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Universität
Braunschweig

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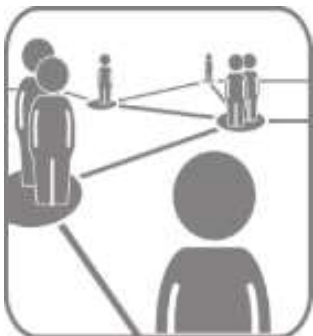
Buildings and Districts as Renewable Energy Source

Stellenbosch March 24th 2017

Univ. Prof. Dr.-Ing. M. Norbert Fisch



494.8 mio
82.0 mio



112 people / km²
226 people / km²

Europe



Who are we?

Technology and Innovation Network MNF

UNIV.-PROF. DR.-ING. **M. NORBERT FISCH**

Stuttgart · Braunschweig · Aachen · Shanghai · Bangkok



Steinbeis-TZ
Stuttgart



EGS-plan
Stuttgart



Energydesign
Braunschweig



EGSplan Int.
Bangkok



Institut für Gebäude-
und Solartechnik IGS
TU Braunschweig



Synavision
RWTH Aachen
TU Braunschweig

Partner in Research
+ Science

**renewable
energy applications**

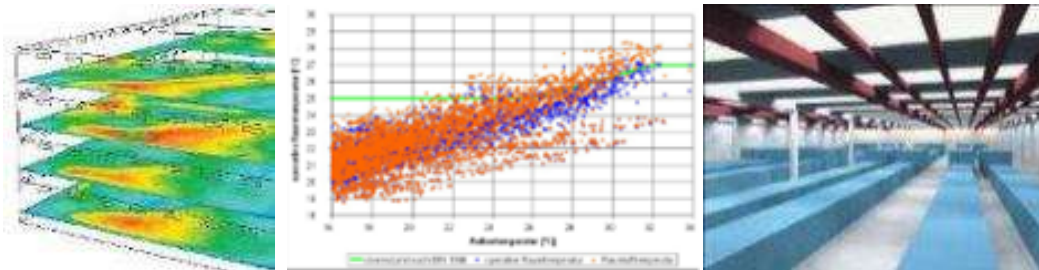
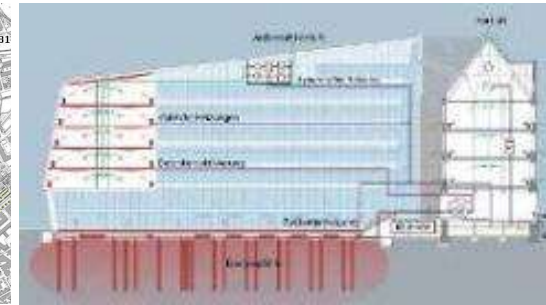
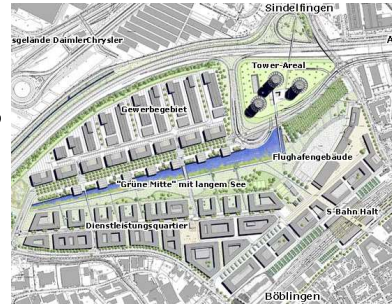
**integral
energy concepts**

**building
physics**

**building
services**

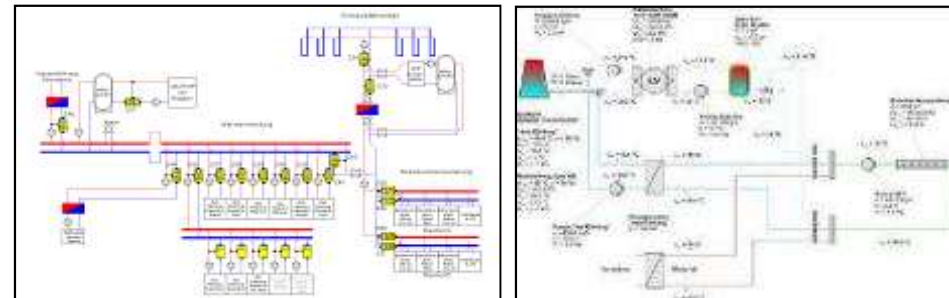


Energy concepts for buildings and city districts



Building simulation

HVAC design, building physics



Building certification (LEED, DGNB, Three-Star)

Rizzi Haus | Obelisk am Löwenwall | Altstadtmarkt | Residenzschloss
© Braunschweig Stadtmarketing GmbH / Gerald Grote



Germany's oldest technical university – founded in 1745

Excellence university - Member of TU9 German Institutes of Technology e.V.



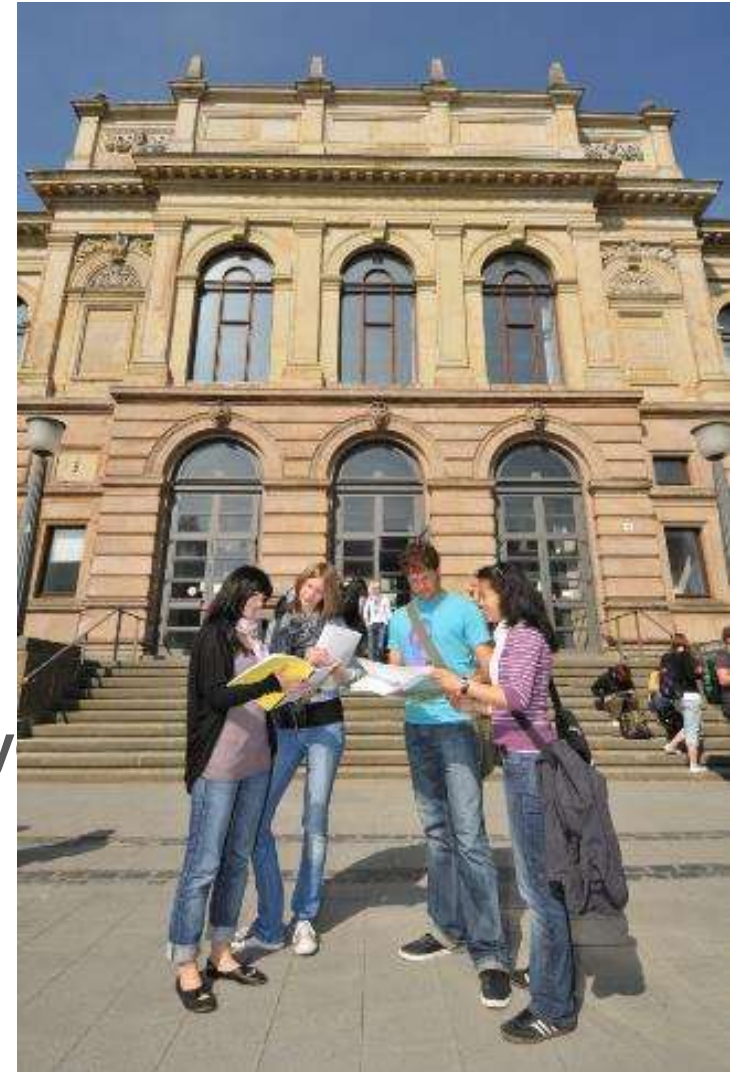
Studierenden Service Center
© dds-online



1 university
6 schools / faculties
64 degree programmes
124 institutes

2,000 scientists
3,380 university employees
3,800 first semester students (each y
ca. 22,000 students (11% international)

78,000,000 euros in outside funding
287,000,000 euros in overall budget



6 Schools / Faculties

- **Carl-Friedrich Gauß:**
Mathematics, Computer Science,
Business Administration and Social Sciences
- **Life Sciences**
- **Architecture, Civil Engineering and
Environmental Sciences**
- **Mechanical Engineering**
- **Electrical Engineering, Information Technology,
Physics**
- **Humanities and Educational Sciences**





Offices – Meeting Points – Communication – Lecturing – Laboratory





Univ.-Prof. Dr.-Ing. M. N. Fisch



Deputy
Director

T. Wilken



Head of
Energy and
Quality
Management

Dr. S. Plesser



Head of
Energy
Efficient
Building

T. Beier

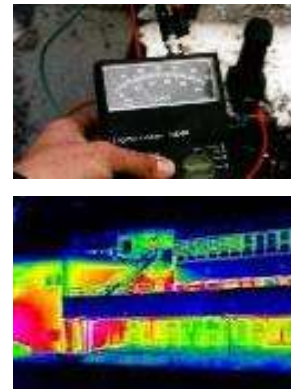
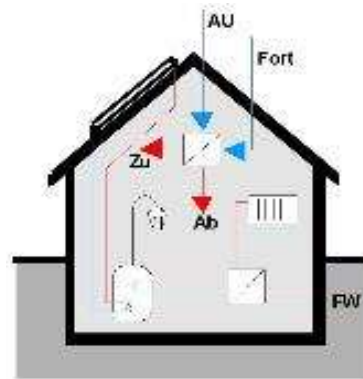


Head of
Sustainable
Energy Supply

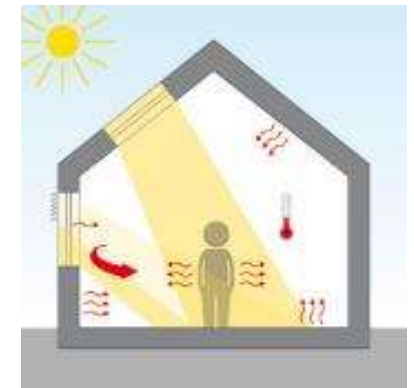
F. Bockelmann

Engaged team - for teaching, research and development





Building Physics - Building Services – Energy Design – Acoustics - Simulations



Integral design approach!

Individual planning approach



INCONSISTANT DATA



INEFFICIENT PROJECT COMMUNICATION



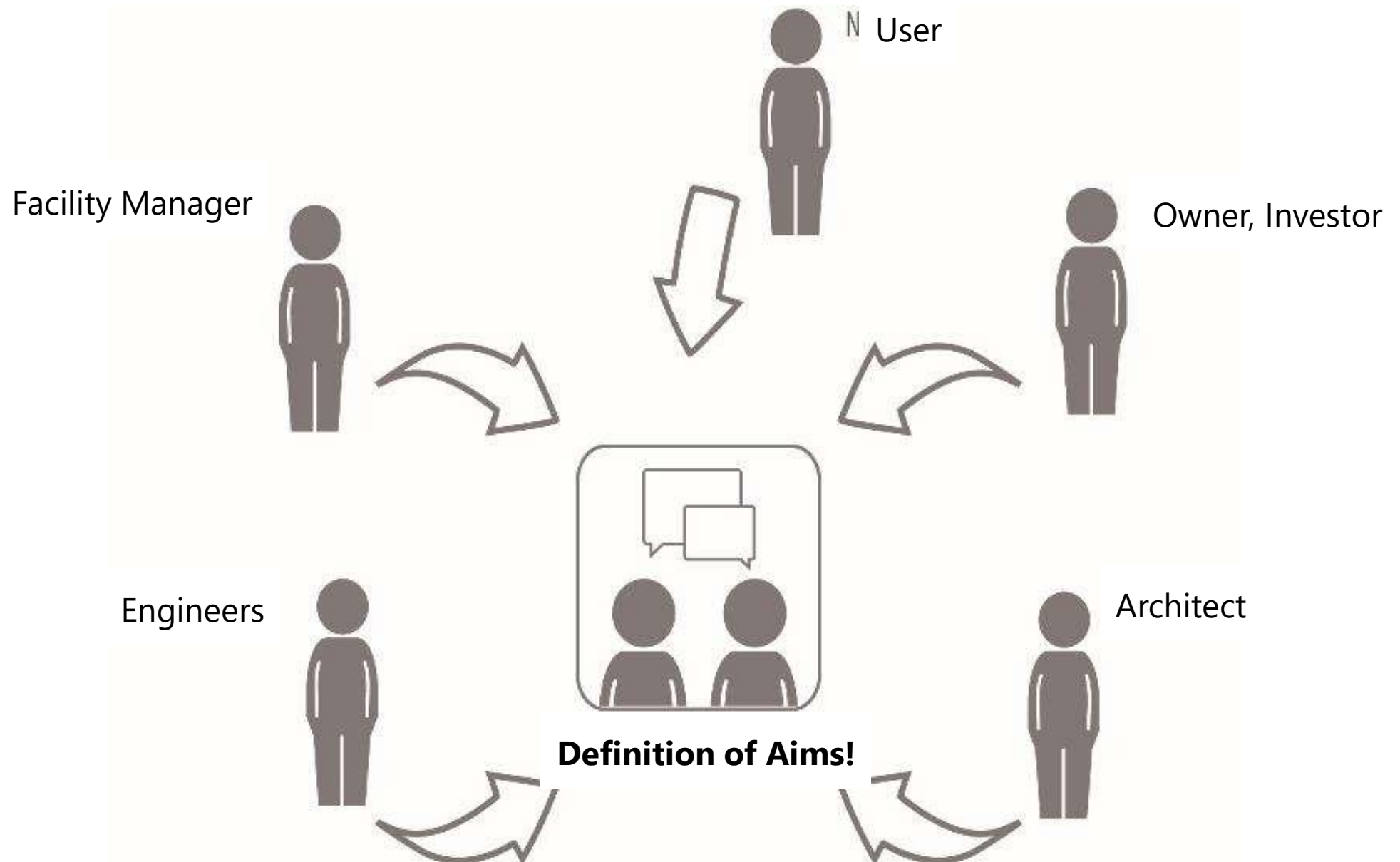
PLANNING ERRORS DISCOVERED TOO LATE

Integral planning approach



CENTRAL 3D-BUILDING MODEL, SYNCRONIZED PROCESSES AND EFFICIENT AND CONTINUOUS FLOW OF INFORMATION

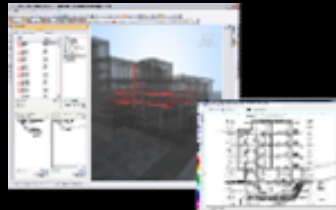
BIM (Building information modeling)
a process from the concept to the operation .



