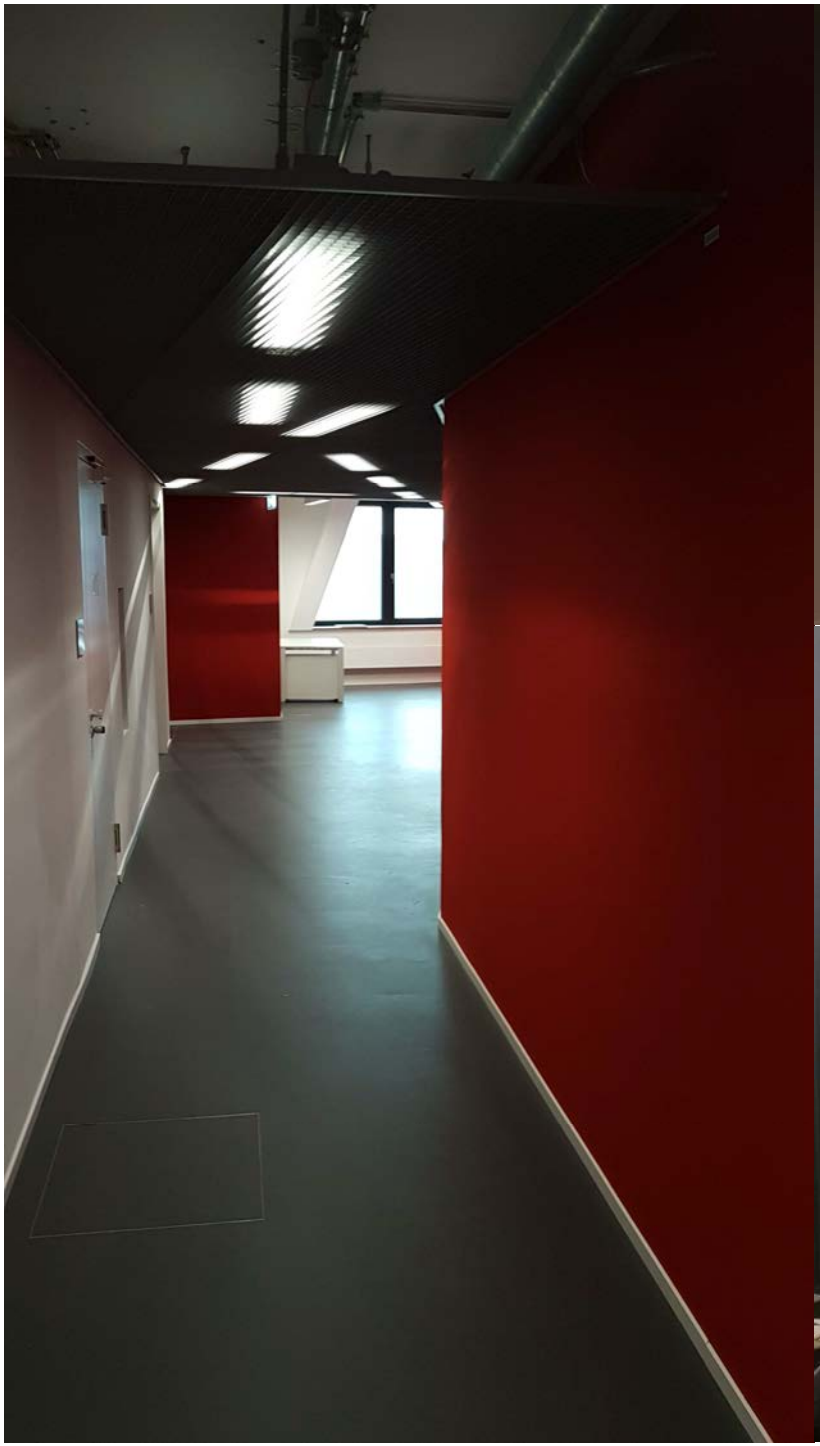
Seminarzentrum

Auditorium

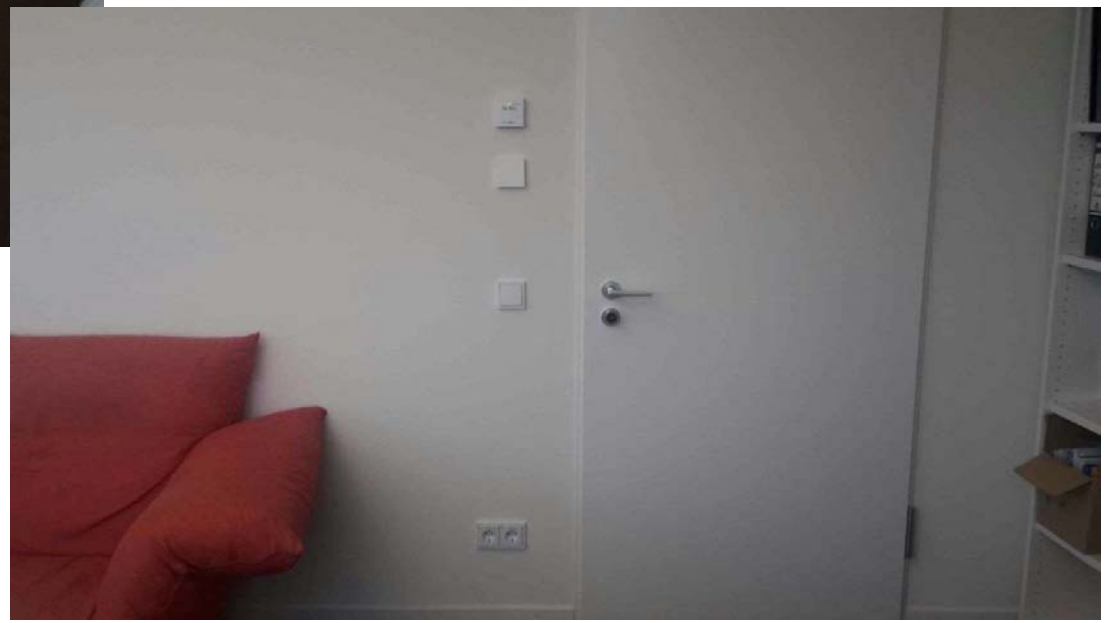


Großer Saal, multifunktional

Musikevent im Foyer



