



Technische
Universität
Braunschweig

Institut für Gebäude- und Solartechnik
Prof. Dr.-Ing. M. Norbert Fisch
Mühlenpfordtstraße 23
D-38106 Braunschweig

www.igs.tu-bs.de



EnEff Campus: *blueMAP* TU Braunschweig

Integral energetic Masterplan TUBS 2020/2050

Dipl.-Ing. Tanja Beier, Dipl.-Ing. Stephan Schulze



Federal Ministry
for Economic Affairs
and Energy

project goals

- energy-efficient optimization of the campus as an urban quarter
- doubling of the climate protection goals of the Federal Republic of Germany to 2020:

40% less primary energy consumption

- period 1 : masterplan - concept and costs



04 | 2012

09 | 2015

2018

2020

2050

Masterplan

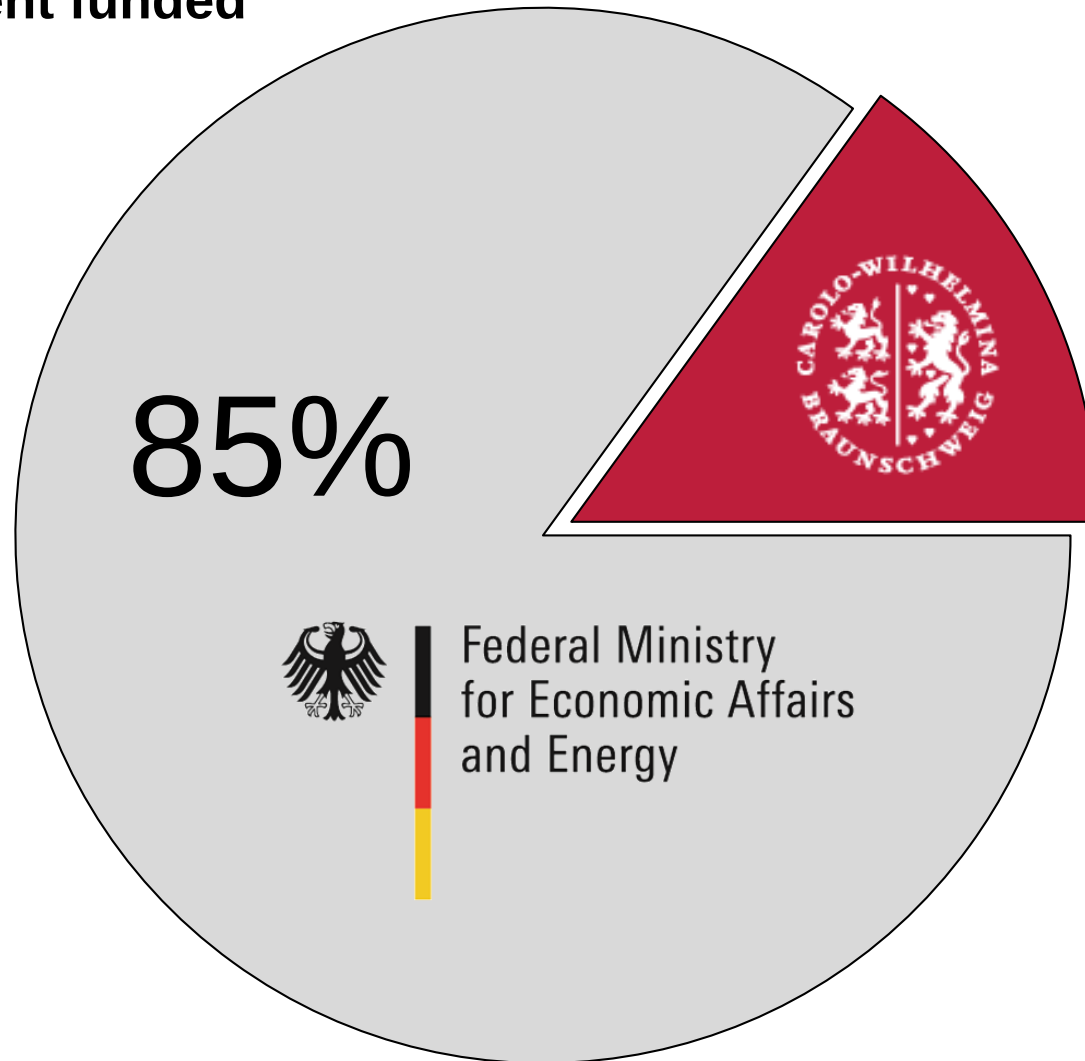
Realisation

Monitoring

1.Phase

2.Phase

government funded



internal funding through:

- personnel costs of the institutes
- investments from TU Facility Management

integral research team TU Braunschweig

Executive board TU Braunschweig

GB3

University Facility Management
Jörg Jaspers

IGS

Institute of Building Services and
Energy Design
Univ.-Prof. Dr.-Ing. M. N. Fisch

ISE

Institute of Urban Planning
Univ.-Prof. U. Brederlau

IfP

Institute of Psychology
Univ.-Prof. Dr. S. Kauffeld

elenia

Institute of high voltage technology
and electrical facilities
Univ.-Prof. Dr.-Ing. M. Kurrat
Univ.-Prov. Dr. Ing. B. Engel

Cooperation partner extern

- ITD - Institut of Transportation Design, Prof. Rammler (HBK)
- HIS GmbH (University Development and Communication)
- synavision GmbH (Monitoring)
- BS I ENERGY

main focuses

1. urban planning, architecture, building technology
2. building physics, building services engineering
3. energy supply, energy production, energy distribution
4. traffic and mobility
5. user behavior



facts and figures TU Braunschweig

6 faculties

120 institutes

3.500 employees

18.500 students

201 buildings (incl. new development)

400.000 m² net area (NGF)

energy consumption

heat: **106 kWh/m²_{NGF} a** (42,5 GWh/a)

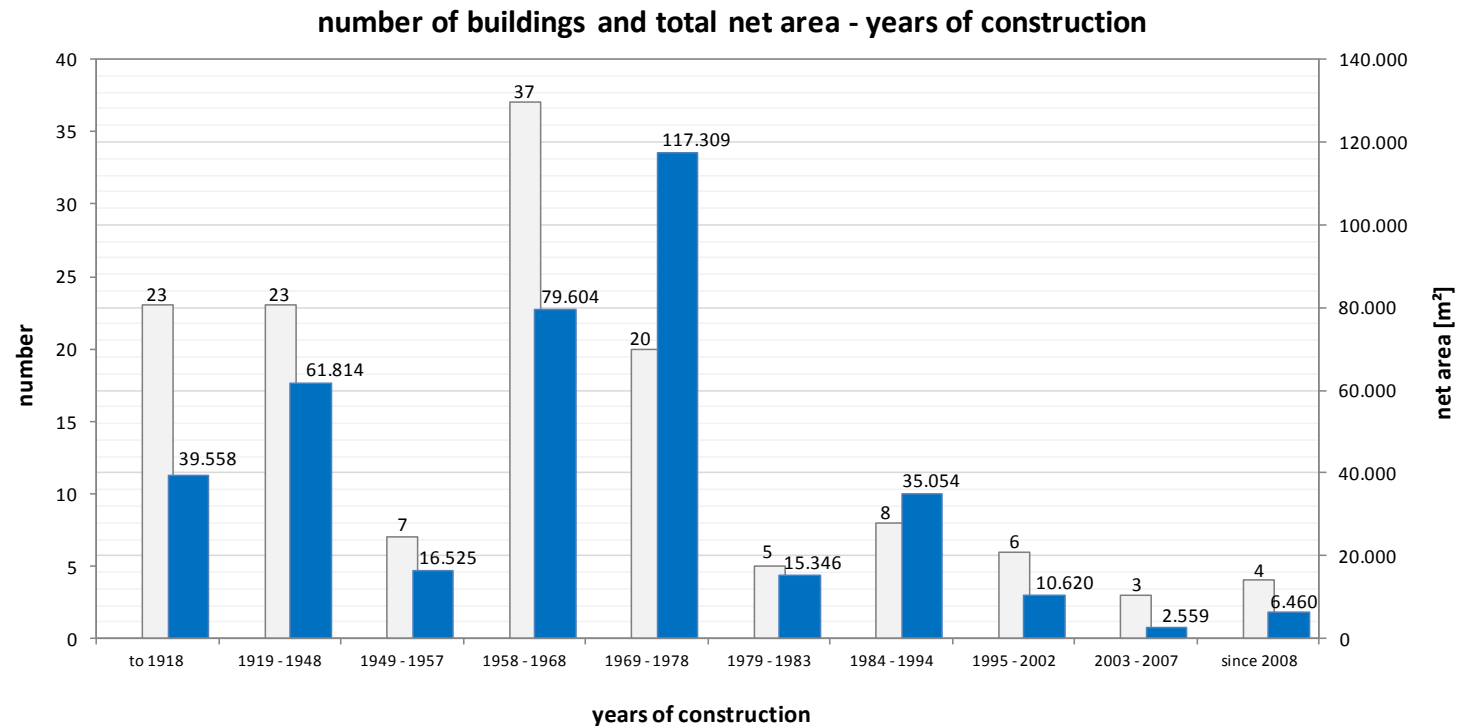
electricity: **87 kWh/m²_{NGF} a** (35 GWh/a)