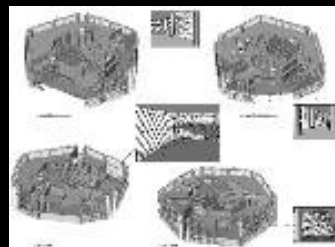
STEP 3:
3D-COMPONENT ORIENTATED
WORK WITH BUILDING
ORIENTATED MODELLING



STEP 2:
PLAN-BASED WORK
WITH 3D-COMPONENTS
AND 2D-SECTIONS /
ELEVATIONS



STEP 1:
PLAN-BASED DIGITAL
DRAWING BOARD



VALUE CHAIN OF
INTEGRATED
PLANNING TOOLS

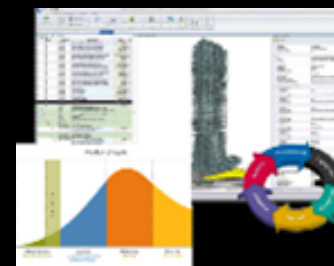
STEP 4:
3D-COMPONENT ORIENTATED
WORK WITH INTEGRATED
COST MANAGEMENT



STEP 5:
BUILDING PROCESS MANAGEMENT
(4D)



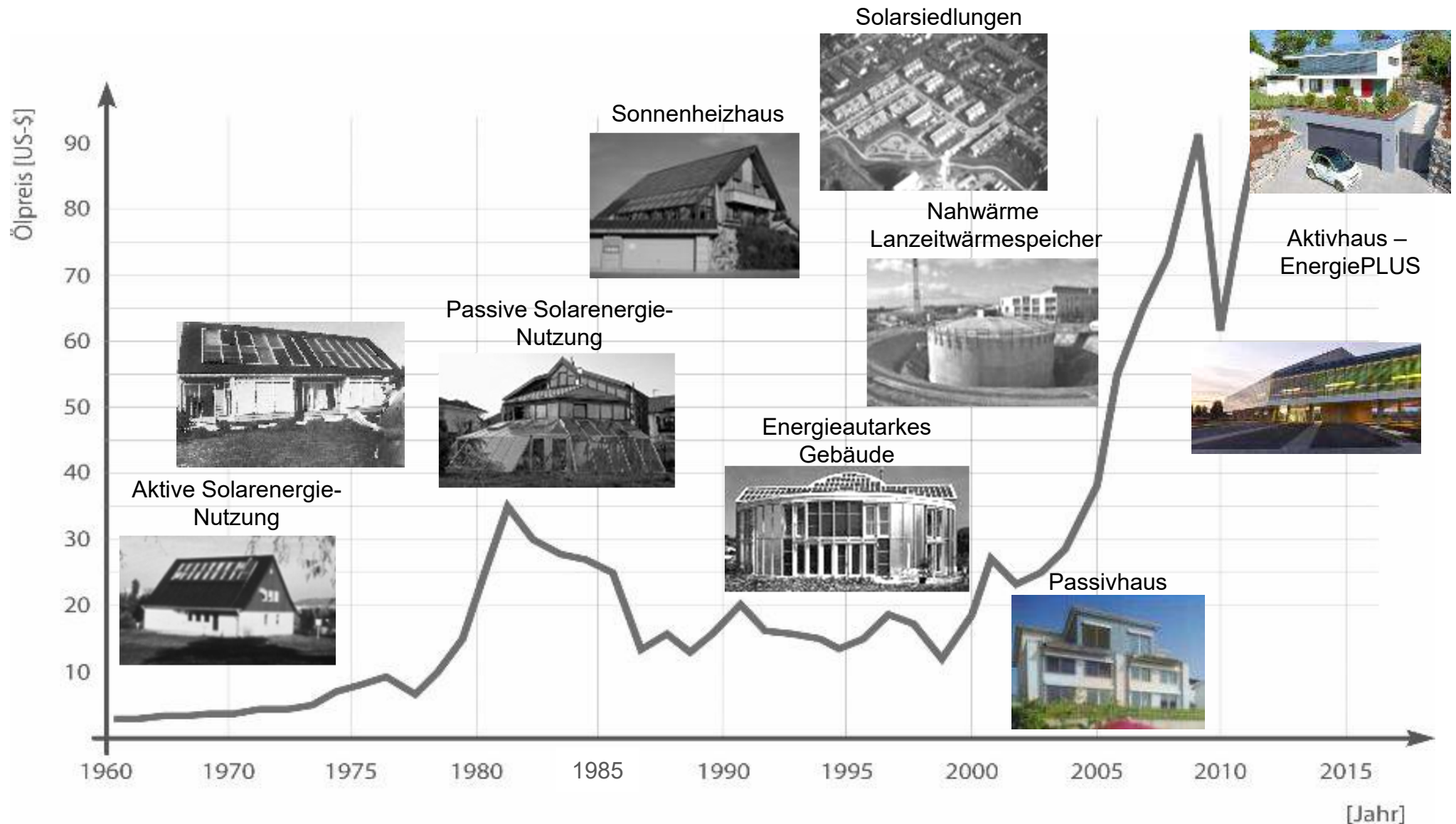
STEP 6:
OPERATION - LIFECYCLE MANAGEMENT (FM)



From

- **1st Solar Houses (1975)**
- **Solar district heating systems with seasonal storage (1990)**
- **Energy efficient commercial buildings (2000)**
- **EnergyPlus Buildings (2010)**
- **Smart Cities (2015)**

development of solar buildings 1970 – 2015 (Germany)



1980

84
2. WSV



passive

- large, south-facing areas of glass
- winter gardens

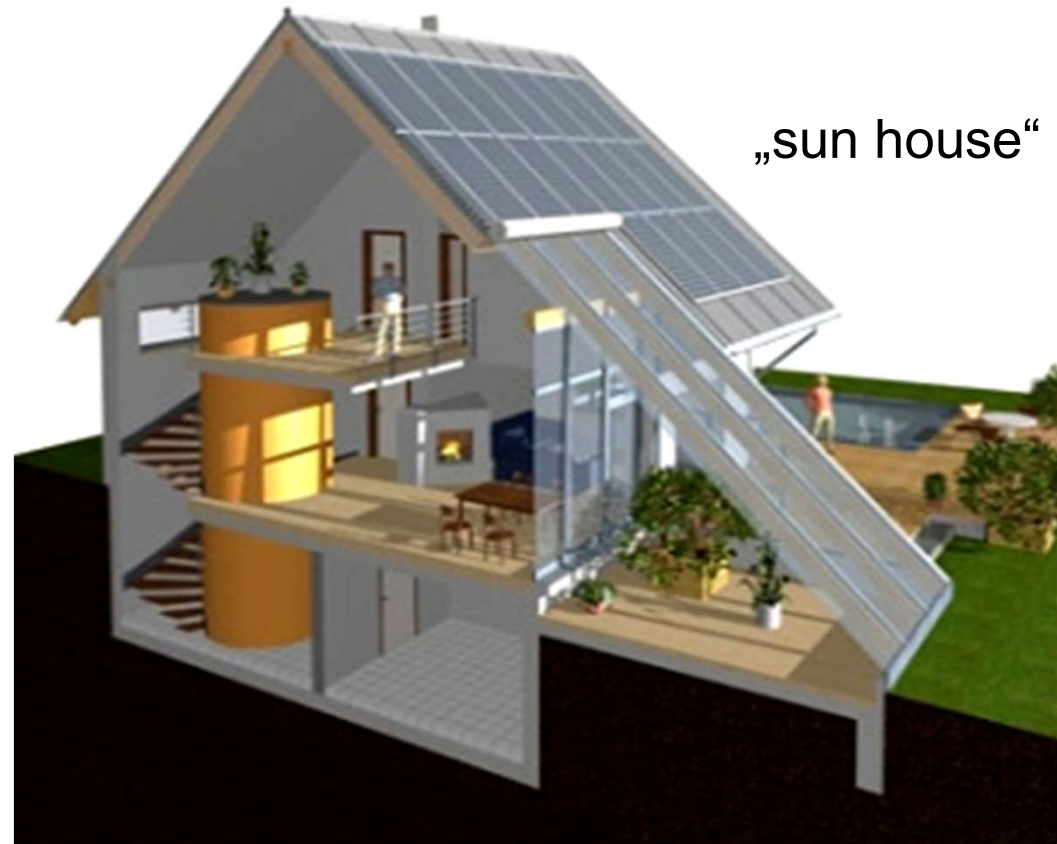


active

- solar thermal systems
- seasonal storage of warmwater

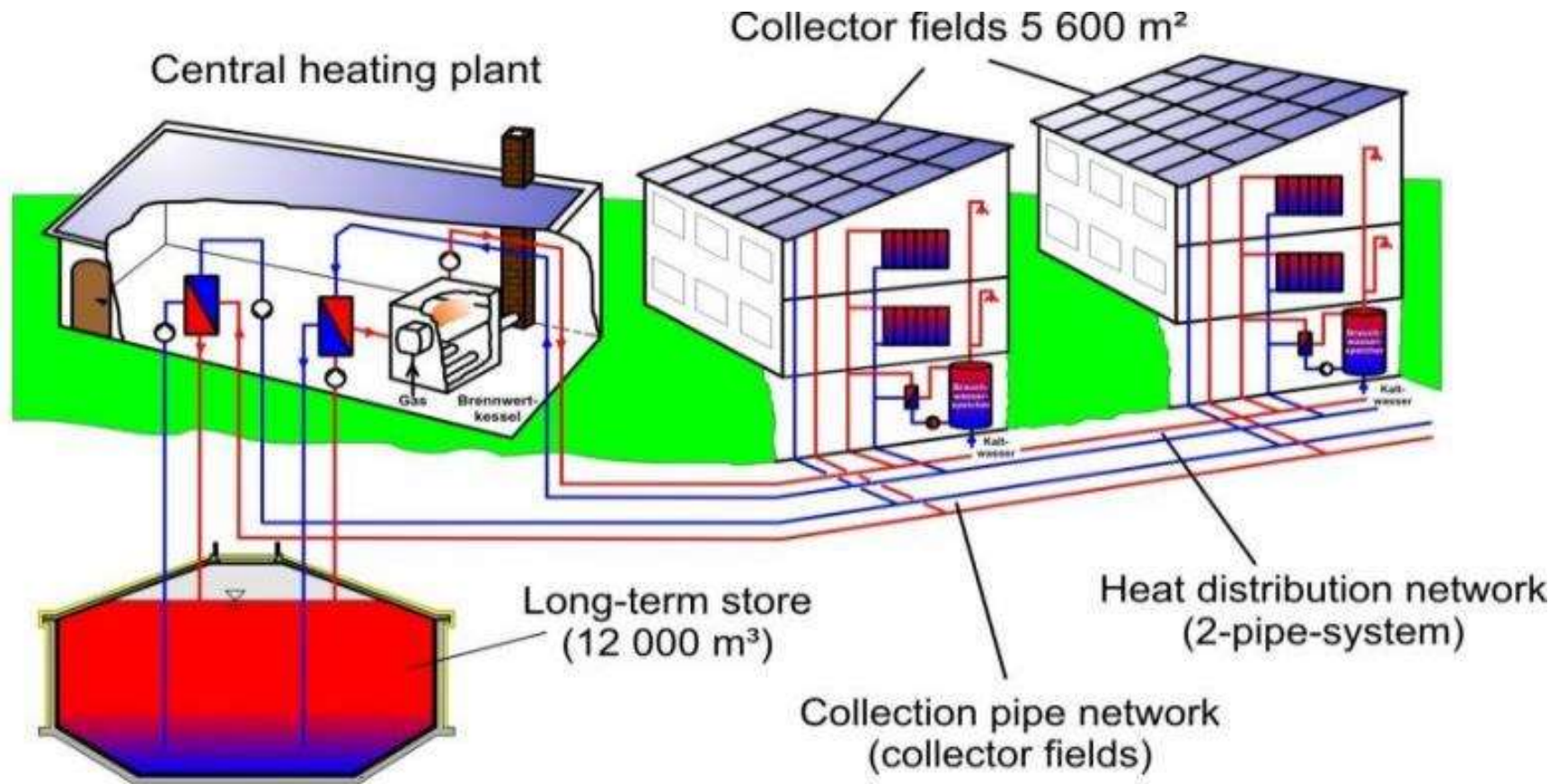


Solar heating with decentralized seasonal storage



source: Sonnenhaus-Institut

Solar assisted heating with long term storage (1990)