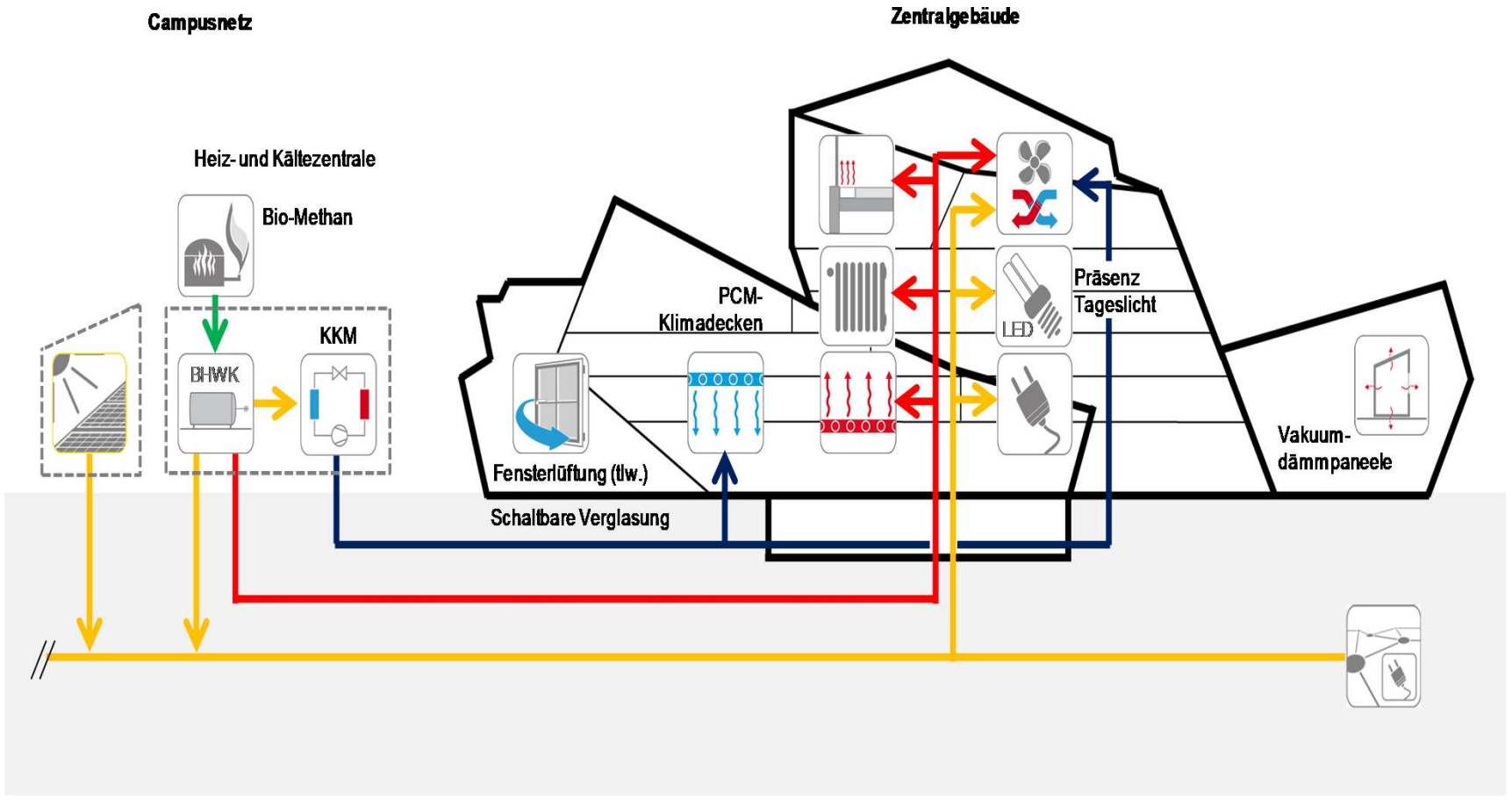
CO_2-traffic lights



PCM cooling ceilings

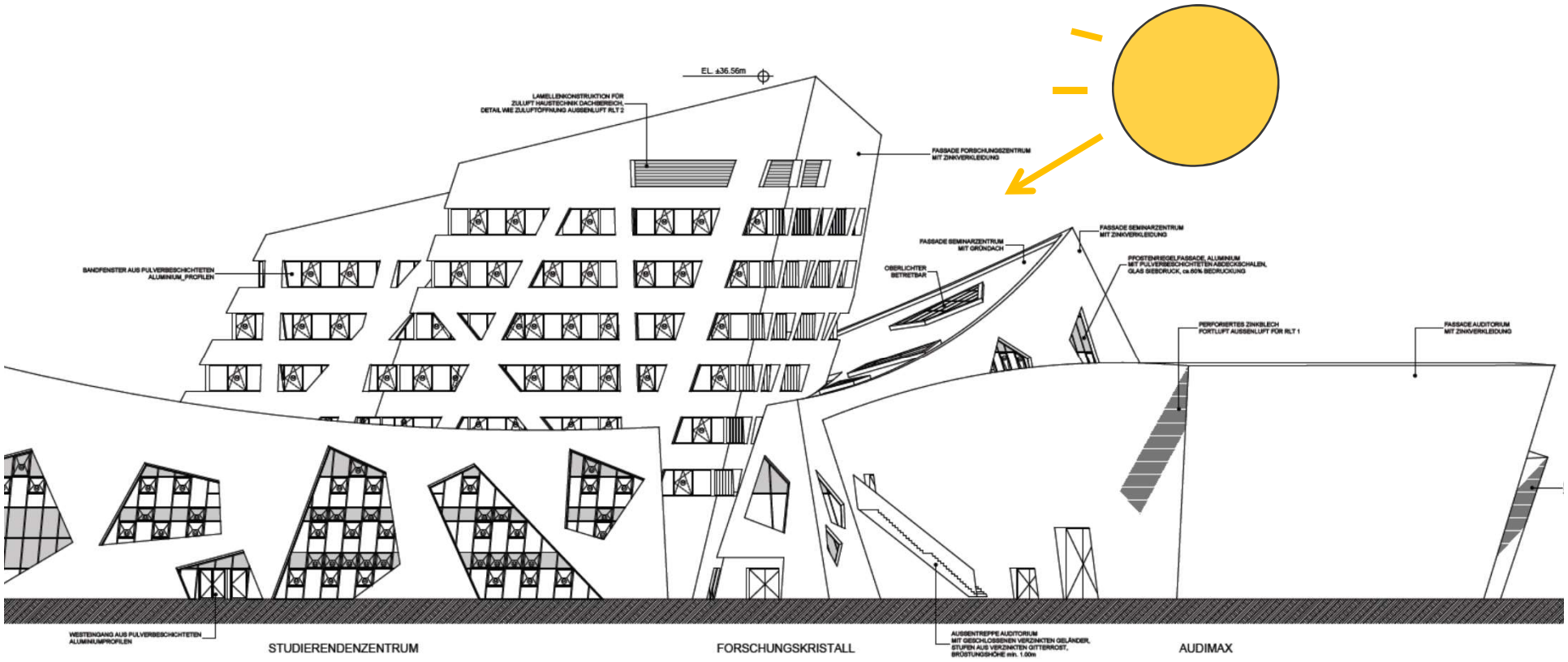
Solar facade design: High