energy costs: ca. 11 Mio. €/a

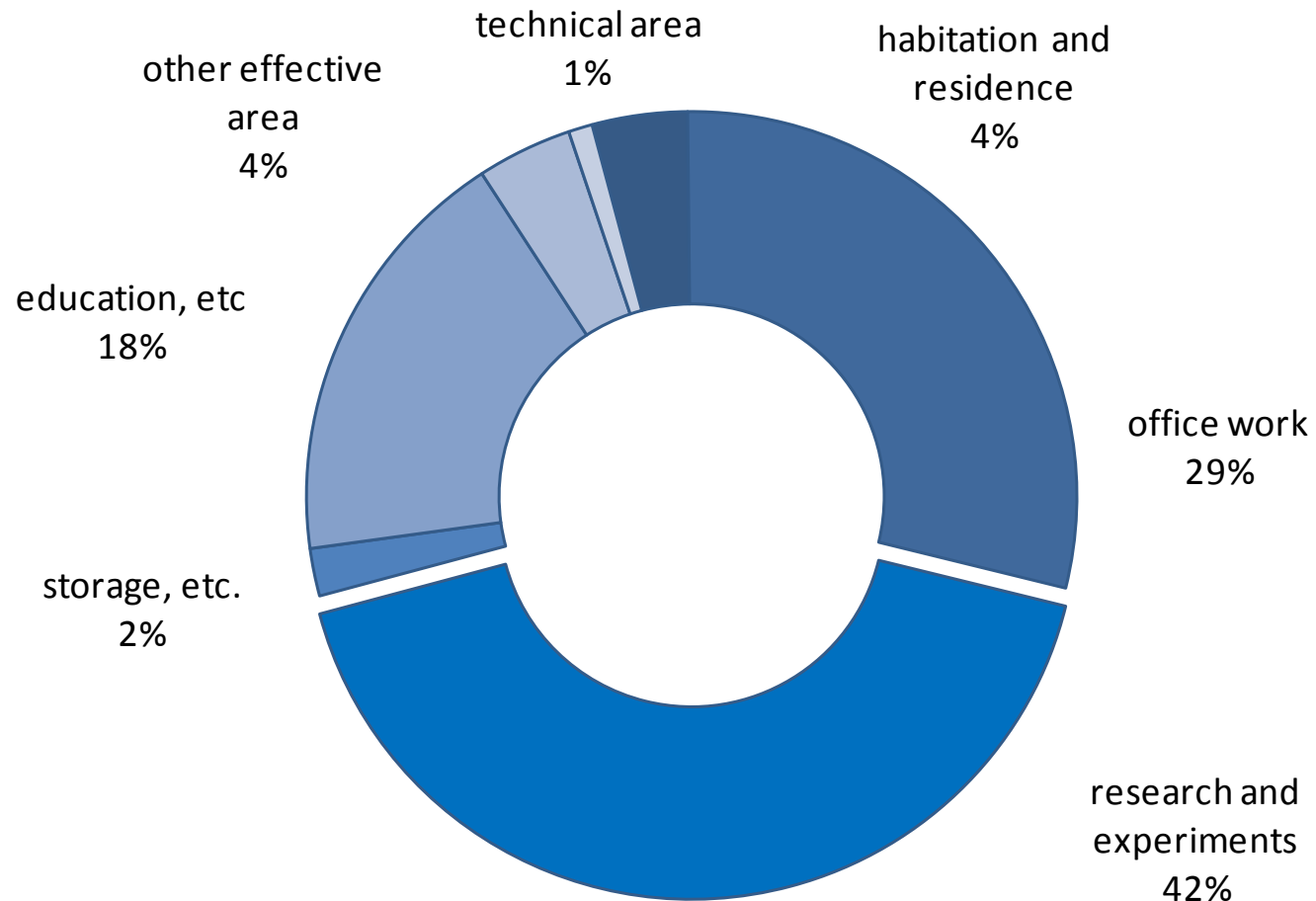


buildings with different years of construction

...before 1979	315.000 m ²	78,8 %	before first german Energy Conservation Act
...since 1979	70.000 m ²	17,5 %	
...age unknown	15.000 m ²	3,7 %	no property of TU Braunschweig / rented area



campus area split in use group (DIN 277-2)