Solar district heating with seasonal storage (1990 – 2005)

Solar assisted heating system with seasonal storage in Germany



Sustainable + Energy Efficient Commercial Buildings

Green / Eco / Buildings 2000 - 2015

Primary Energy (PE) < 100 kWh/(m²a)



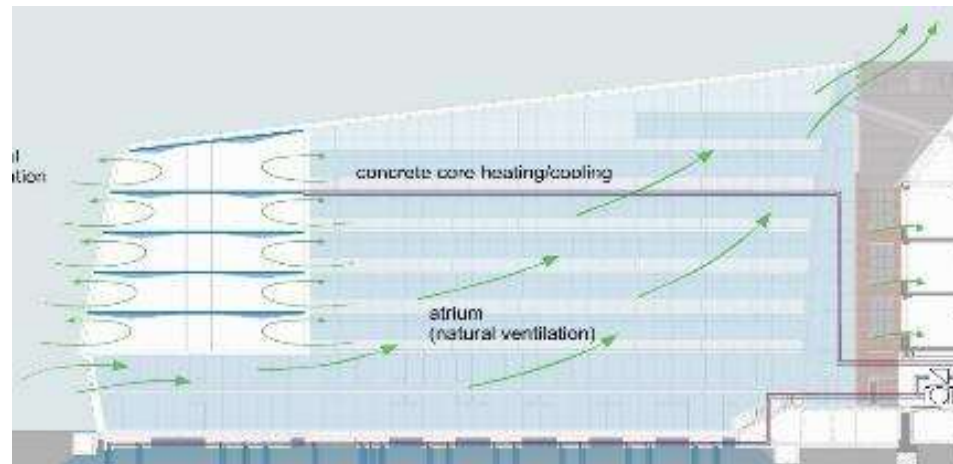
Comprehensive concepts demanding
new requirements for
Design, Construction, Commissioning
and Operation

New Office Buildings

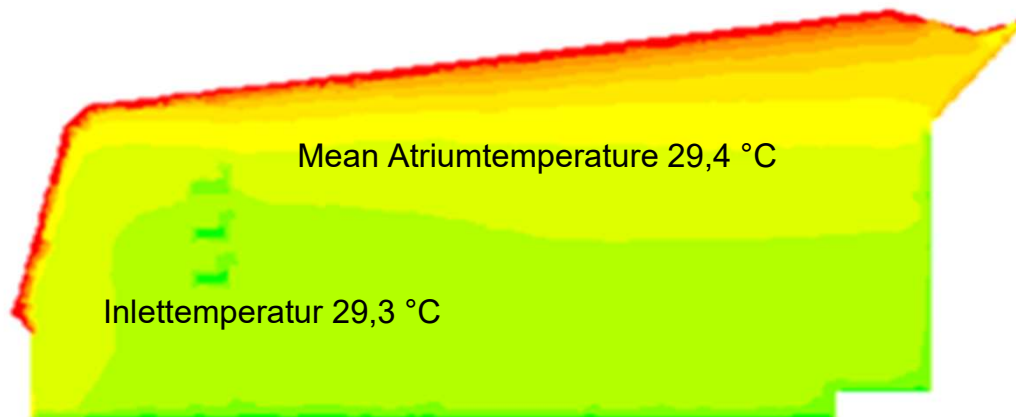


Energieforum Berlin (1995)

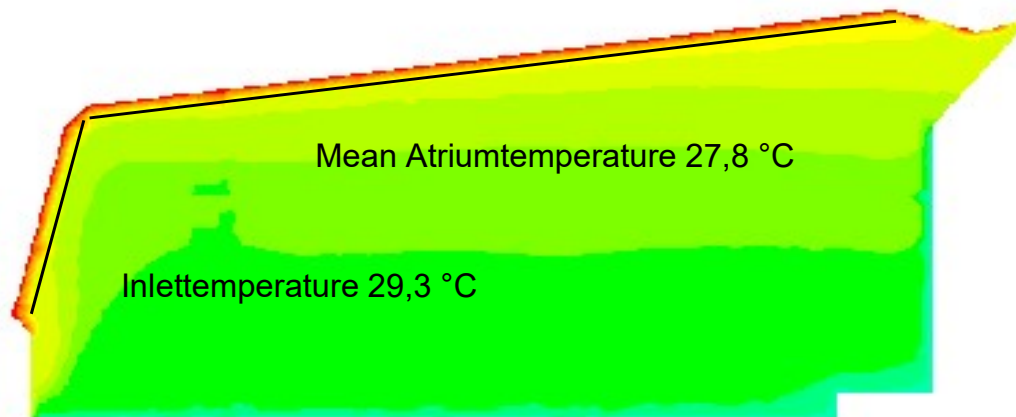
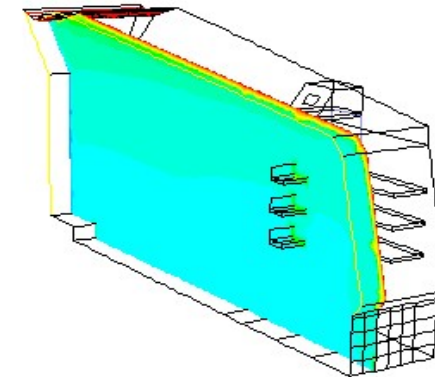
Energy concept – air flow experiments – natural ventilation