solar gains in winter

Lower heat demand!



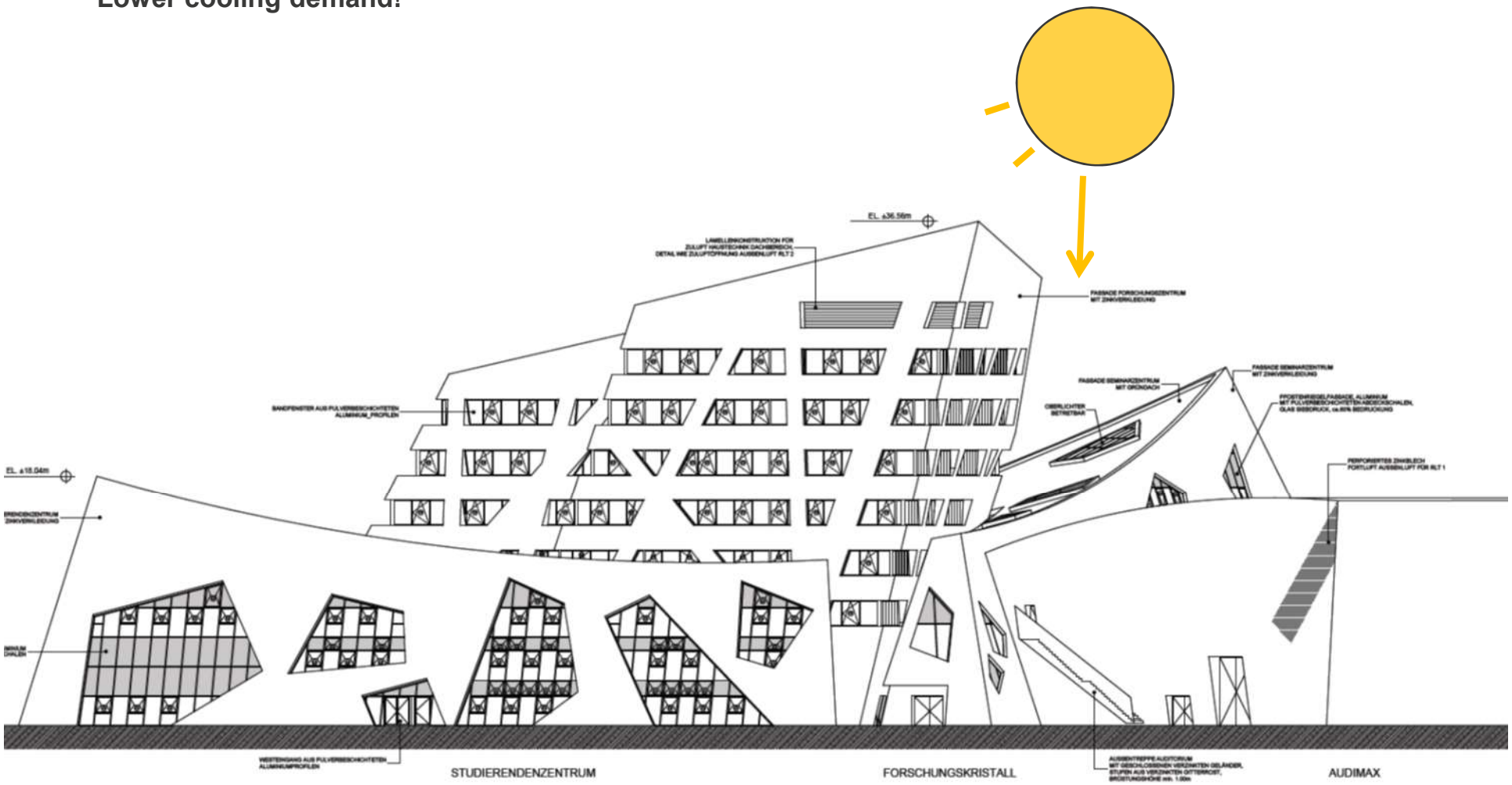
Solar facade design: High solar gains in winter

Lower heat demand!