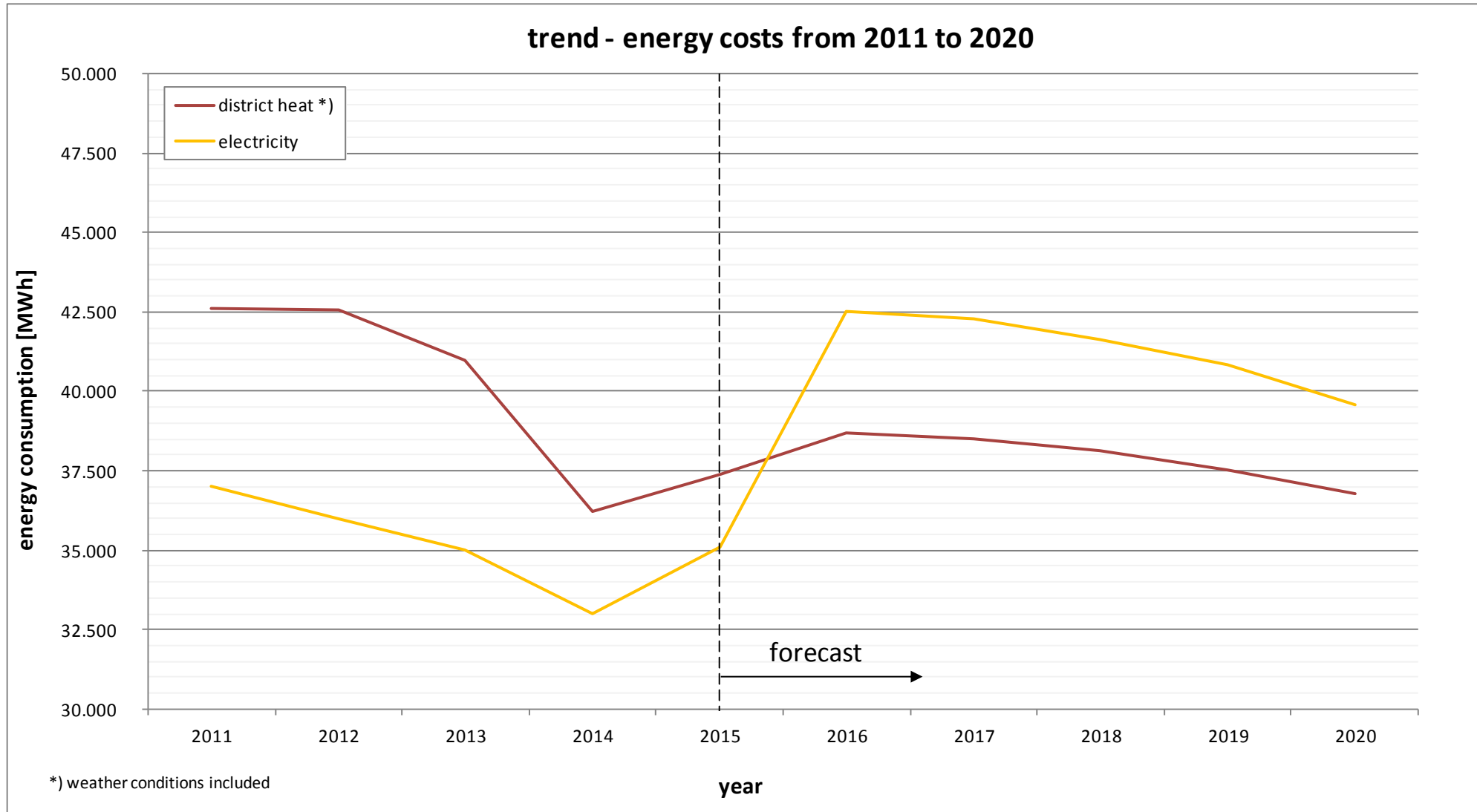


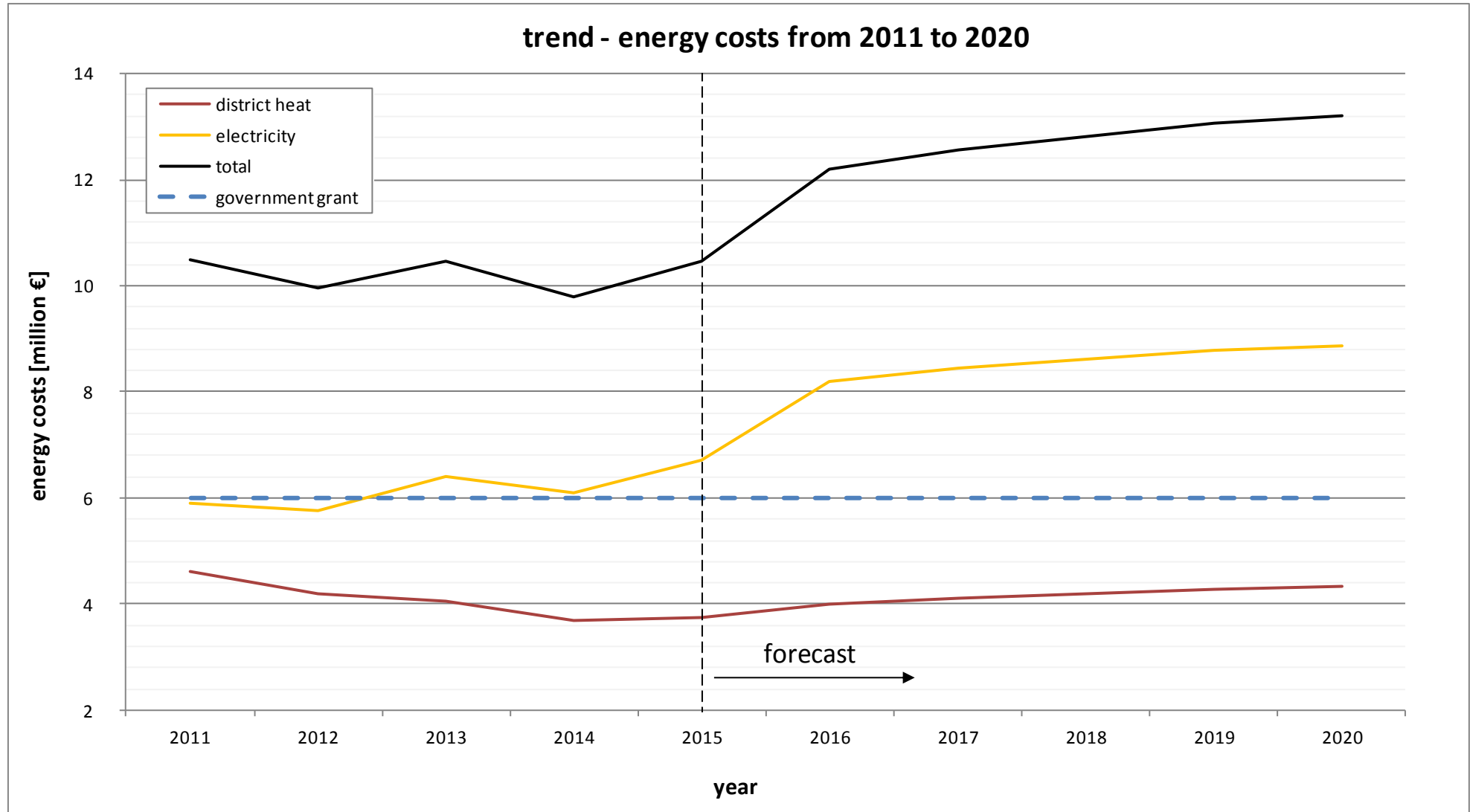
construction in progress - **research center**

additional area to 2016: **15.740 m² HNF (6,3 % gain)**

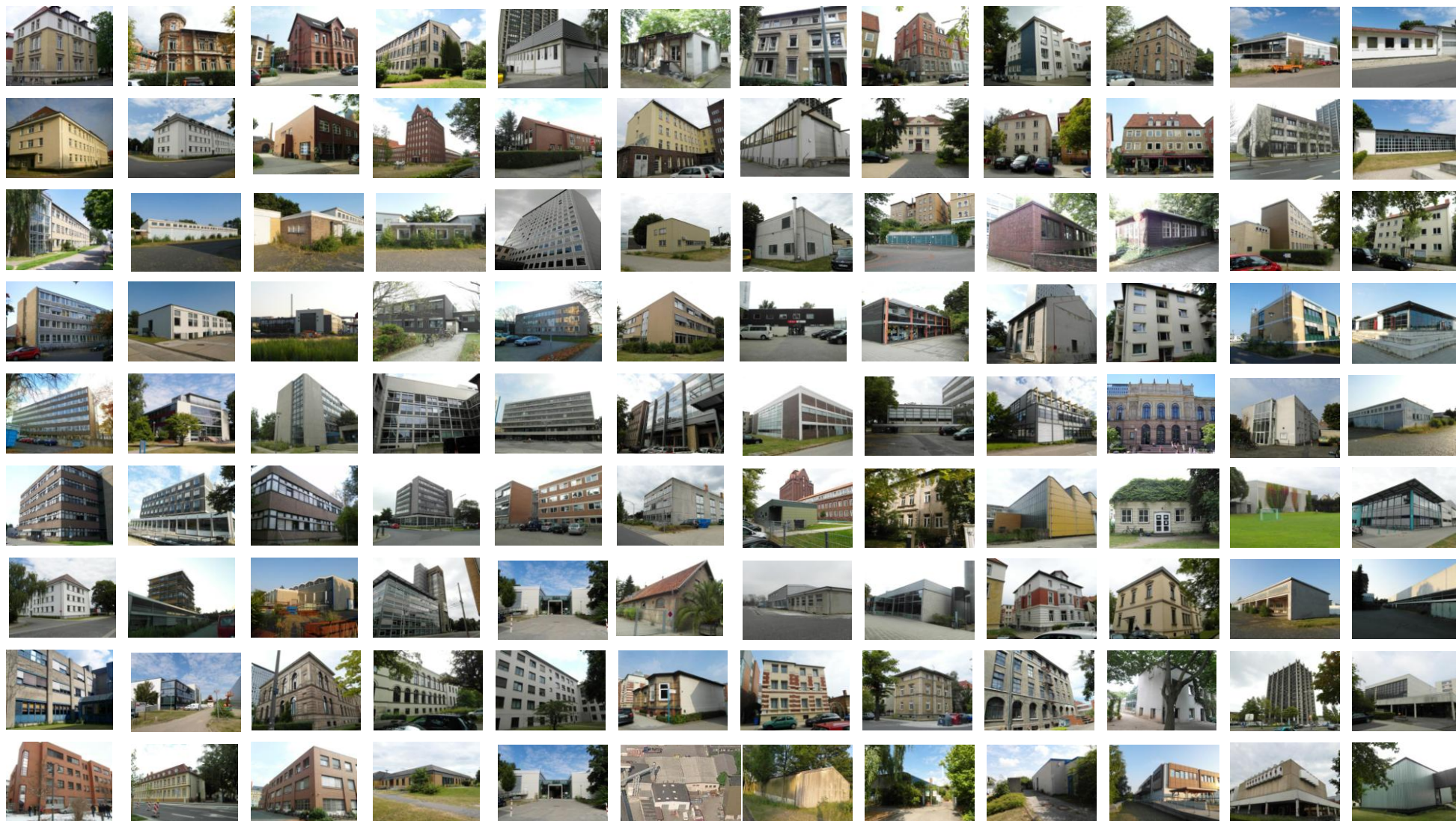
No promotion of additional aid for operating costs from the federal state/government !





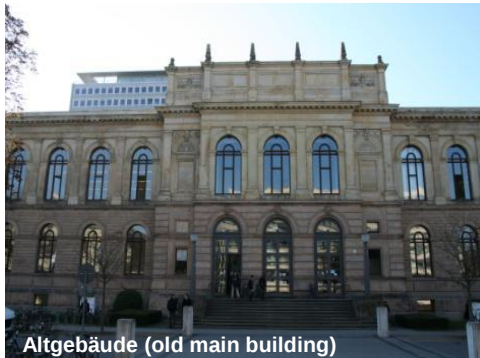


Campus TU Braunschweig



Energy consumption: collection of data

- building-specific parameter (area, use, structure, building services engineering)
- metering and measuring installations (> 500 measuring points, collecting 15-min.-consumption)
- comprehensive building-specific, high-resolution capture of energy use
- comprehensive, centrally controlled energy management system
- comprehensive building services management system



Altgebäude (old main building)



Audimax (lecture hall)



TU Hochhaus „Scheibe“ (high-rise)



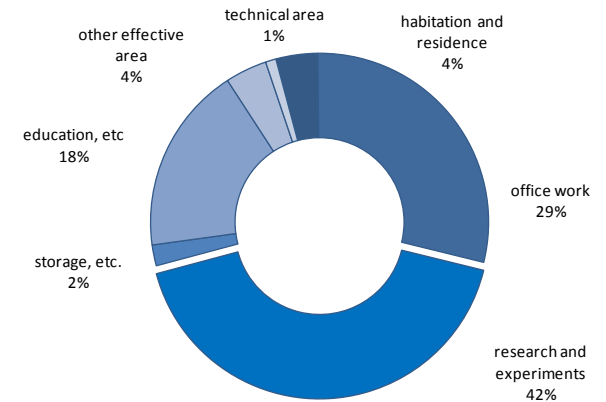
Informatikzentrum NIZ (IT center)

type of construction

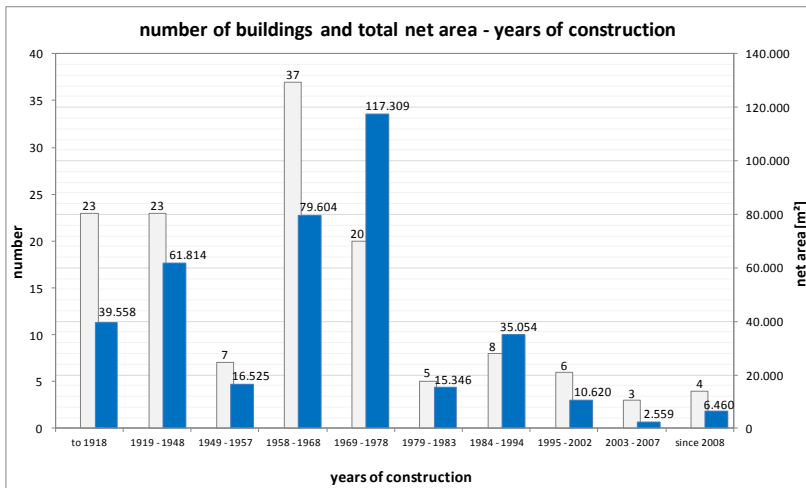


use (DIN 277-2)

campus area split in use group (DIN 277-2)