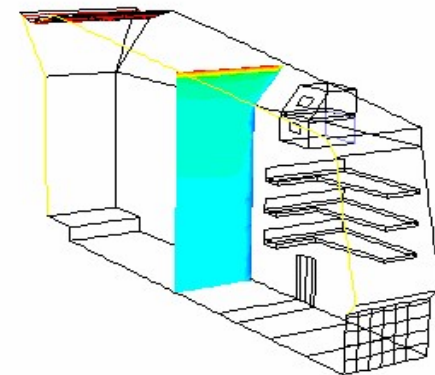
CFD – Simulation support atrium design



Without Shading Device

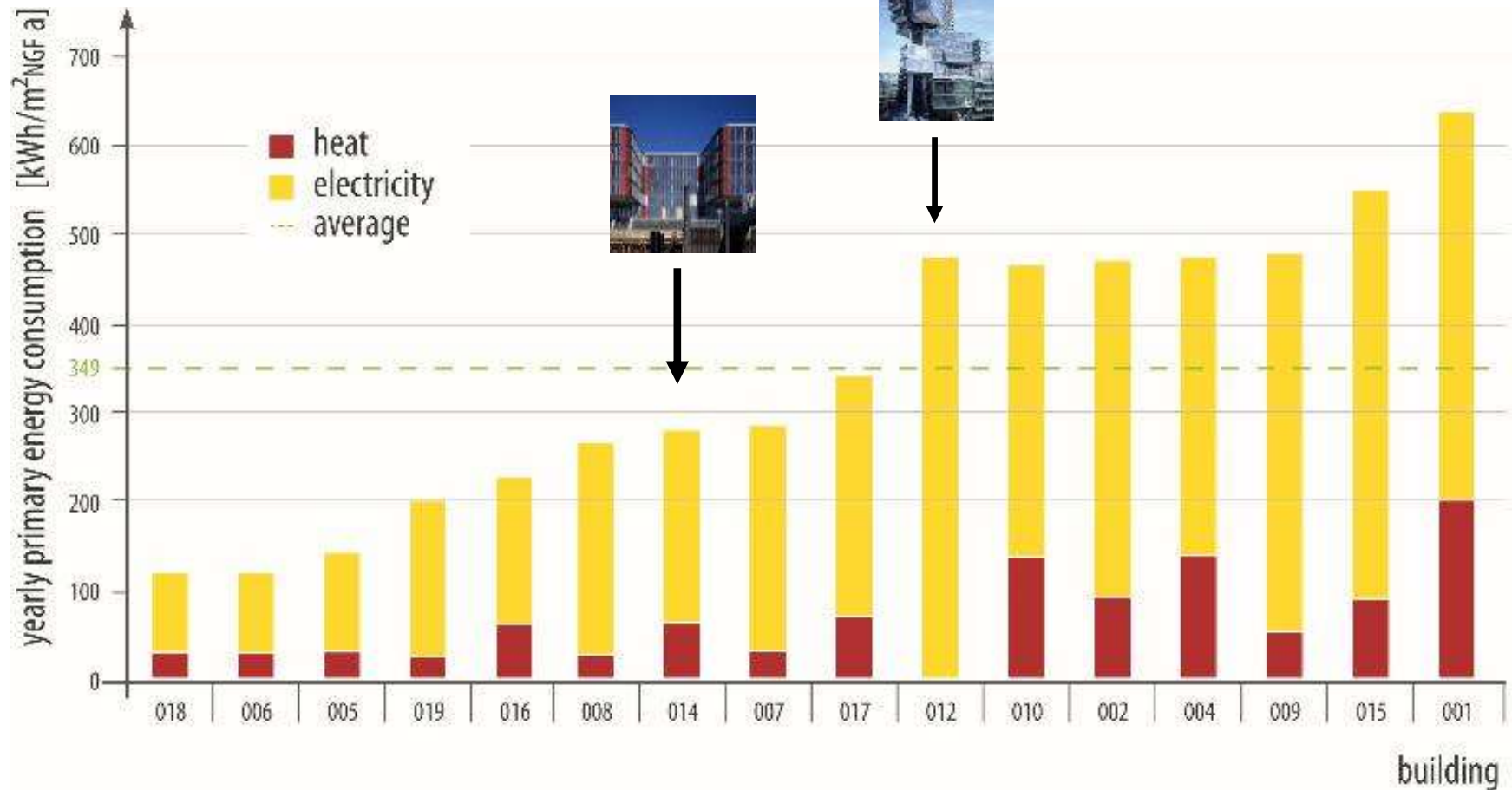


With internal Shading Device

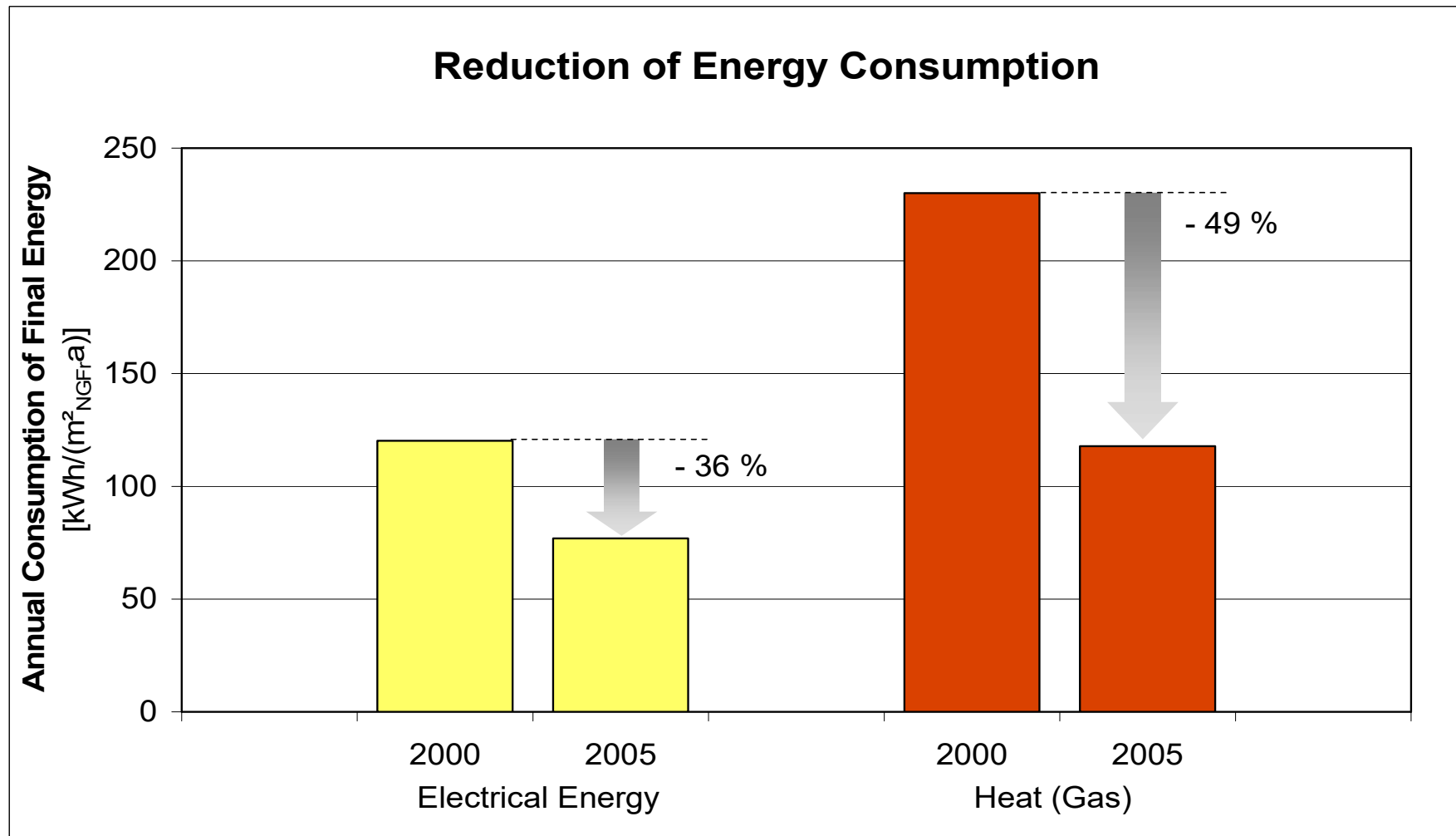


Evaluation of new office („Green“) buildings

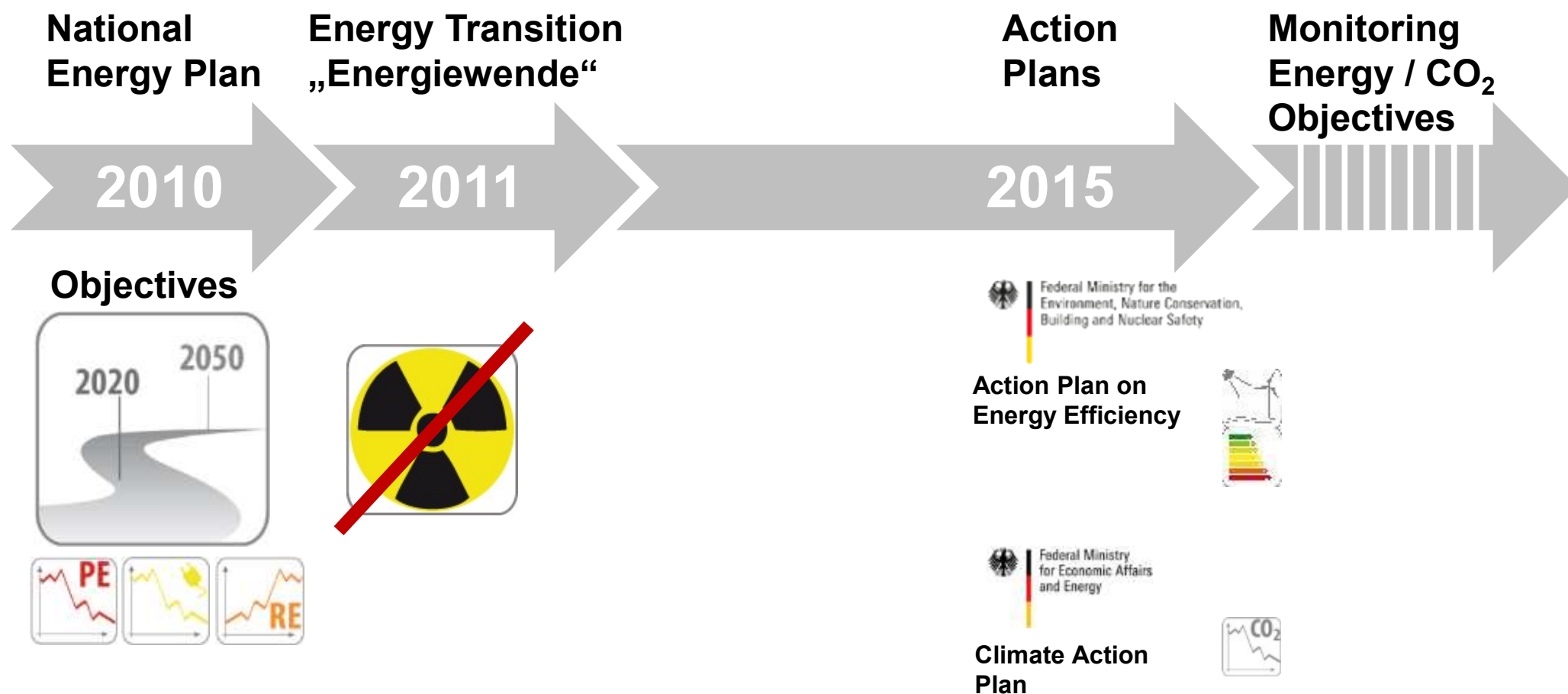
Primary energy consumption



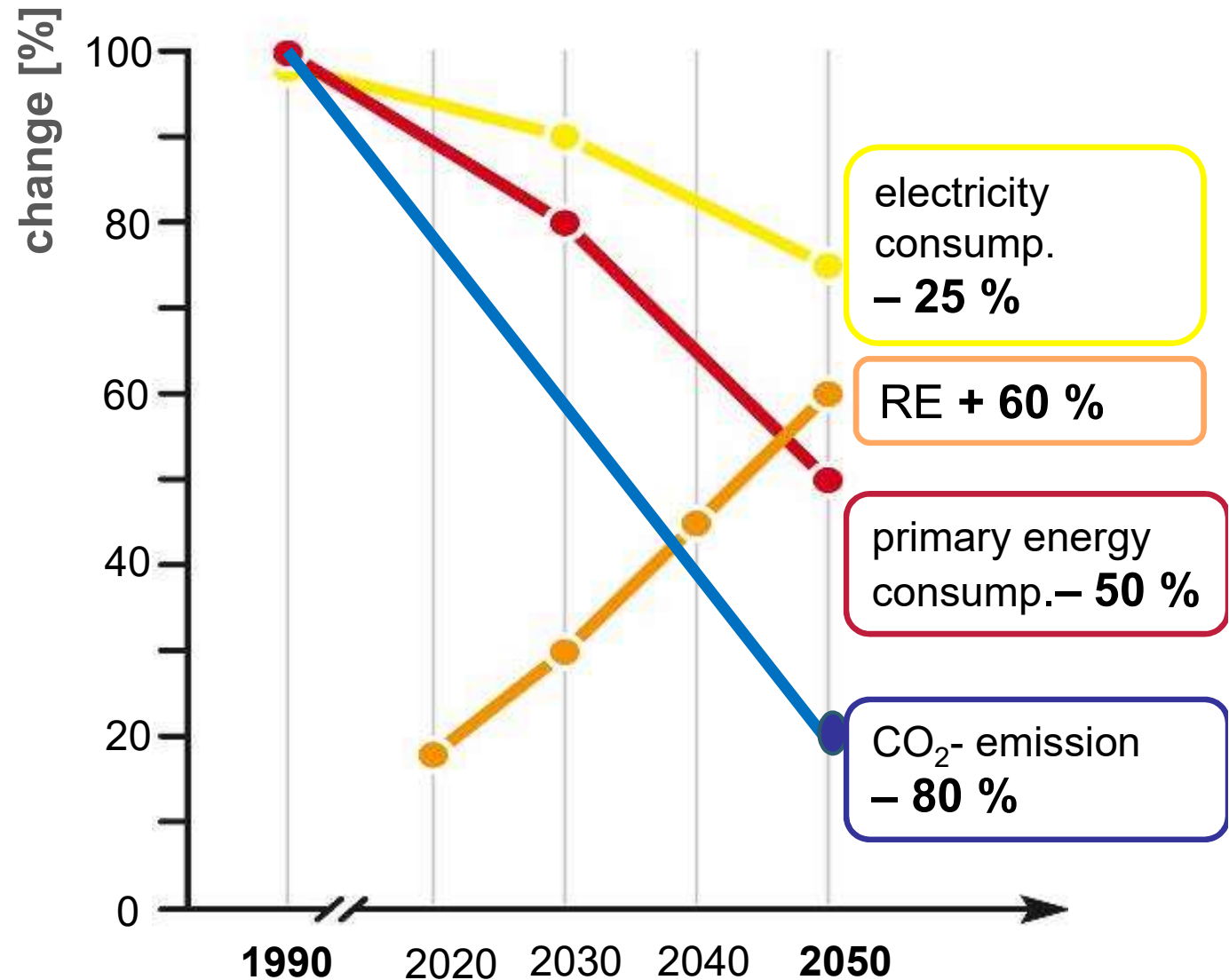
Operation Optimization - Monitoring



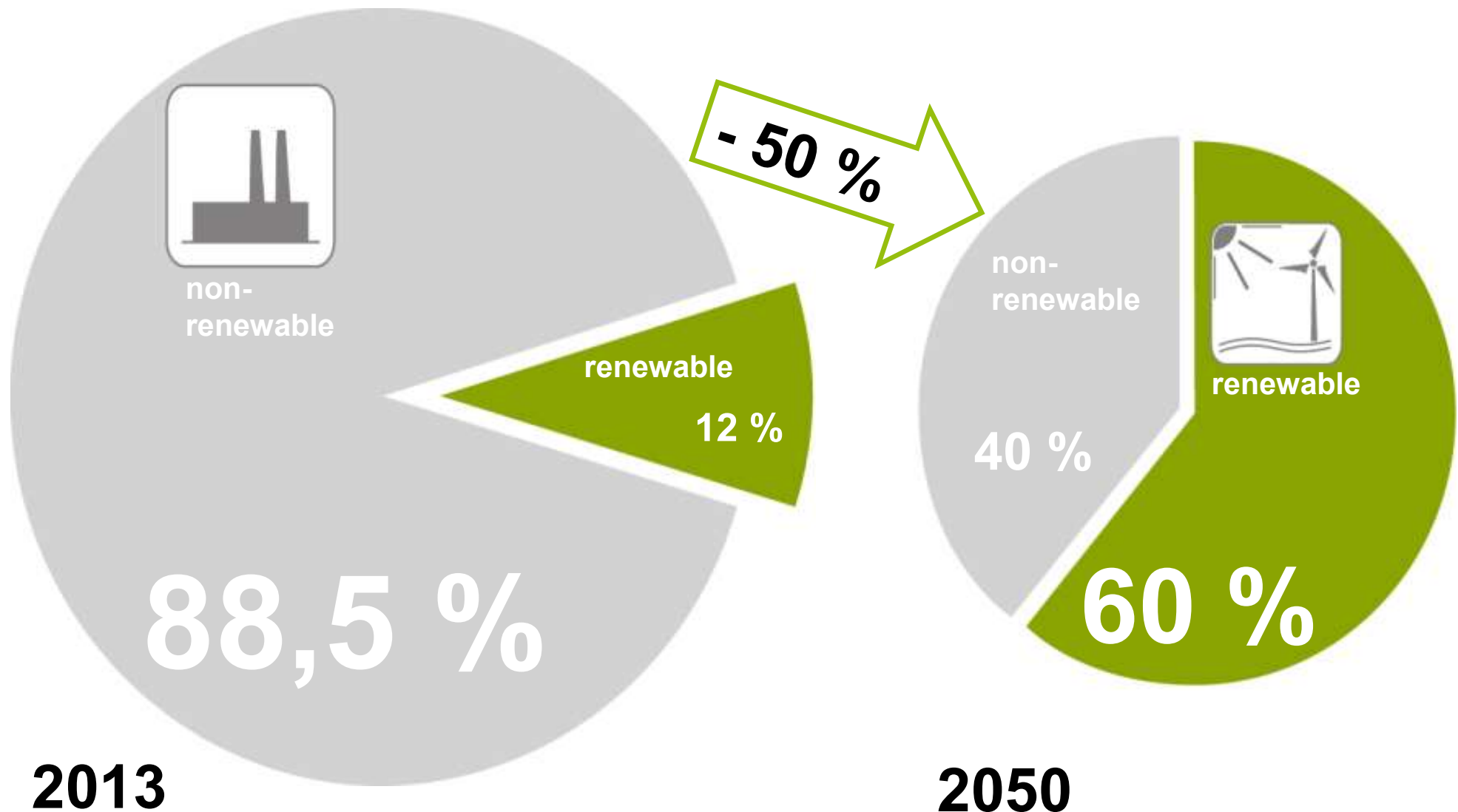
Energy and CO₂-emission policy in Germany



Long term objectives 2050



Primary energy consumption share of renewable energies in Germany



40% of total energy in existing buildings

18 Mio. Residential Buildings



1.5 Mio. Non-Residential Buildings



Transport and buildings need **70 %**
of total energy demand in Germany

Since 2010:

EnergyPLUS - Building as power plant!