Low solar gains in summer due to shadowing

Lower cooling demand!

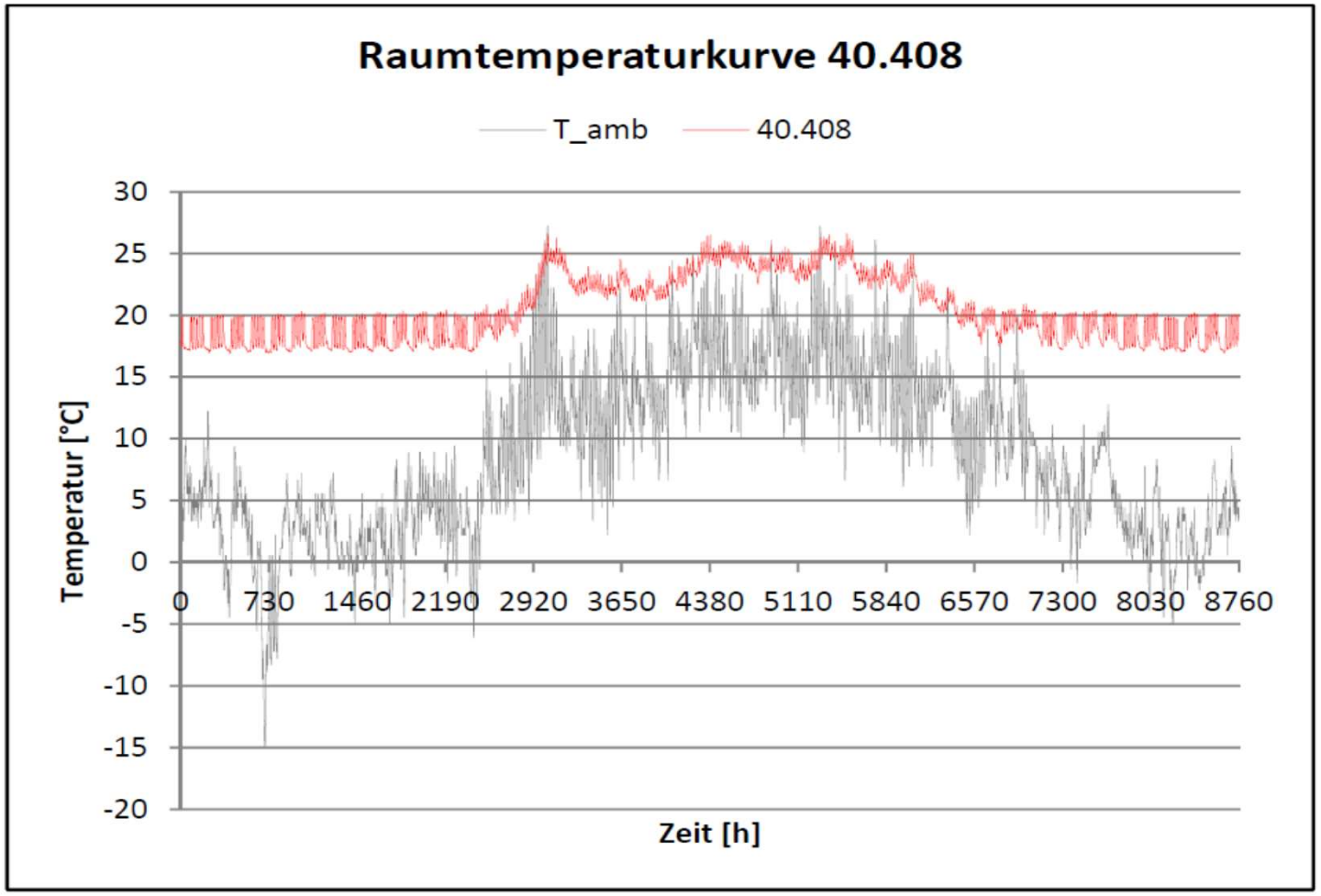


The switchable glazing „E-Control“ (electrochrom) has big advantages
It will be used in the south-east and south-west facades