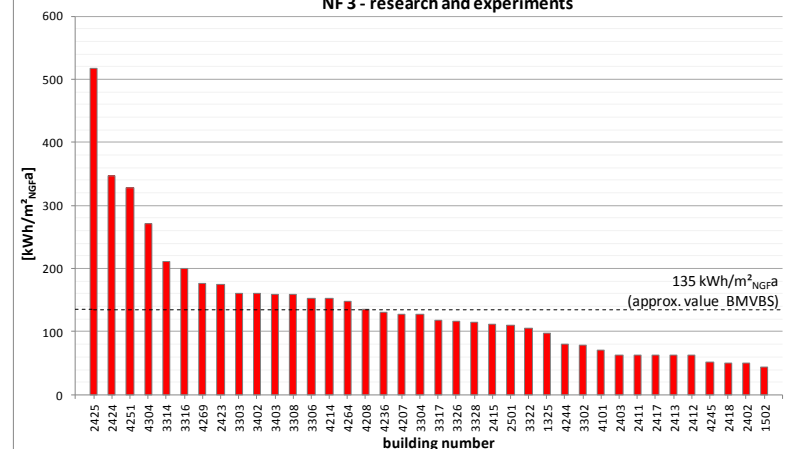


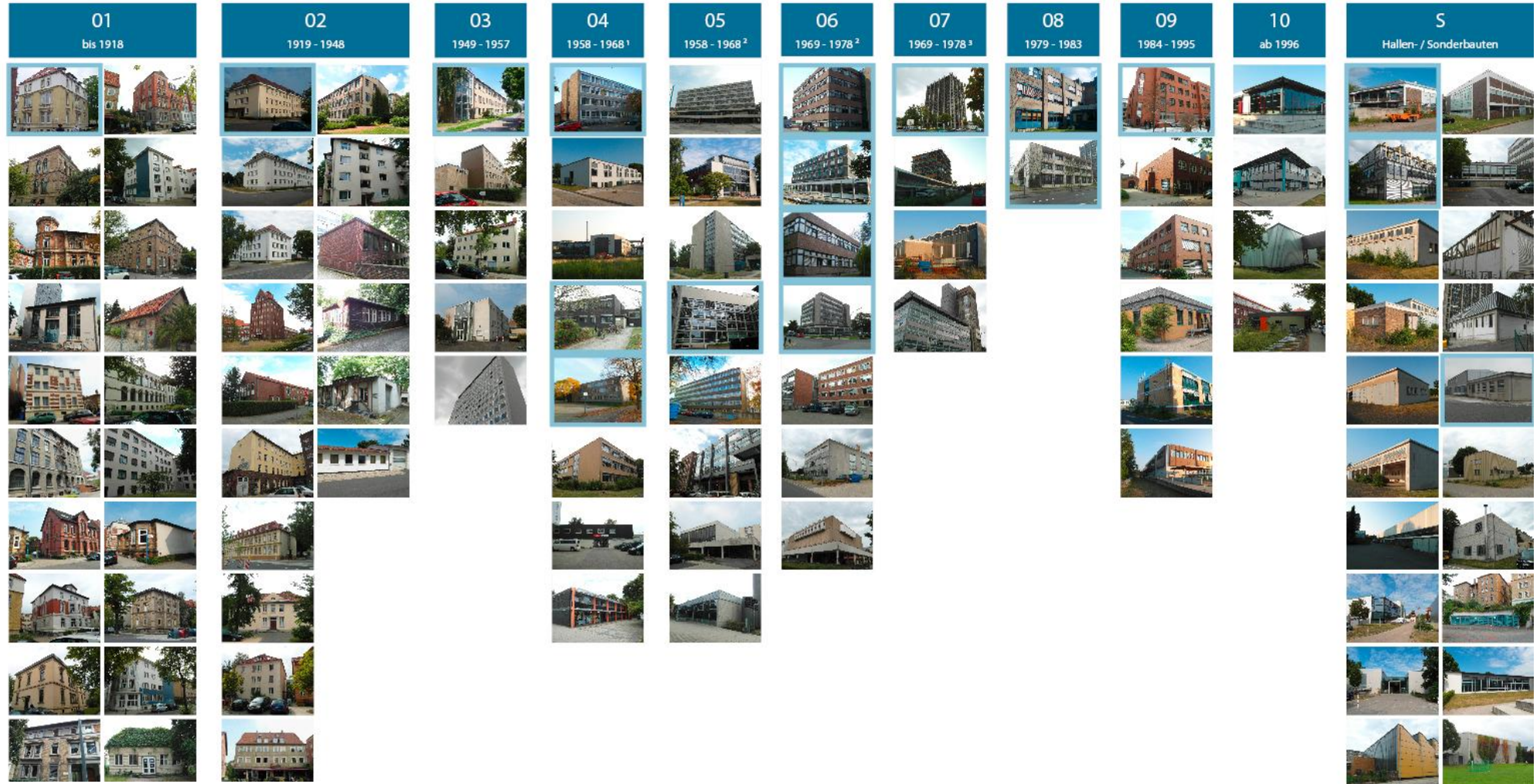
year of construction



energy consumption

final energy consumption (weather conditions included) kWh/m²_{NGFA}
NF 3 - research and experiments





¹ Lochfassade ² Bandfassade ³ Bandfassade auskragend

concept development – from a building to an urban quarter

Campus TU BS



classification

type of
construction

year of
construction

use

energy
consumption
(heat / electricity)

typification

Type 01

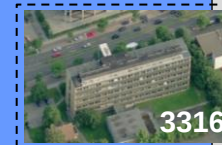
Type 02

Type 03

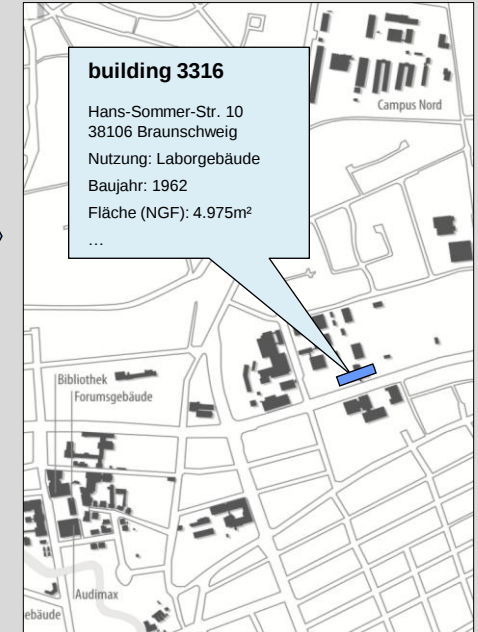
Type ...

Type ...