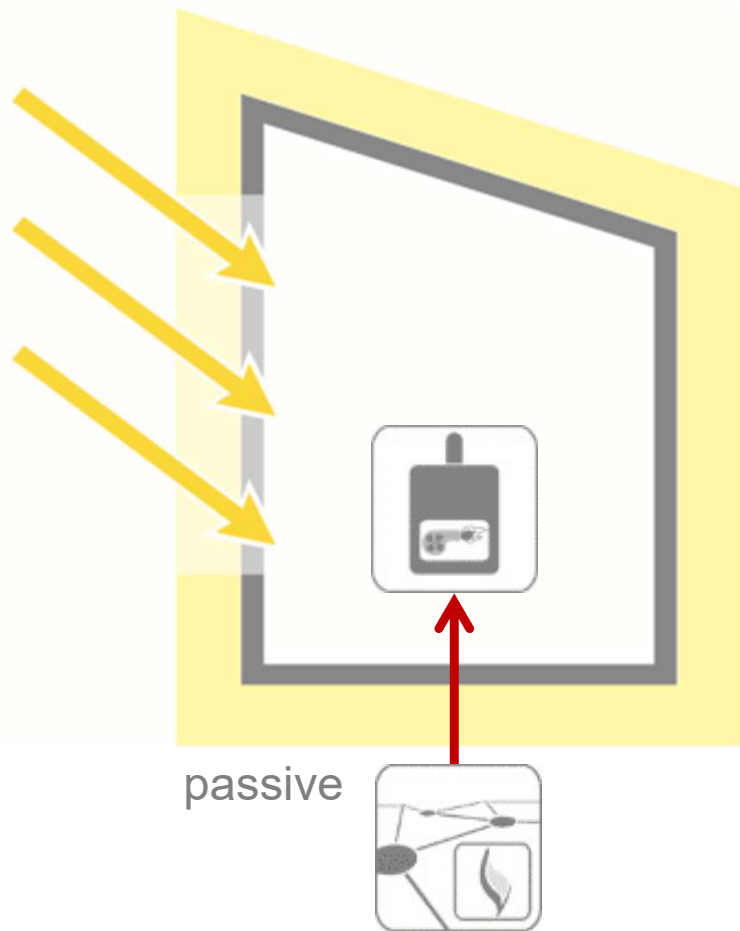


After 2020:

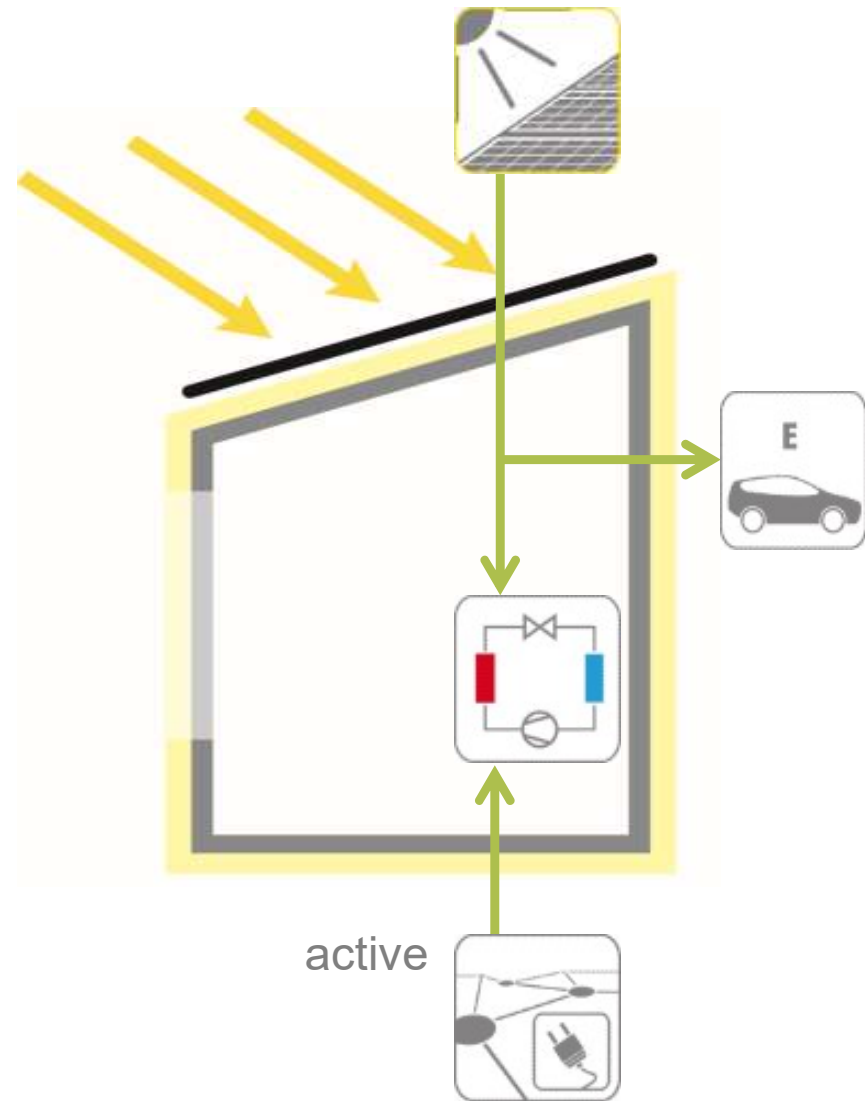
Climate neutral building



building as power plant and filling station



from **consumer...**



...to **prosumer**



1st prize
Architecture
TU Darmstadt
Prof. M. Hegger

Tech. Concept
TU Braunschweig
Prof. Dr. M. Fisch

2010 EU- EPBD
nearly zero energy buildings

integral approach:
saving and generate

2010/11 amended

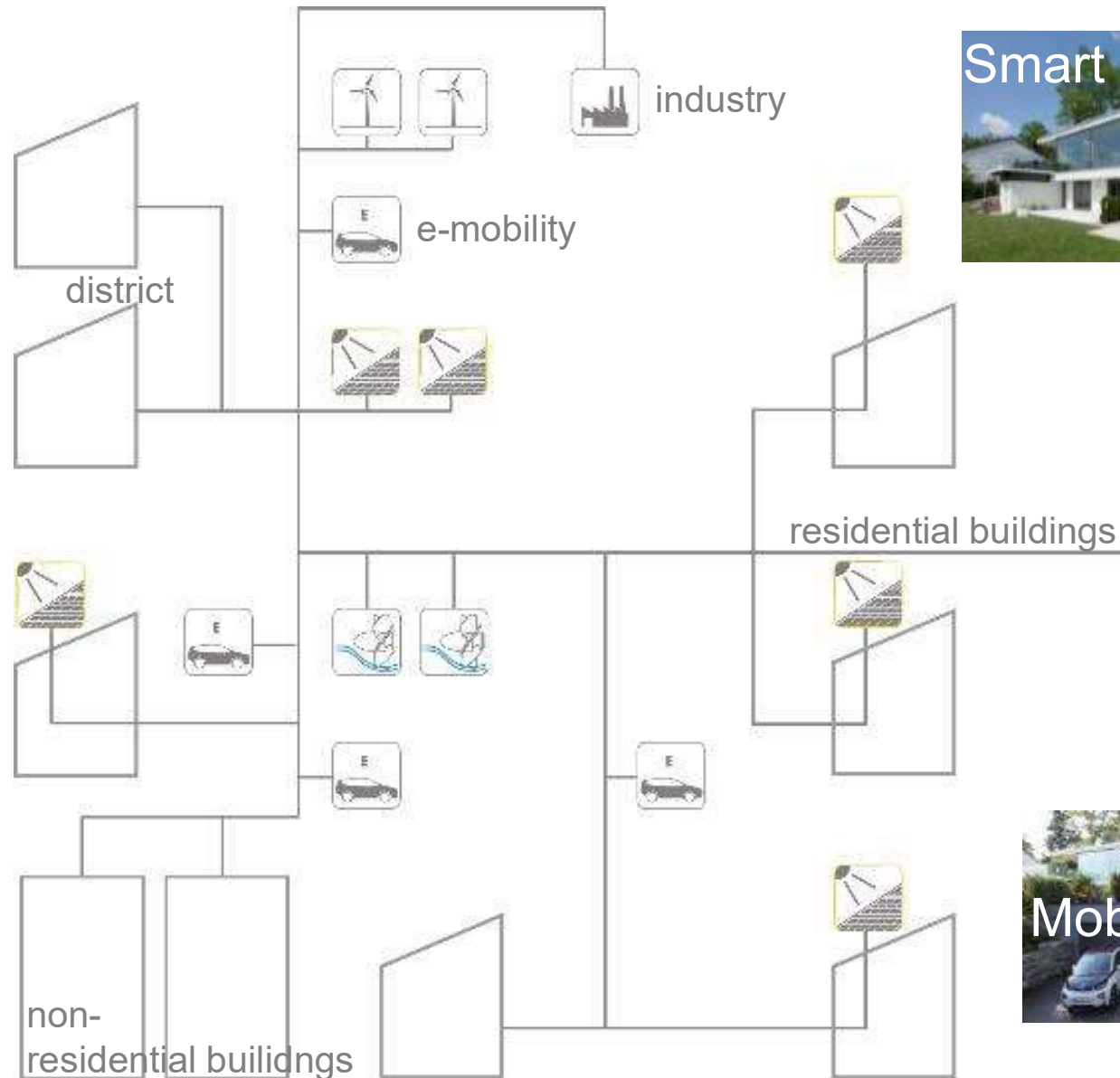
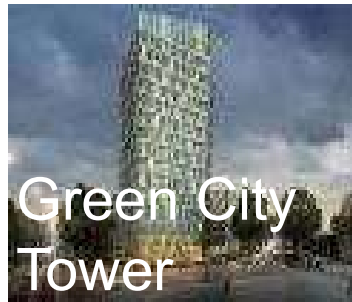
energy concept of the
german government



**...the building as
power plant**

**Solution for
EnEV?**

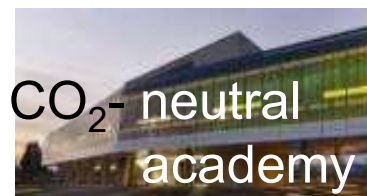
German “Energiewende” - energy turn around decentralization of energy supply



Smart Homes



Smart
Buildings

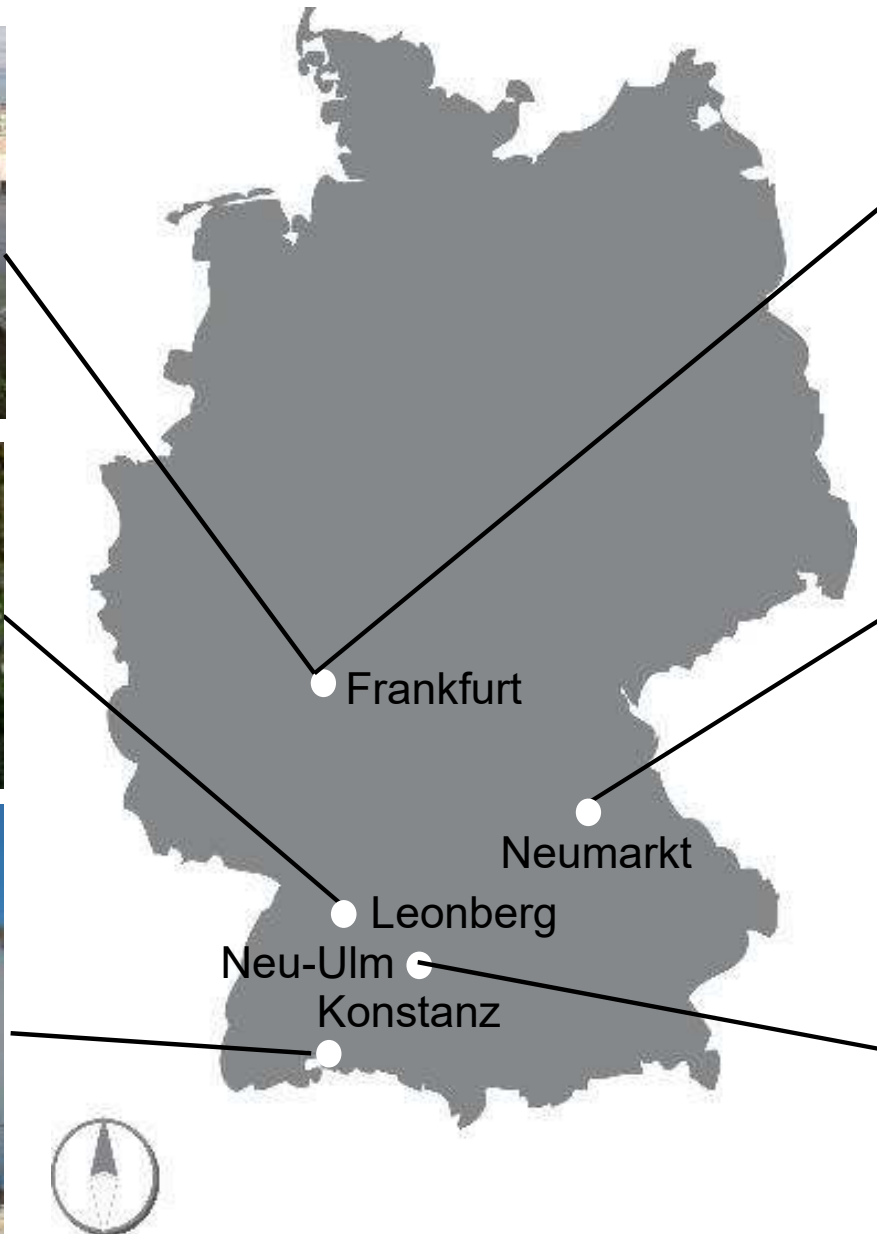


- development decentralized power plants >> down-top
 - middle size GUD, CHP und Mini CHP
 - BIPV (building integrated PV) - with high direct electricity use ...
- demand-site management (industry, large consumer, ..)
- „storage battery“ (e- mobility,)
- power to gas and power to heat
- „Buildings as power plant“