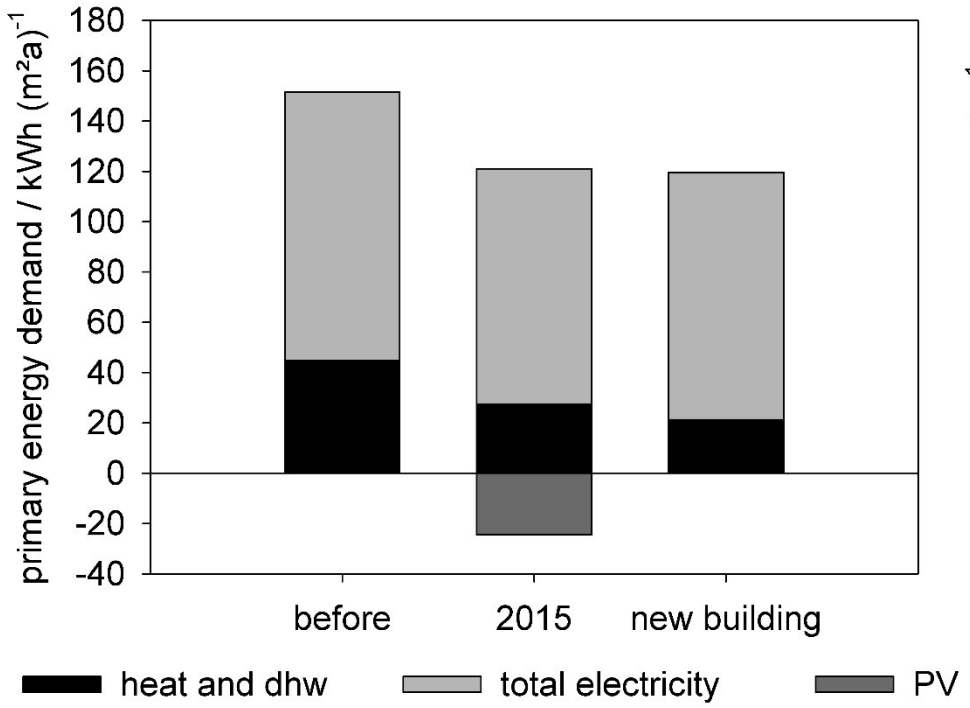
- **- 50% cooling demand in summer compared to sunshade glazing**
- **+ 50% solar gains in winter whilst providing good insulation (Triple glazed)**
- **savings in total > 160 MWh/a ~ 10 % of the end energy consumption**
- **(no active cooling and mechanical ventilation needed in facade-sided rooms)**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