type 1

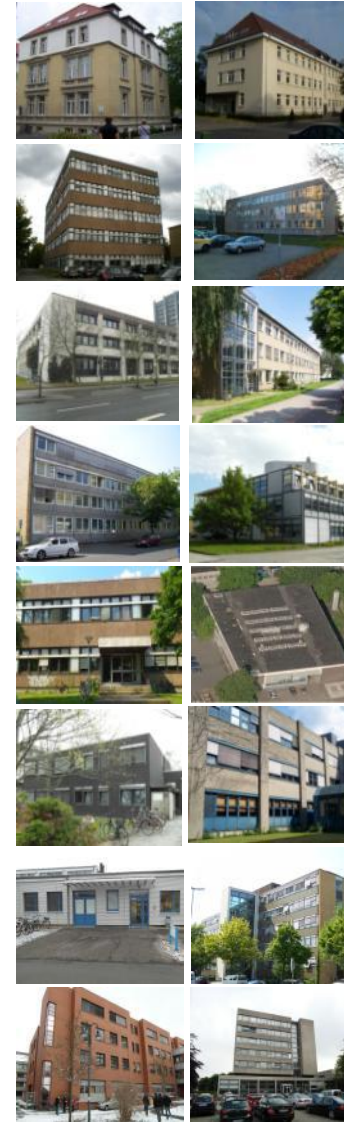


energy register



structural inventory

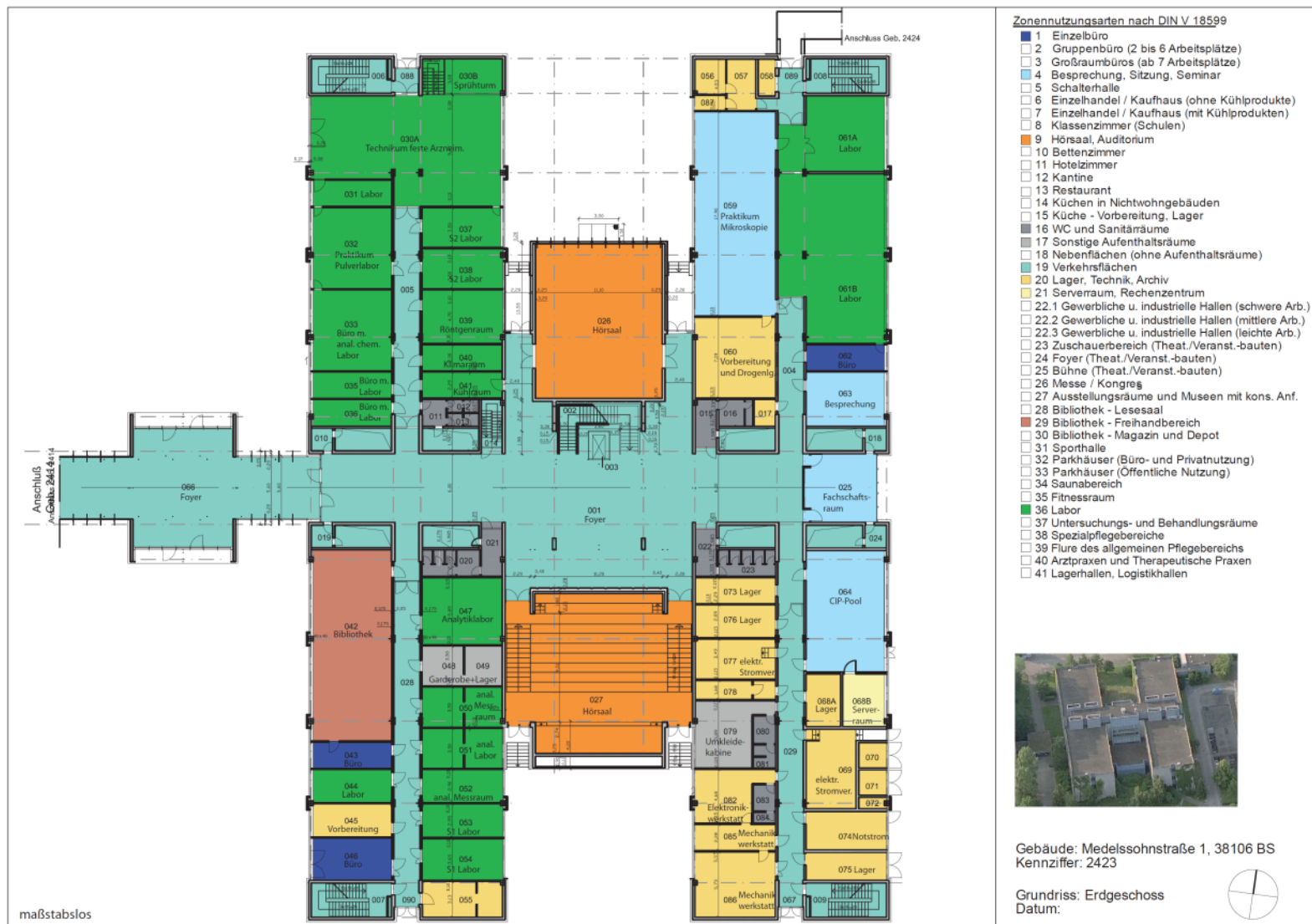
buildings total:	201 (incl. new development) ca. 400.000 m ² NGF
buildings relevant:	145 (without garages, greenhouses, etc.)
buildings evaluated:	19 buildings ca. 107.000 m ² NGF



Register – type of use

Objekt-ID	Standort	Geb	GS	Raum	Bezeichnung	DIN 277	DIN 277 Kap	KST	Nutz- Anteil %	KST-Bezeichn	Nutzer Nr	Fläche [m²]	hausnummer21	bezeichnung22	strasse22	Nutzer
207102		0001	01	001	Kino 1	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207105		0001	01	002	Kino 2	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207106		0001	01	003	Kino 3	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207107		0001	01	004	Kino 4	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207108		0001	01	005	Kino 5	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207109		0001	01	006	Kino 6	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207110		0001	01	007	Kino 7	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207111		0001	01	008	Kino 8	5.1	NF 5	15000101	100	Zentrale Hörsäle	951200	60		C1-Cinema	Lange Straße	Zentral verw. Hörsäle
207645		0002	01	101	Großer Saal	5.6	NF 5	15000101	100	Zentrale Hörsäle	951200			Stadthalle	Leonhardplatz	Zentral verw. Hörsäle
207649		0002	01	102	Congress Saal	5.6	NF 5	15000101	100	Zentrale Hörsäle	951200			Stadthalle	Leonhardplatz	Zentral verw. Hörsäle
216020		0003	00	H.1.11A	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	32 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216033		0003	00	H.1.11B	Feinwerkstatt	3.2	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	32 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216034		0003	00	H.E.01	Metallwerkstatt	3.2	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	50 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216010		0003	00	I.1.11	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216027		0003	00	I.2.20	Labor Analytik	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	25 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216023		0003	00	I.2.50	Labor	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	29 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216024		0003	00	I.2.52	Labor	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216012		0003	00	I.2.54	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216021		0003	00	I.2.55	Labor	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	25 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216015		0003	00	I.2.56	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	27 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216022		0003	00	I.2.57	Labor	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	37 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
207715		0003	00	I.2.58	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216007		0003	00	I.2.60	Sekretariat	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216026		0003	00	I.2.61	Labor	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	58 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216008		0003	00	I.2.62	Besprechung	2.3	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216030		0003	00	I.2.63	Labor	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	14 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216009		0003	00	I.2.64	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	20 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216014		0003	00	I.3.03	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216011		0003	00	I.3.15	Büro Doktoranden	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216013		0003	00	I.3.60	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	20 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216025		0003	00	I.E.05	Labor	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	70 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216017		0003	00	S.1.11	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216018		0003	00	S.1.29	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216019		0003	00	S.1.43	Büro	2.1	NF 2	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216016		0003	00	S.1.57	Lager Elektro	4.1	NF 4	13422000	100	Inst.f. Oberflächentechnik	360344	21 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216028		0003	00	S.E.02	Lager Diffusion	4.1	NF 4	13422000	100	Inst.f. Oberflächentechnik	360344	18 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216029		0003	00	S.E.05	Labor Korrosion	3.5	NF 3	13422000	100	Inst.f. Oberflächentechnik	360344	35 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216031		0003	00	S.E.06A	Lager Werkstatt	4.1	NF 4	13422000	100	Inst.f. Oberflächentechnik	360344	26 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
216032		0003	00	S.E.06B	Hochregallager	4.1	NF 4	13422000	100	Inst.f. Oberflächentechnik	360344	12 54 e		Fraunhofer-Institut f. Bienroder Weg		Inst. f. Oberflächentech
67733		1301	-01	-101	Theaterfundus	4.2	NF 4	48883026	100	Theatergruppe TU Braunschweig	951631	28 80		Campus Nord	Bienroder Weg	Theatergruppe TU
67734		1301	-01	-102	Aktenlager	4.2	NF 4	13603000	100	Englisches Seminar	482632	12 80		Campus Nord	Bienroder Weg	Englisches Seminar
67735		1301	-01	-103	Aktenlager	4.2	NF 4	13603000	100	Englisches Seminar	482632	12 80		Campus Nord	Bienroder Weg	Englisches Seminar
67736		1301	-01	-104	Aktenlager	4.2	NF 4	13603000	100	Englisches Seminar	482632	12 80		Campus Nord	Bienroder Weg	Englisches Seminar
67737		1301	-01	-105	Bibliothekssachiv	4.2	NF 4	13603000	100	Englisches Seminar	482632	12 80		Campus Nord	Bienroder Weg	Englisches Seminar
67738		1301	-01	-106	TUBS- Player	5.2	NF 5	13603000	100	Englisches Seminar	482632	20 80		Campus Nord	Bienroder Weg	Englisches Seminar

building – type of use



development of an inventory guide

collection of data

building envelope

room level

technical equipment

lighting

building services

building level

energy supply

building services

Gebäudehülle										Bemerkungen
Konstruktion										
Konstruktionstyp		Massivbau	☐	Skelettbau	☐	Leichtbau	☐	Mischbau	☐	
Dach										
Dachtyp		Satteldach	☐	Flachdach	☐	Pultdach	☐	Sonstige	☐	
Konditionierung Dachgeschoss		beheizt	☐	unbeheizt	☐					
Aufbau										
Dachfenster		ja	☐	nein	☐					
Typ										
Fassade (opak)										
Fassadentyp A		Lochfassade	☐	Bandfassade	☐	Elementfassade	☐	Sonstige	☐	
Orientierung		alle	☐							
oder abweichend		Nord	☐	Ost	☐	Süd	☐	West	☐	
Aufbau (opak)										
Fassadentyp B		Lochfassade	☐	Bandfassade	☐	Elementfassade	☐	Sonstige	☐	
Orientierung		alle	☐							
oder abweichend		Nord	☐	Ost	☐	Süd	☐	West	☐	
Aufbau (opak)										
Bodenplatte										
Konditionierung		gegen Erdreich	☐	gegen unbeheizt	☐					
Aufbau										

results of different single measures – existing buildings

building envelope



modernizing insulation of buildings
EnEV 2009

investment: 120 Mio. € ($300 \text{ €/m}^2_{\text{NGF}}$)
cost savings: 1,6 Mio. €/a

primary energy: - 9 %

building services



optimizing operations
ventilation systems

investment : 4 Mio. €
cost savings : 1,2 Mio. €/a

primary energy : - 16 %

technical equipment



fridge(-freezer)
replacement of older devices

investment : 1 Mio. €
cost savings : 165.000 €/a

primary energy : - 3 %

measures lighting

replacement of fluorescent lamps by LED-lamps

laboratories



investment: 1,22 Mio. €
19,30 €/m² laboratory area

cost savings: 330.000 €/a

primary energy: -5 %

offices



investment: 799.000 €
13,20 €/m² offices area

cost savings: 100.000 €/a

primary energy: -1 %

traffic area / corridors



investment: 550.000 €
6,60 €/m² traffic area

cost savings: 135.000 €/a

primary energy: -2 %

integration CHP

(combined heat and power unit)

in coordination with BS I ENERGY
(regional energy utility company)

use of renewable energy :
biomethane

■ own use of heat supply
from CHP [%]