“**Optimization** through the reduction of energy demand and the efficient use of renewable energy resources



... pilot residential building projects



EnergyPlus single family house (2010) Berghalde, Leonberg



Building
Management
System
(BMS)



photovoltaics

lightning



Smart
Meter



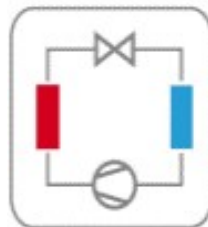
battery-
storage



e-mobil



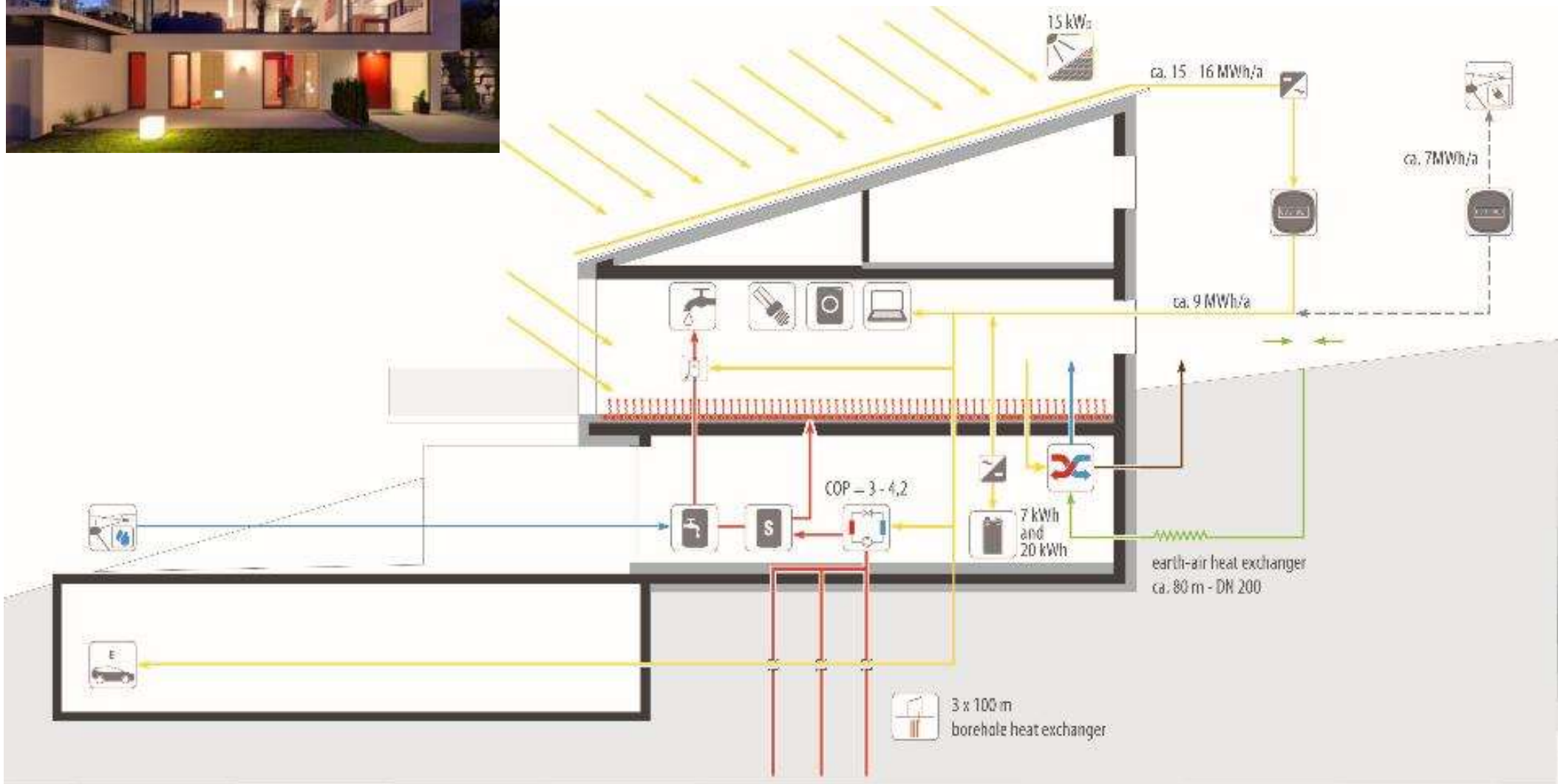
heat
pump



household
appliances



A photograph of the 'Haus der Kunst' building at night. The building is a modern, two-story structure with a prominent upper floor featuring large glass windows that reveal the interior. The ground floor has several large, brightly lit openings, some with red walls. The building is surrounded by a courtyard with a lawn and some small plants. The sky is dark blue, and the overall atmosphere is modern and sophisticated.



EnergyPLUS – Design



excellent building envelope

openable windows

mech. ventilation with heat recovery

PV + heat pump

low temp. radiation

floor heating

or ceiling cooling

concept for

energy storage

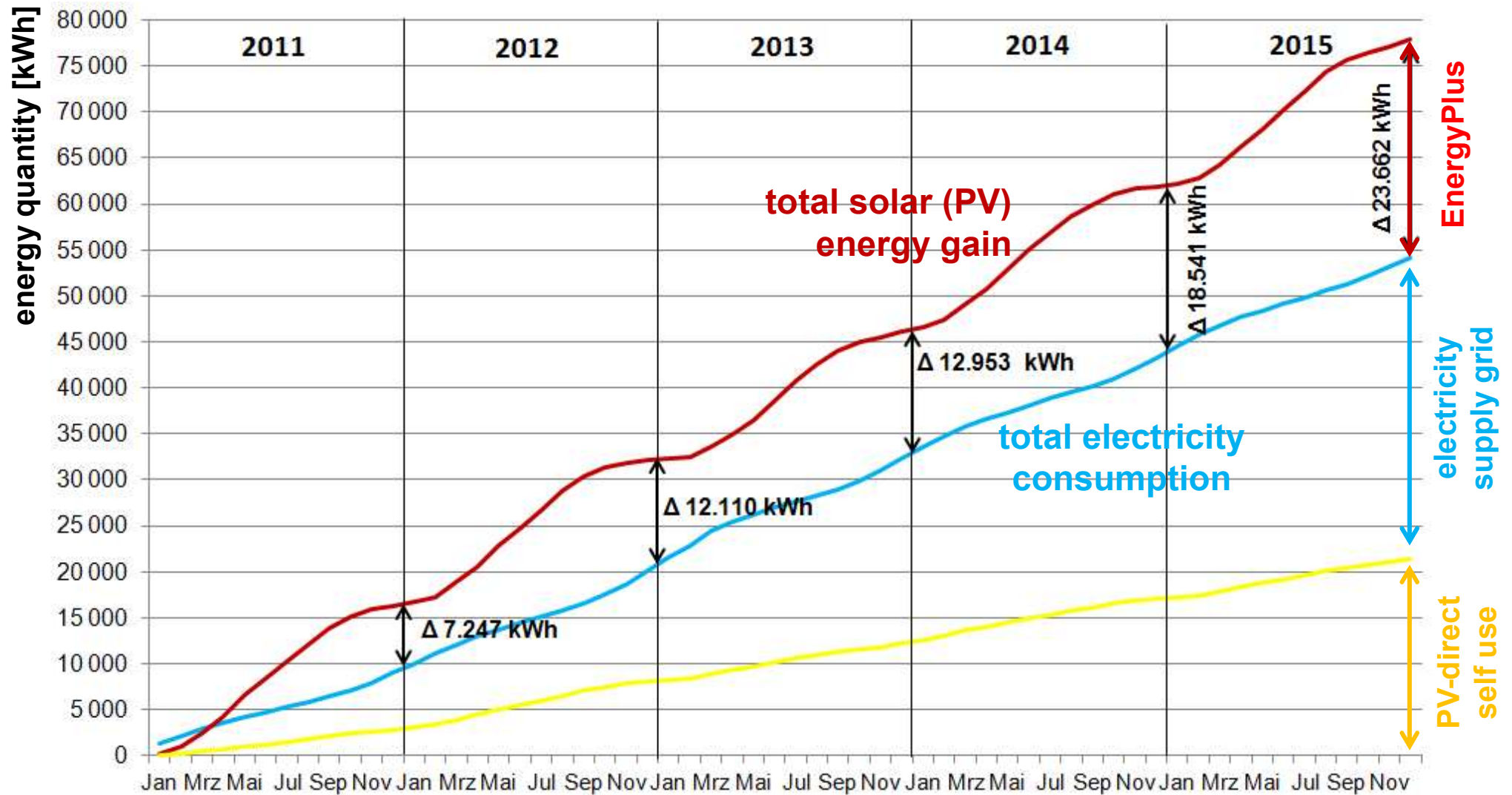
demand site management

(DSM)

Next step coupling the house with electric mobility



EnergyPlus single-family house Leonberg, Berghalde



EffizienzhausPLUS – Pilotprojekt in Bangkok

Fertigstellung 10 2016



Architektur, Energiekonzept, Technikplanung, Gebäudetechnik
Made in Germany

Monitoring?

Prukha-House, Bangkok



EffizienzhausPLUS – Export nach China!

Intern. Studenten-Wettbewerb 2017 / 2018



Kooperation TU- Braunschweig
South East University, Nanjing

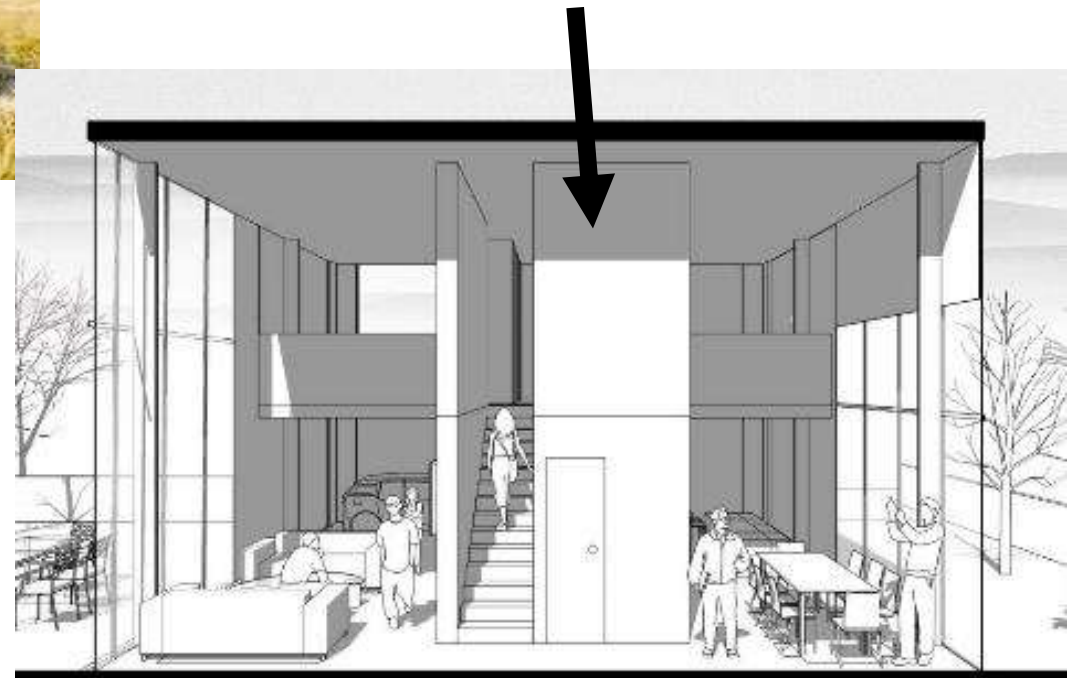


The Cube-House

Technical Core – Made in Germany



Technical Core (Made by TU-BS)



EffizienzhausPLUS – Export nach China!