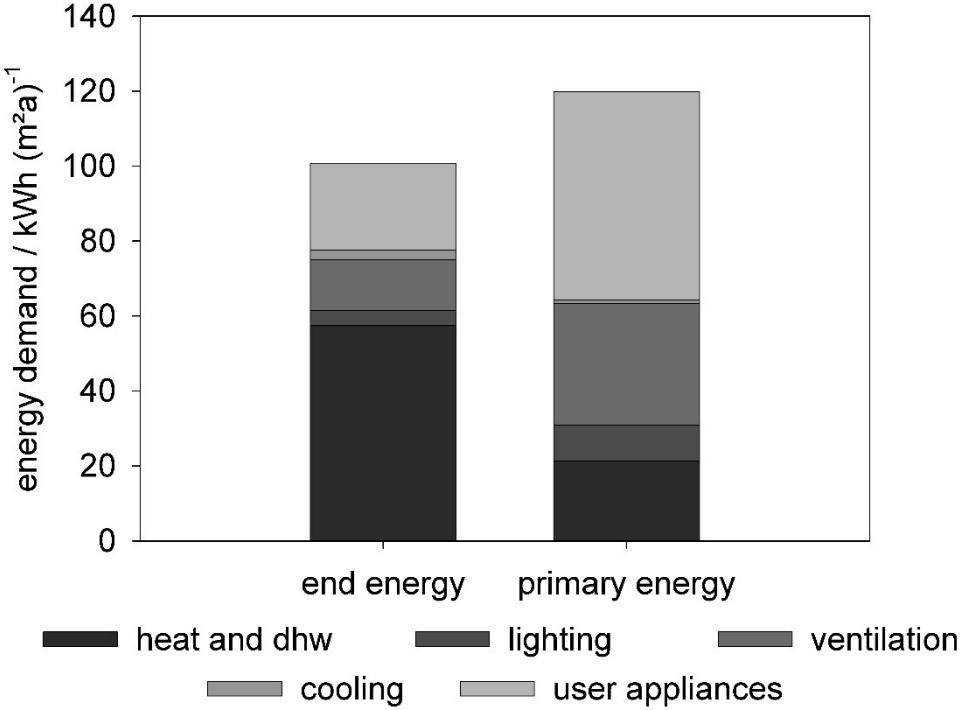
In the model (DOE.2E) it works fine…

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



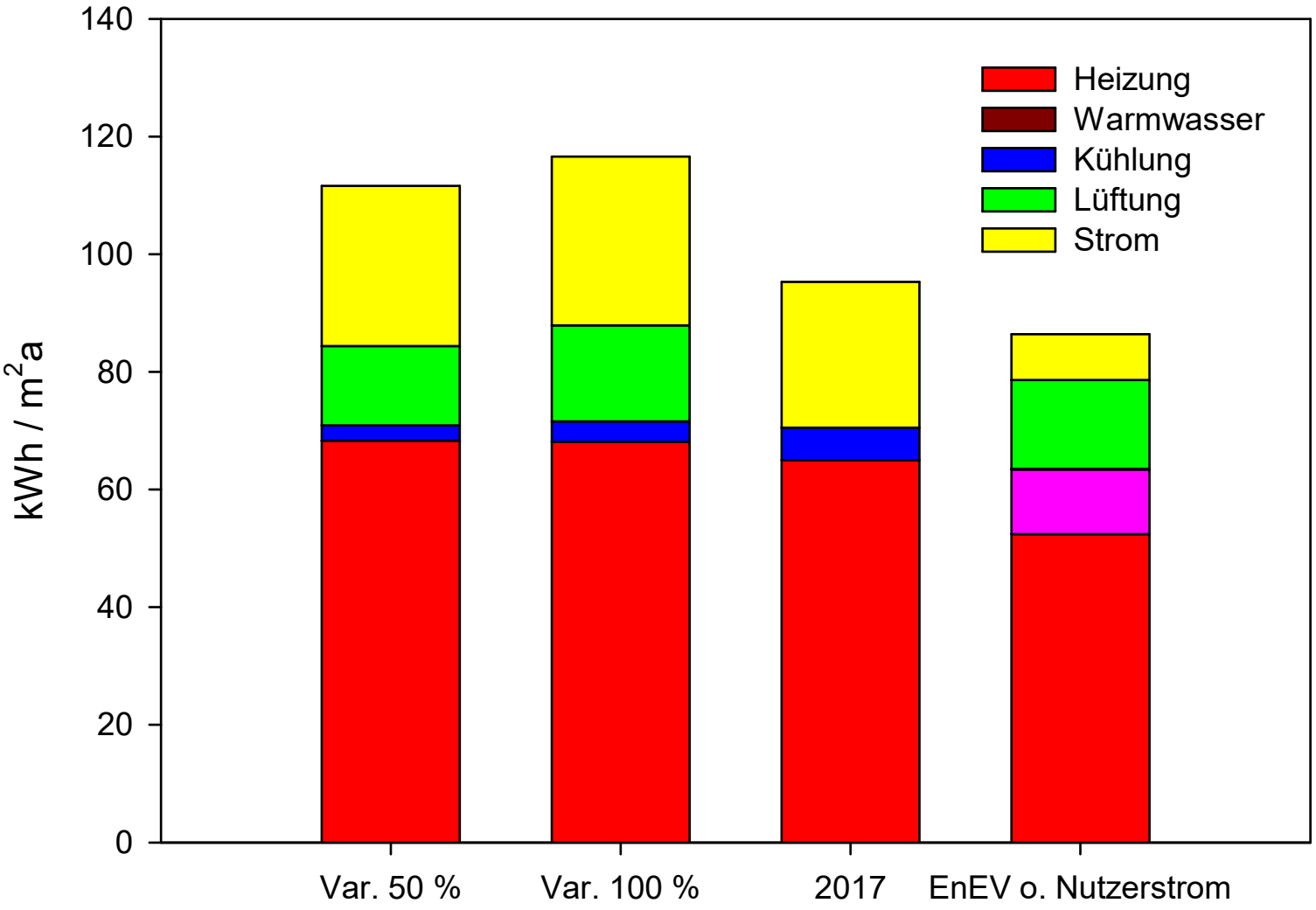
Some numbers… (Measurements, DOE.2E and DIN 18599 modeling)



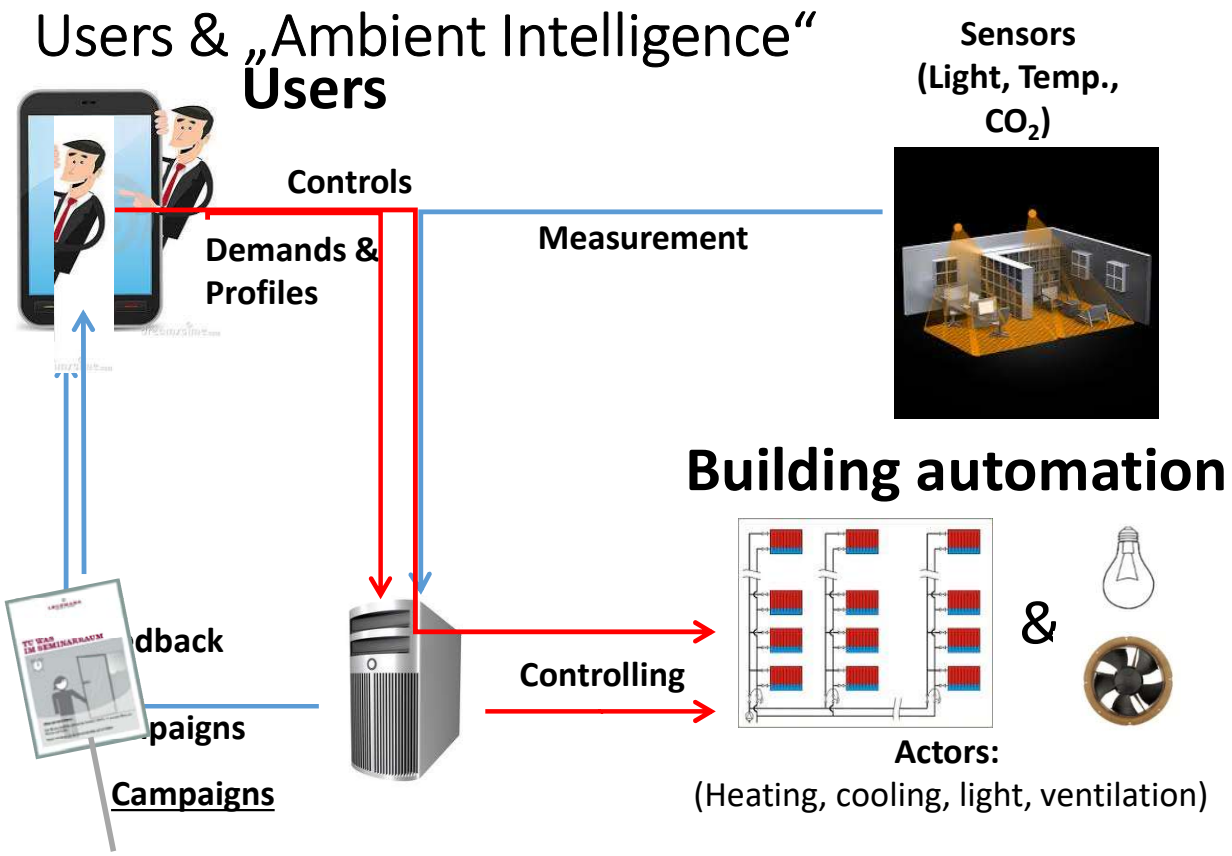


f_{PE} (Wärme) = 0,37
f_{PE} (Strom) = 2,4

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!