■ residual heat supply
district heat [%]

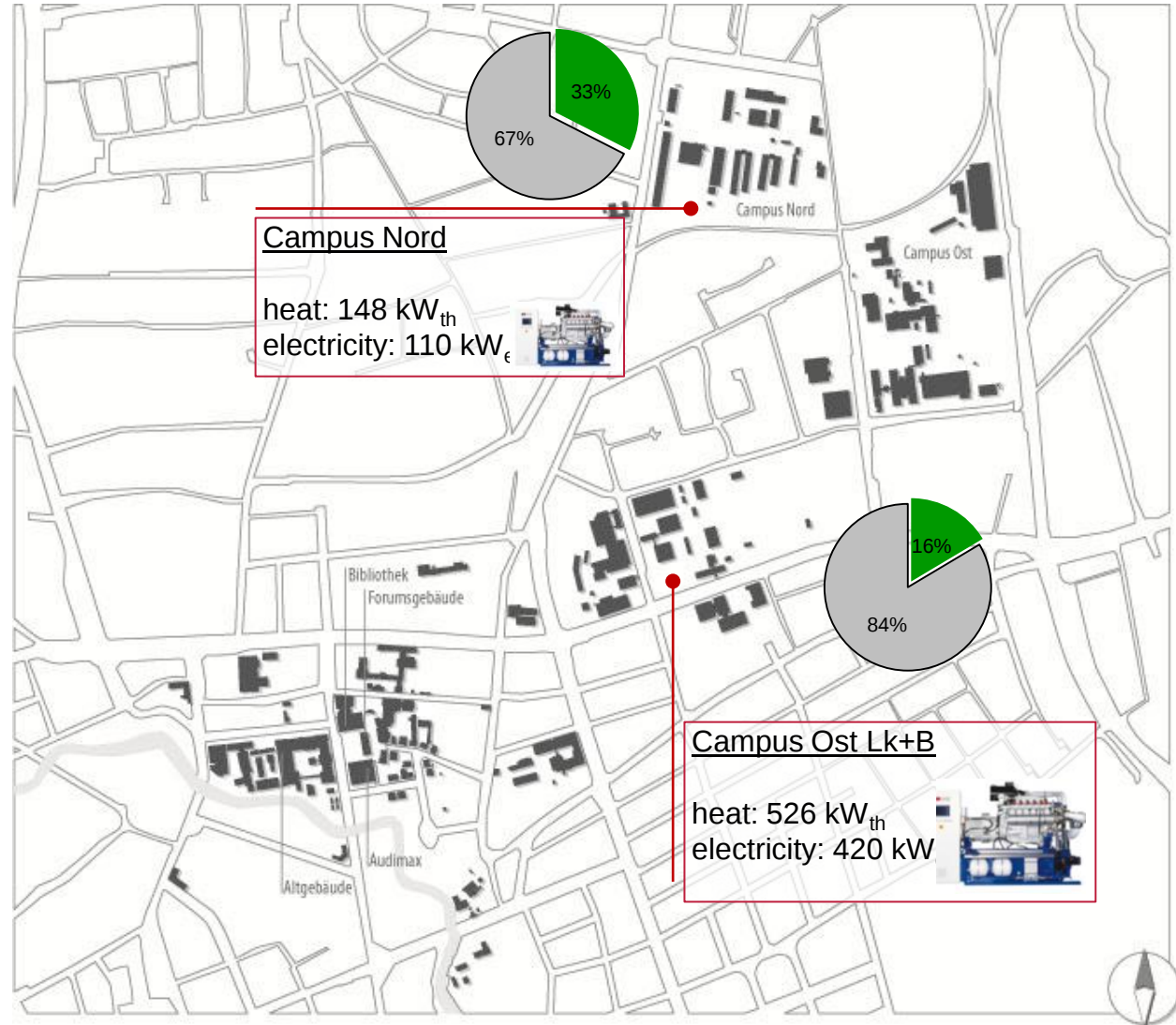
energy production:

heat: ca. 4.380 MWh/a

electricity: ca. 3.430 MWh/a

cost savings: 320.000 €/a

primary energy: -2 to -8 %



photovoltaics (PV)

analysis of total roof area on campus

roof area suitable for PV: 100.000 m²
total area PV: 20.000 m²

total power: 3.000 kW_p

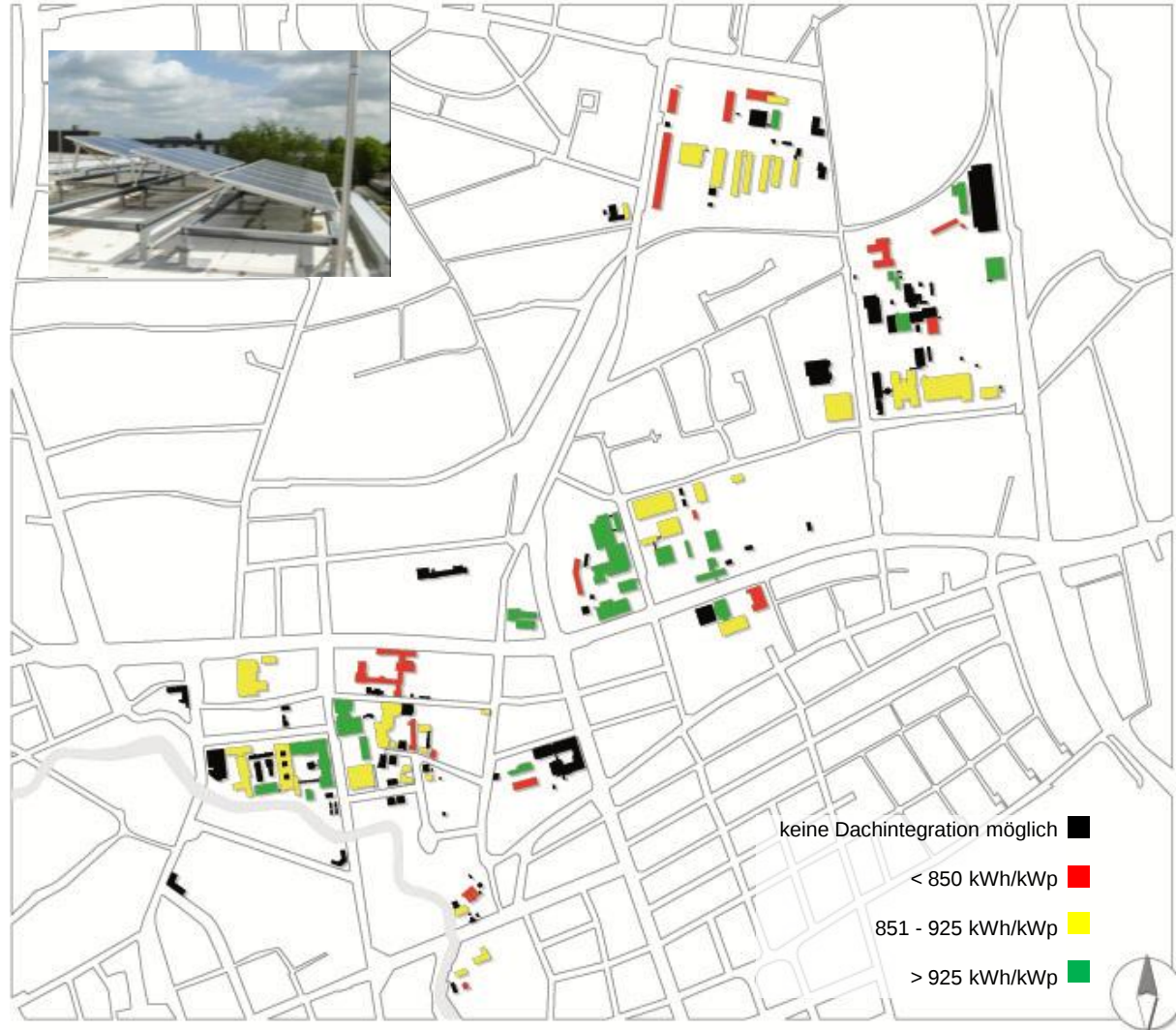
investment^{*1)}: 7,2 Mio. €
2.500 €/kW_p

annual return: 2,5 GWh/a
cost savings: 480.000 €/a
(in case of **100% internal consumption**)

coverage electricity consumption:
ca. 9 %

primary energy: - 6 %

^{*1)} incl. all constructional and other costs



area efficiency

officework: $A_{NGF} = 59.200 \text{ m}^2$

employees TU BS: ca. 3.500

other staff: ca. 450

→ occupancy : ca. 15 m^2 office/person
(according to DIN V 18599-10 medium occupancy rate)

high occupancy rate (10 m^2 /person):