Intern. Studenten-Wettbewerb 2017 / 2018



EnergyPlus apartment house, Frankfurt



apartment house

64 flats

living area

6.500 m²

PV- power

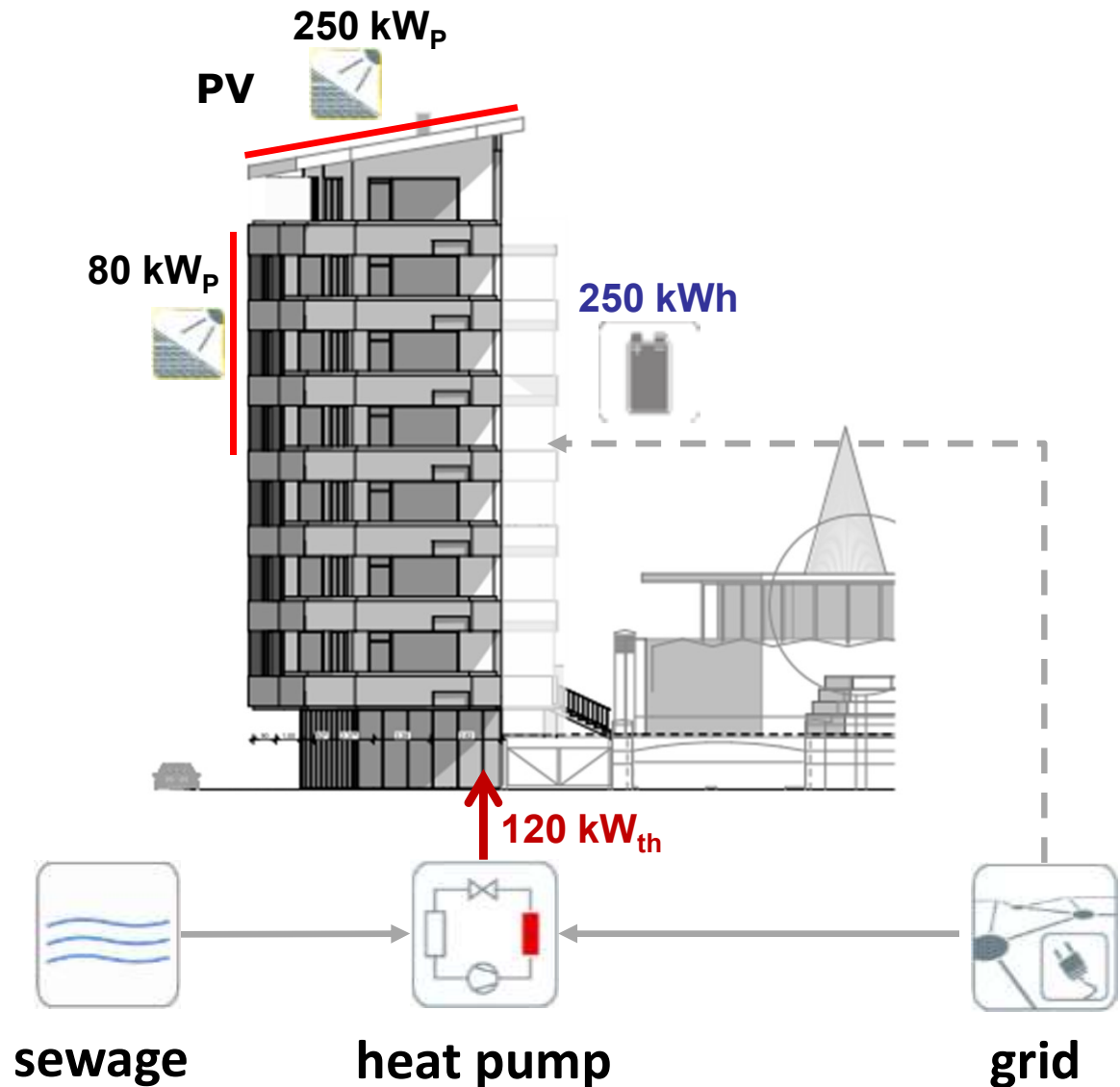
330 kW_p

yearly gain

300.000 kWh/a

Energypayback time

7–8 years



Stadt- Aktivhaus Frankfurt

Technikkomponenten



Photovoltaik



**Lithium-Eisen-Phosphat-
Stromspeicher**



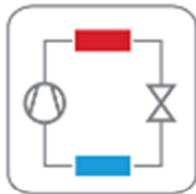
**Elektromobilität
mit Car-Sharing**



Quelle: egs-plan



**Abwasser-
wärmetauscher**

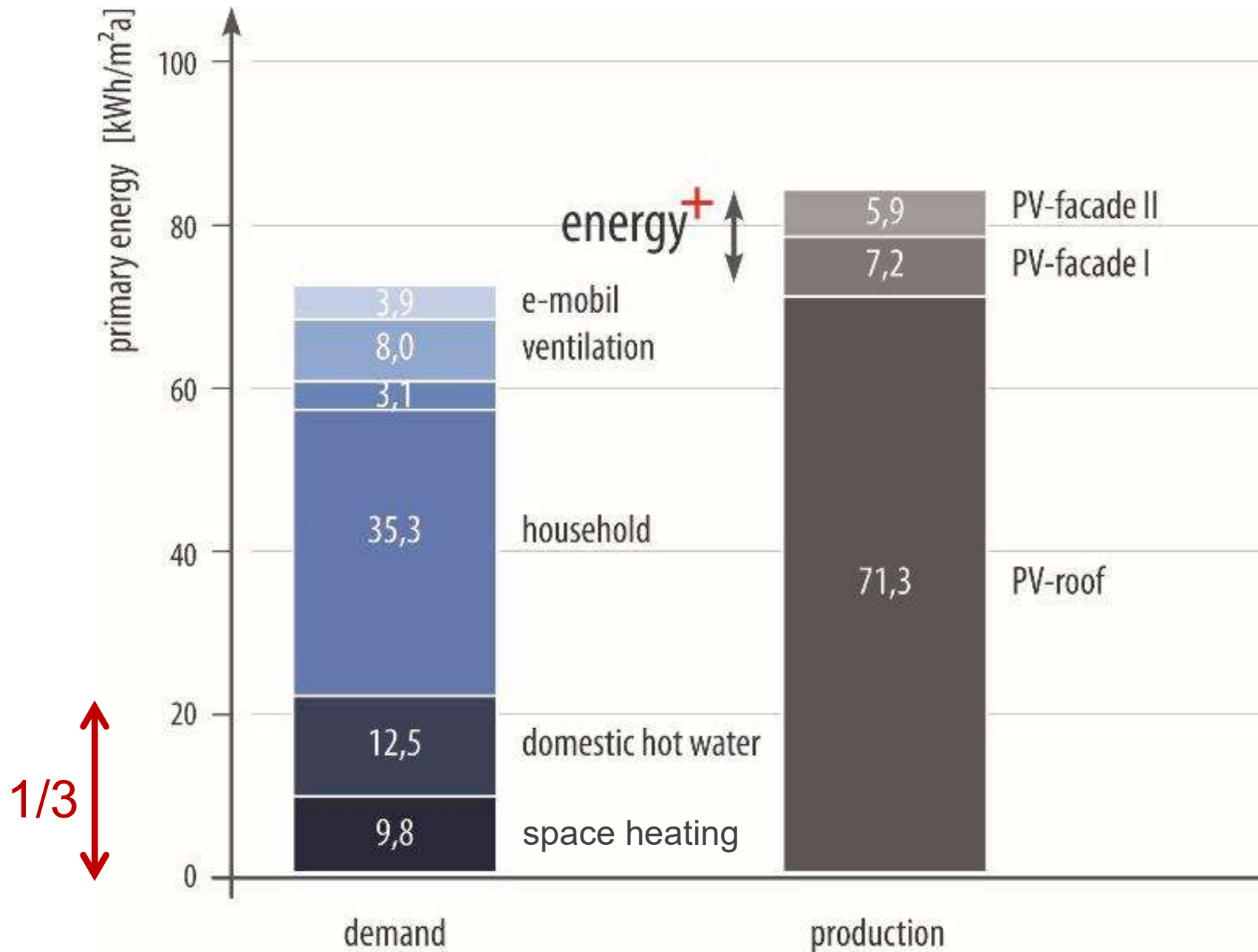


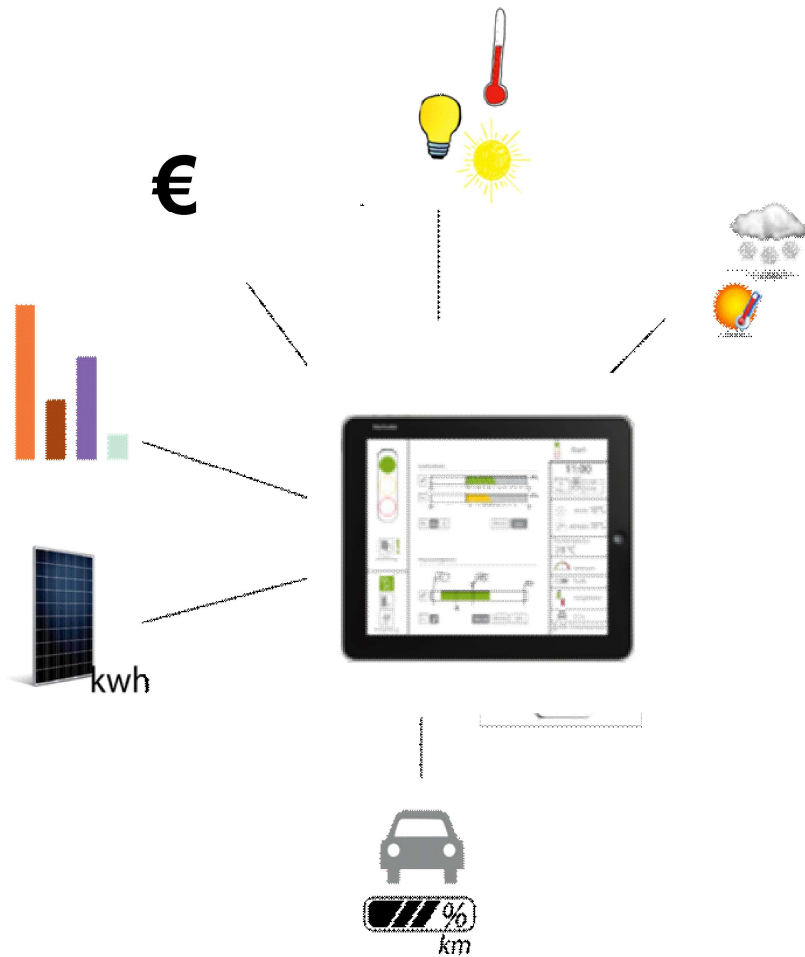
Wärmepumpe



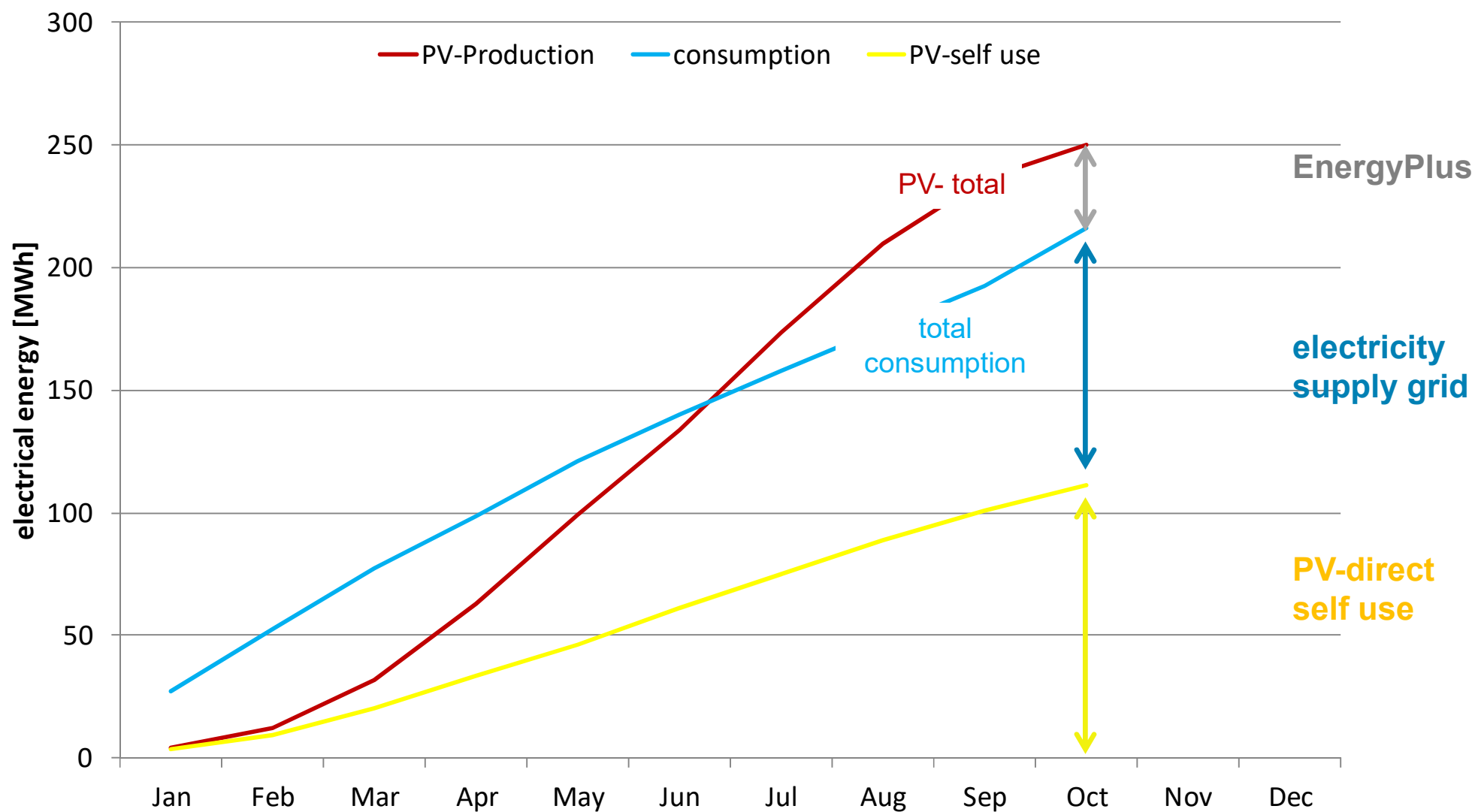
Quelle: egs-plan

EnergyPlus balance - demand and production





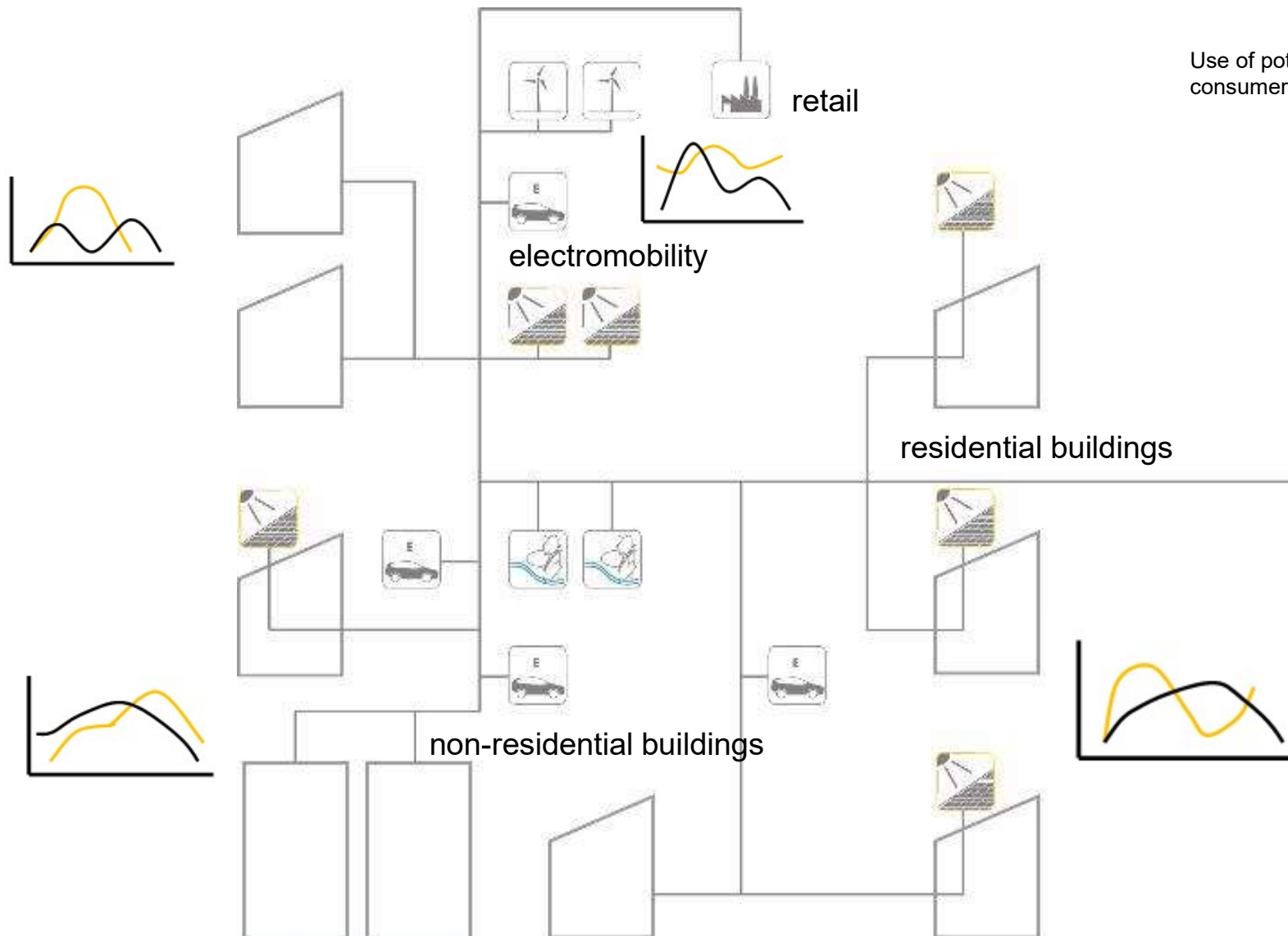
power production/-consumption (accumulated) 2016



- EnergiePlus up to 5 - 7 floors achievable
- Key role: PV + heat pump + Low temperature systems
- Larger thermal energy storage requested
- Demand site management (DSM)
- Self-use of PV-electricity more important as „EnergyPLUS“