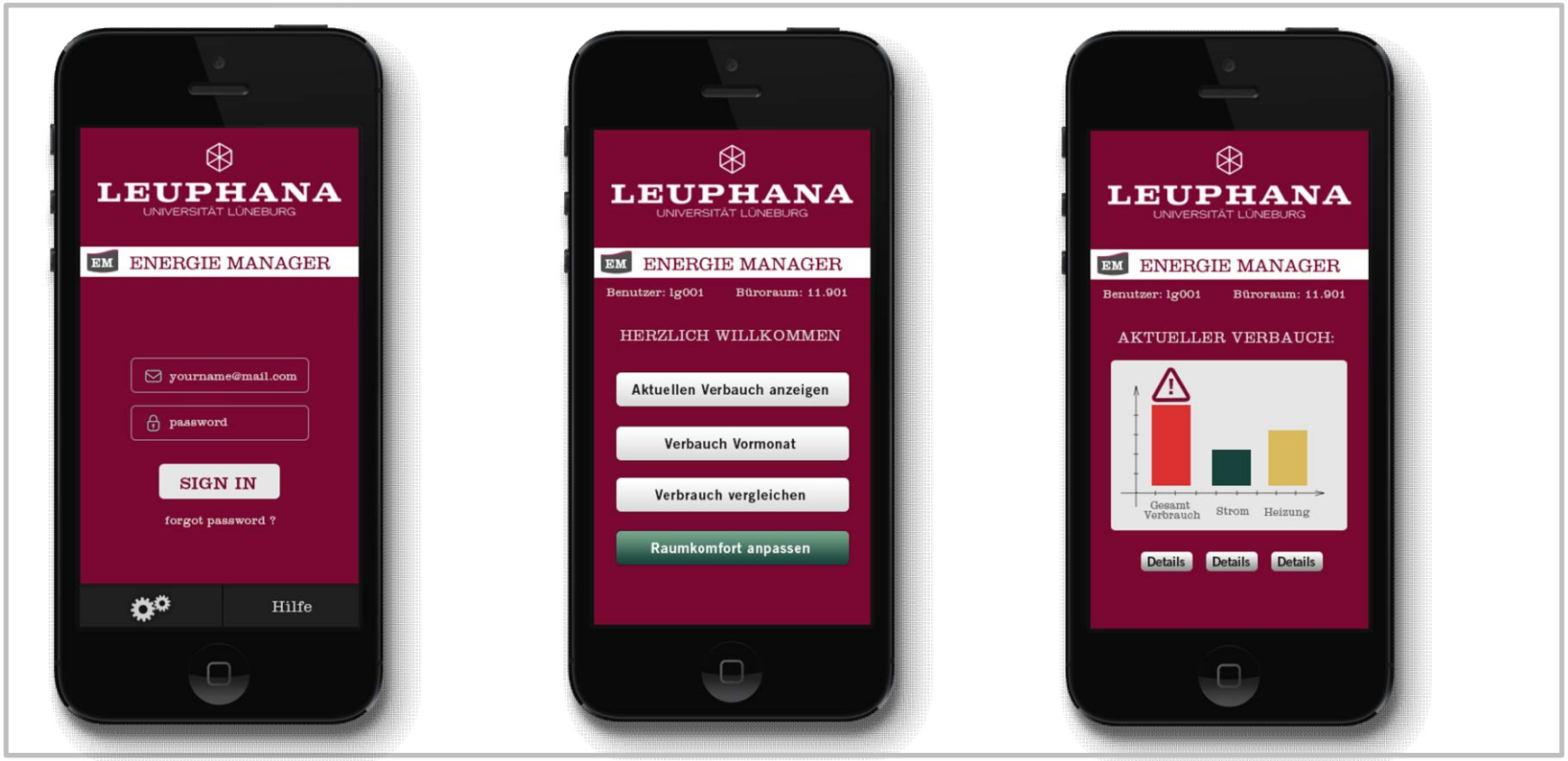
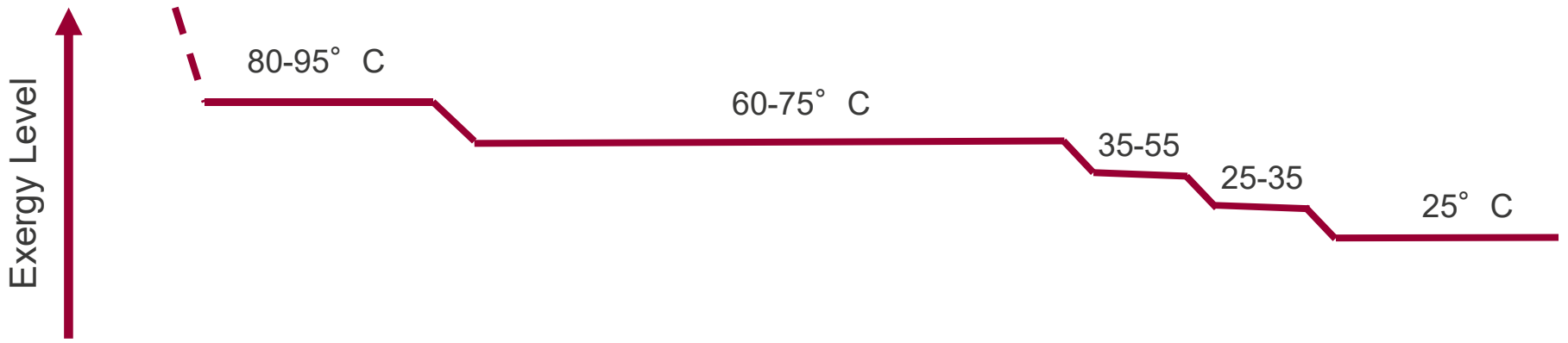