$A_{NGF} = 39.500 \text{ m}^2$

possible savings: max. **19.700 m²**

 possible savings offices [%]

 residual area [%]

reduction final energy:

heat: ca. 2.400 MWh/a

electricity: ca. 590 MWh/a

cost savings: ca. 390.000 €/a

Primary energy: - 3 %



user behavior

action for increase the user motivation „to save energy“

primary energy: -8 %

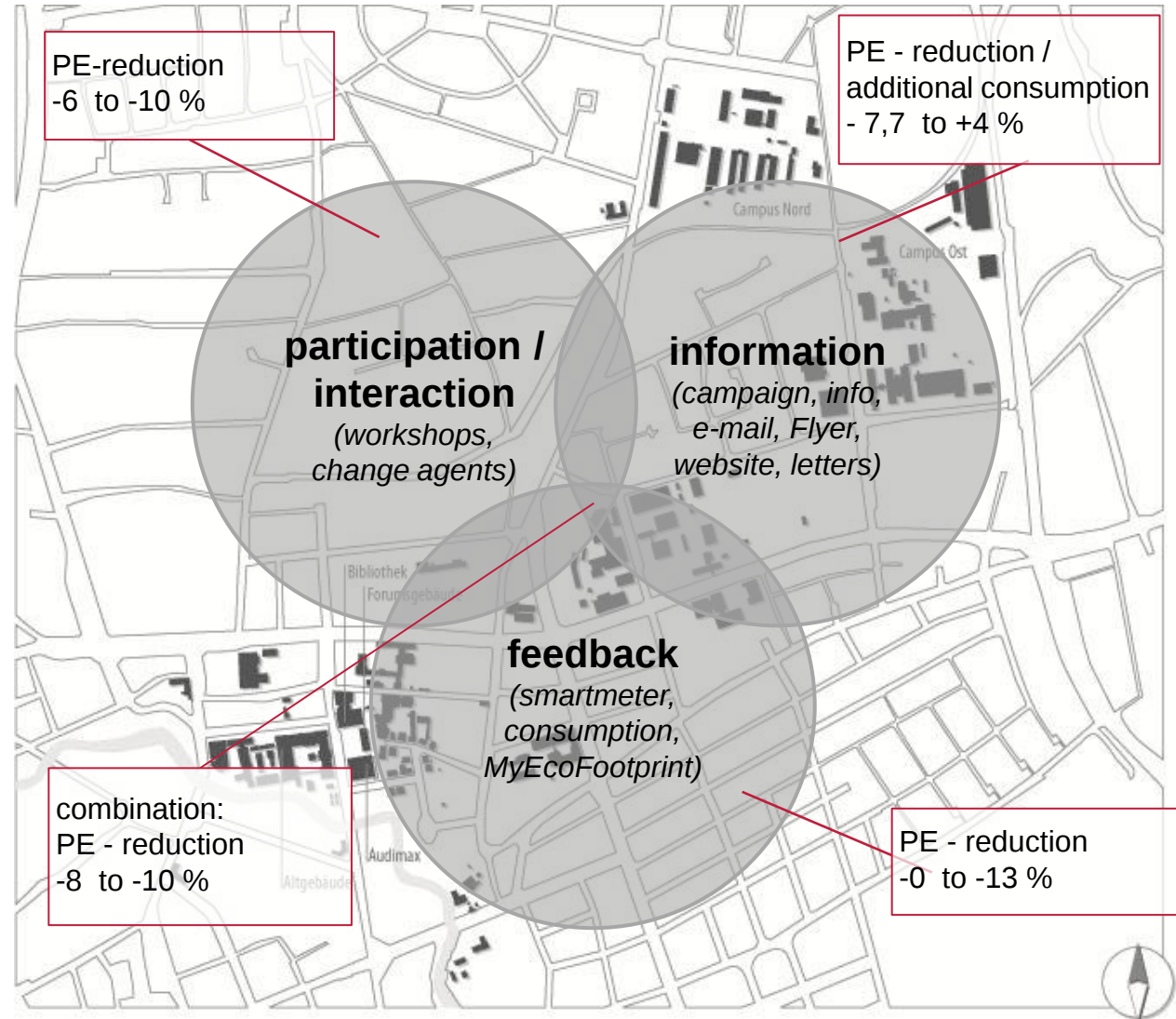
communication
trainings



user workshops



energy coaching



Frohe Weihnachten

★ Trennen Sie zentrale Geräte wie Drucker und Kopierer vom Netz.

★ Trennen Sie alle Küchengeräte vom Netz.

★ Drehen Sie alle manuell regelbaren Heizungsthermostate in die Richtung des „Frostschutzes“ (*).

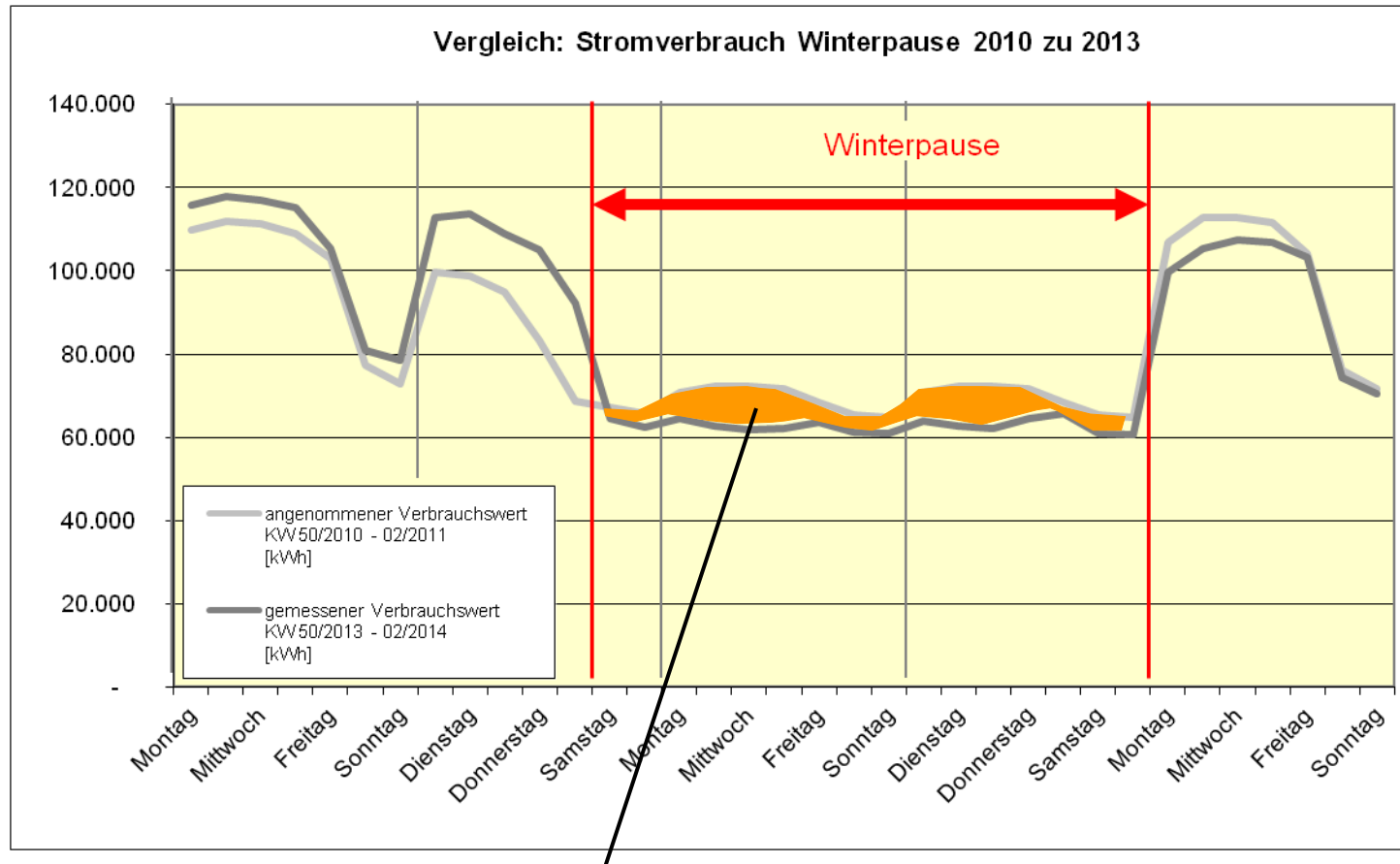
★ Überprüfen Sie auch die Arbeitsplätze der Studierenden.

★ Schließen Sie alle Fenster und Türen.