Abb. 1 Abb. 2 Abb. 3

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



Electricity	Cooling	HT-Heating	Storing of heat	Use of stored heat	LT-Heating (central building)	Return flow
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.	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.	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.	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.	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.	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.	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

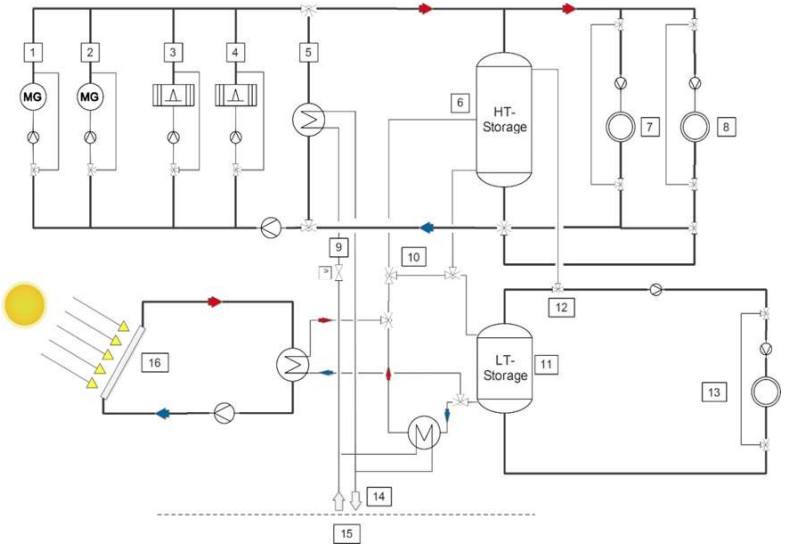
	Exergy eff. η_c	Exergy use
Oil+Gas Boilers	0.03	$0.68 \cdot Q_{Heat}$
Baseload-CHP	0.49	$0.66 \cdot Q_{Heat}$
Power-operated CHP with short time storage	0.63	$0.53 \cdot Q_{Heat}$
CHP with aquifer storage	0.68	$0.52 \cdot Q_{Heat}$

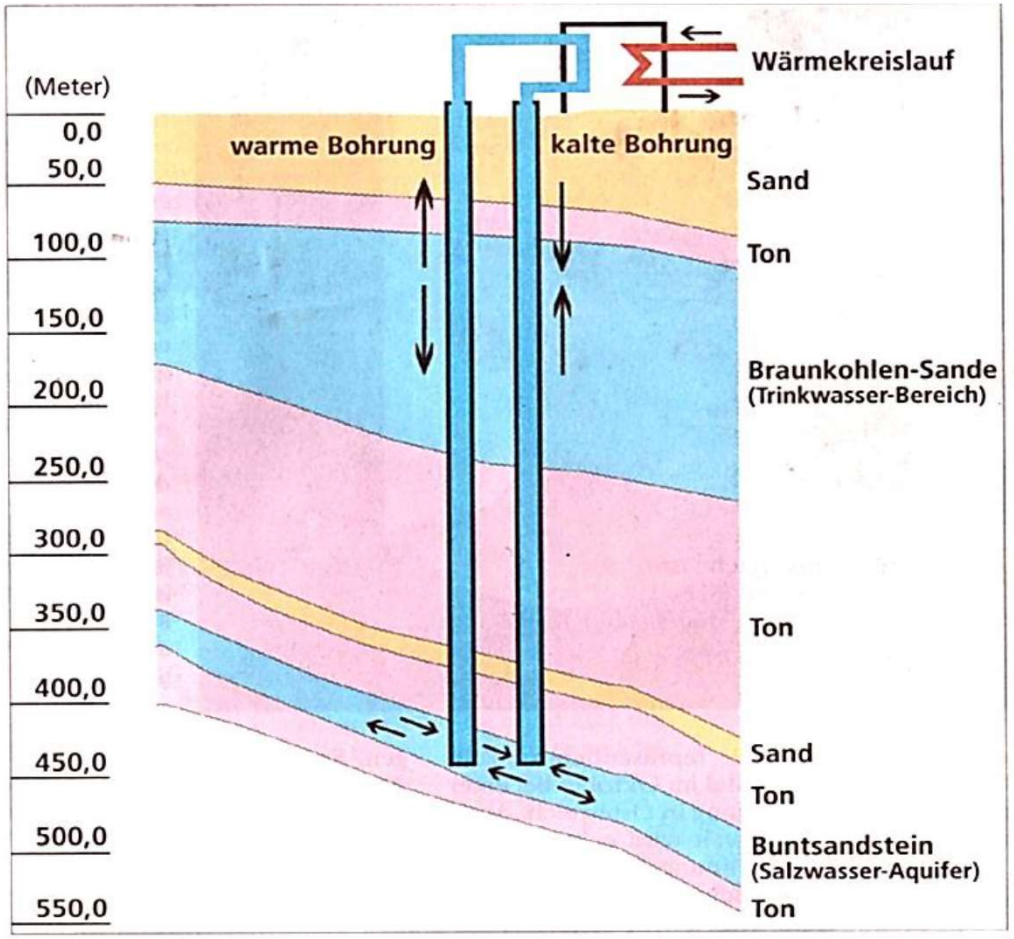
- baseload plant: 60% CHP heat, 40% boiler, 50m³ water storage
- power-operated plant: 90% CHP heat, 10% boiler, 200 m³ water storage
- CHP with aquifer storage: 100% CHP heat, 60% heat recovery, 33% stored heat

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 additional efficiency 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**

Danke!

LEUPHANA
UNIVERSITÄT LÜNEBURG

Steinbeis-Innovationszentrum
energie+

synavision

FHW