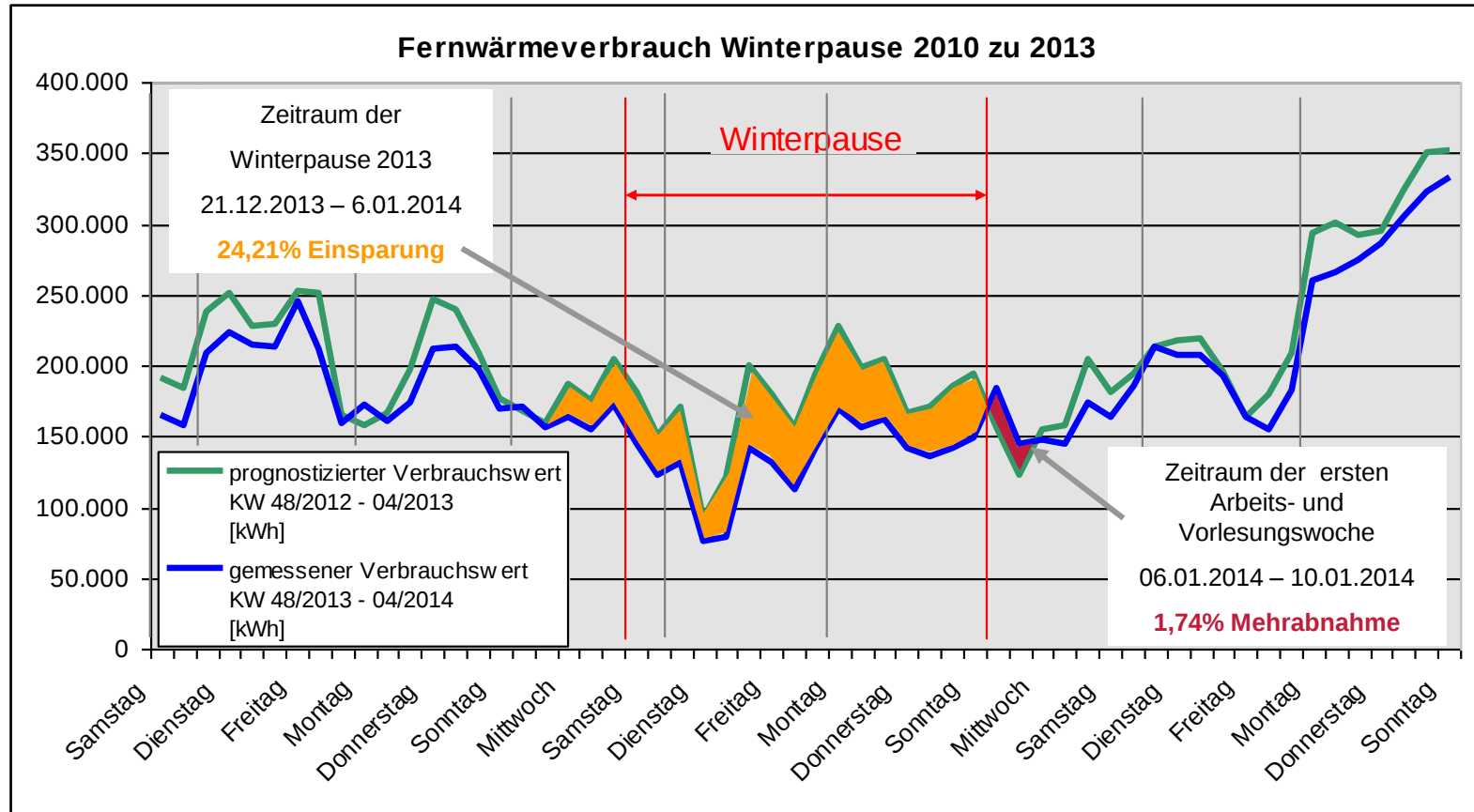
★ Sie sollten alle Geräte Ihres Arbeitsplatzes vom Netz trennen.

★ Löschen Sie alle Lichter.





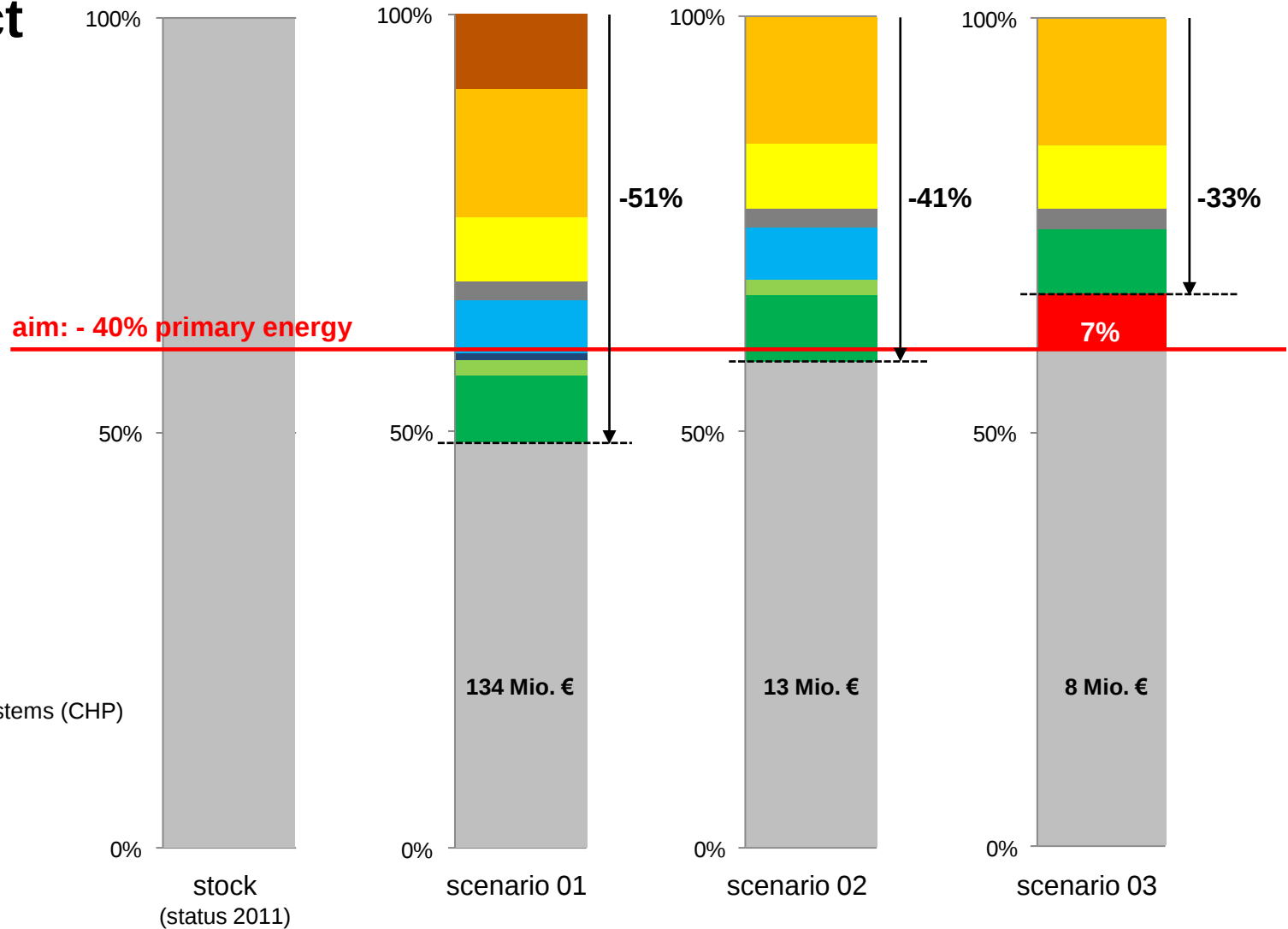
reduction of the electricity consumption in the christmas holidays 2013/14



reduction of the heat consumption in the christmas holidays 2013/14

measures	scenario 01	scenario 02	scenario 03
building envelope	X	-	-
building services / ventilation systems	X	X	X
lighting	X	X	X
energy production			
PV	X	X	-
CHP	X	-	-
technical equipment	X	X	X
efficient user behavior	X	X	X
area efficiency	X	X	-

goals of project





**Technische
Universität
Braunschweig**

Institut für Gebäude- und Solartechnik
Prof. Dr.-Ing. M. Norbert Fisch
Mühlenpfordtstraße 23
D-38106 Braunschweig

www.igs.tu-bs.de



forecast - EnEff Campus 2020

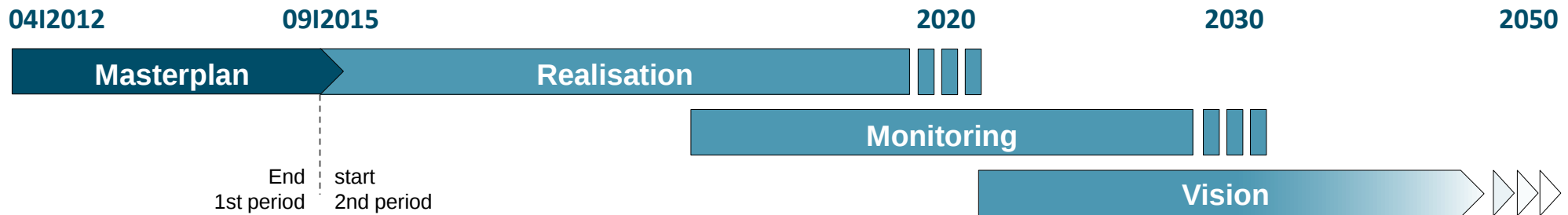
support and monitoring of implementation



Bundesministerium
für Wirtschaft
und Energie

EnEff Campus II

→ support + monitoring
of implementation



ca. 25- 30 Mio. EUR/a

main focuses

implementation

- energy efficient optimization Campus TU BS until 2020
- processing long-term strategy :
TU Campus zero emission / CO2 neutral

energy laboratory - Real-Life-Lab Campus TU BS

- developing an integrated „technology research platform“ for the use of building data to optimize building performances



focus I – implementation

Strategies

1. new building, renovation, maintenance
2. energy supply (CHP, PV)
3. Trainings and workshops for efficient user behavior
4. urban planning
5. process optimization



Forumsgebäude (renovation)



NFF - new construction



urban planning



e-mobility

focus II – „energy laboratory“

- implementation and evaluation of the concepts developed in EnEff Campus I
- investigation of options (small district heating and „small power grid“) to supply the campus / quarter
- transfer of investigated measures to other district and monitoring these
- implementation of building-type-specific measures to other educational institutions in Germany
- further development of the calculation tools designed in EnEff Campus I



discussion / Q & A



picture: ISE