- Interaction between building and grid requested

.. districts projects in Germany

Why districts?



Use of potentials given by different consumers and producers on a large scale!

... energy efficient district projects



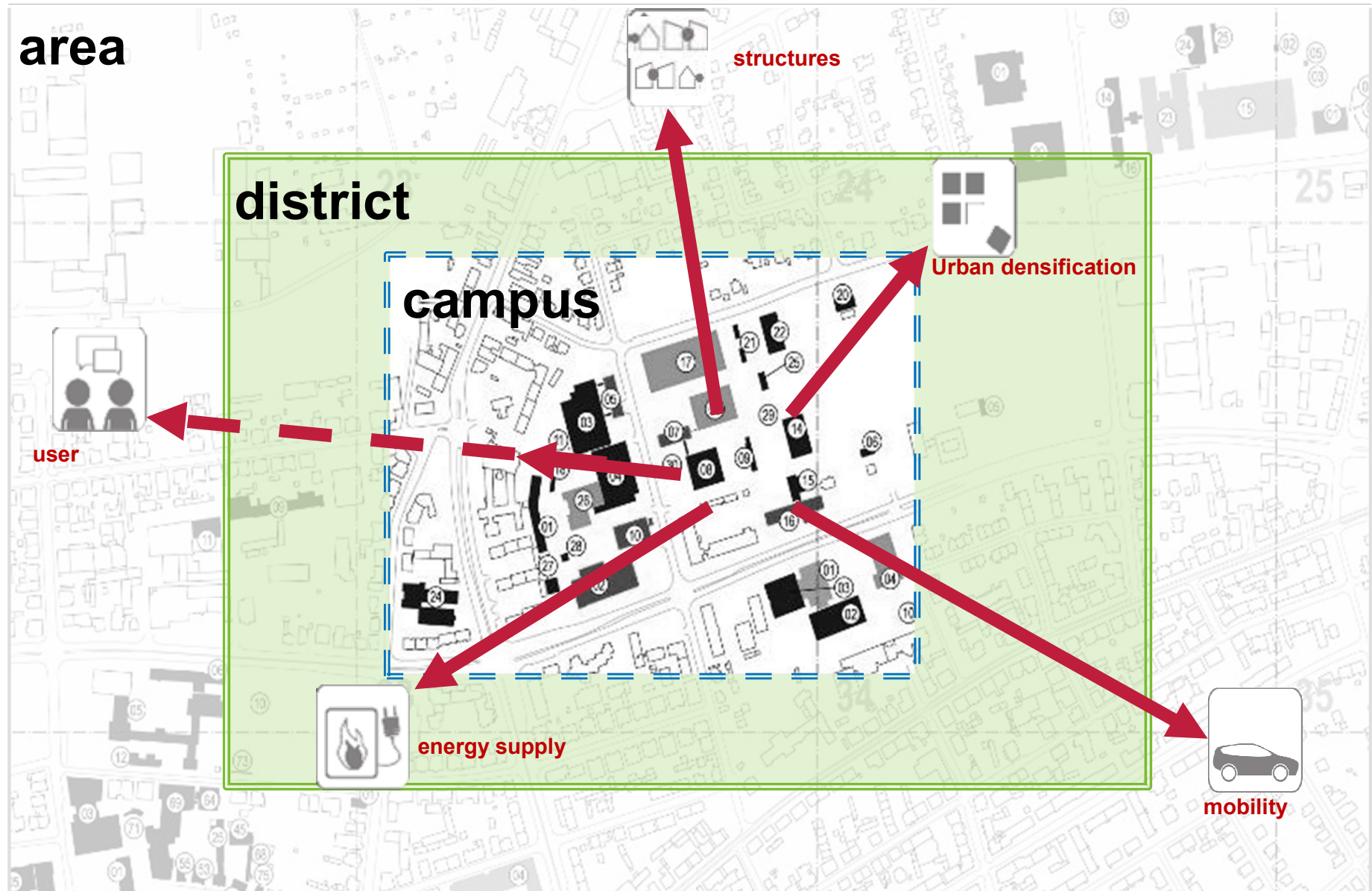
... Campus Technical University Braunschweig

2020: primary energy minus 40%
improvement of learn and living conditions



2035: climate-neutral Campus
nearly balanced CO₂- footprint

Campus 2020 model (nucleus) for of urban development



TU Braunschweig

3.500 employees

18.500 students

201 buildings (incl. new development)

82 % before 1978

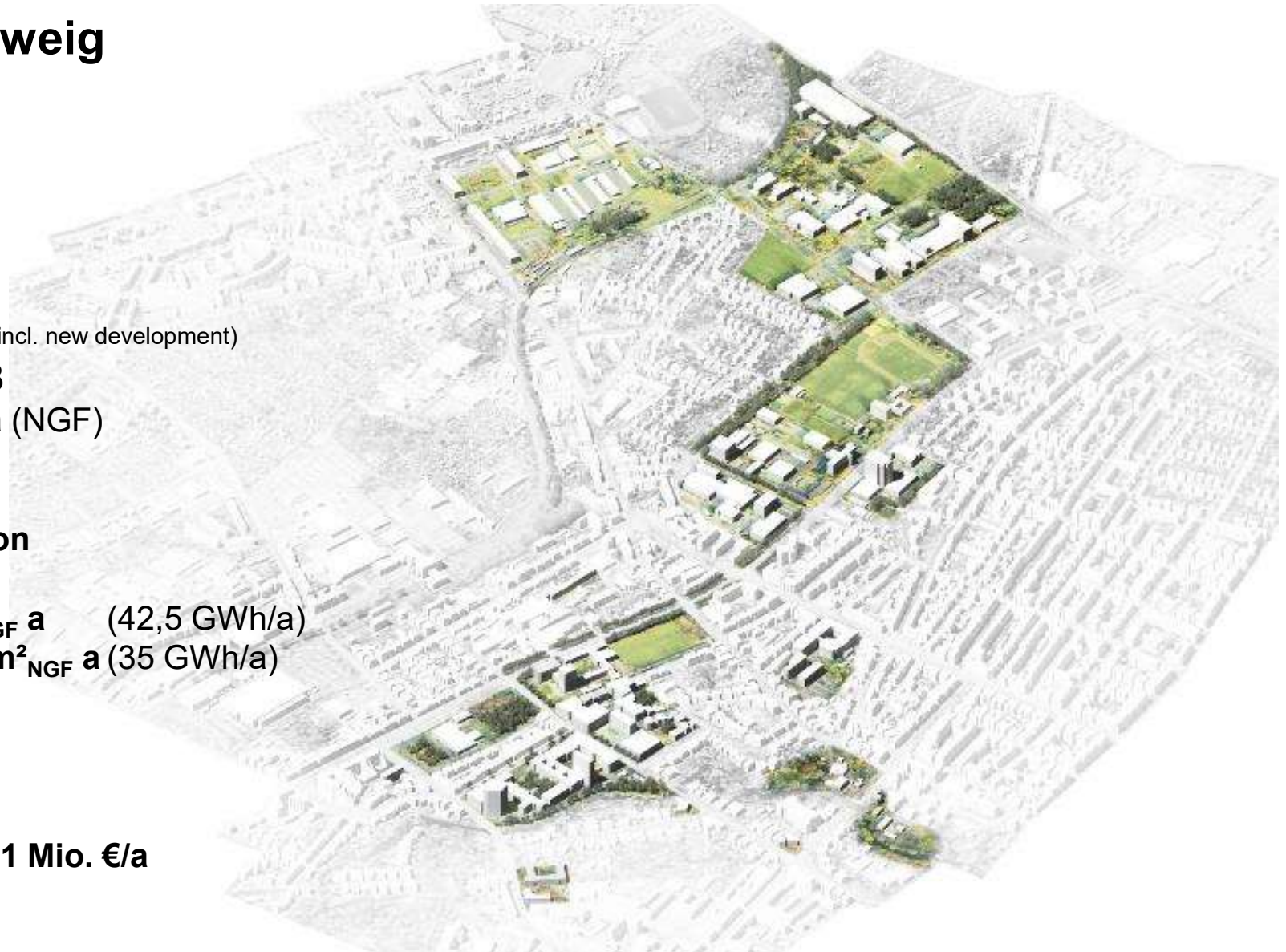
400.000 m² net area (NGF)

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



- metering and measuring installations
(> 500 measuring points, collecting 15-min.-consumption)
- building-specific parameter (area, use, structure, building services engineering)
- comprehensive building services management system



Altgebäude



Audimax



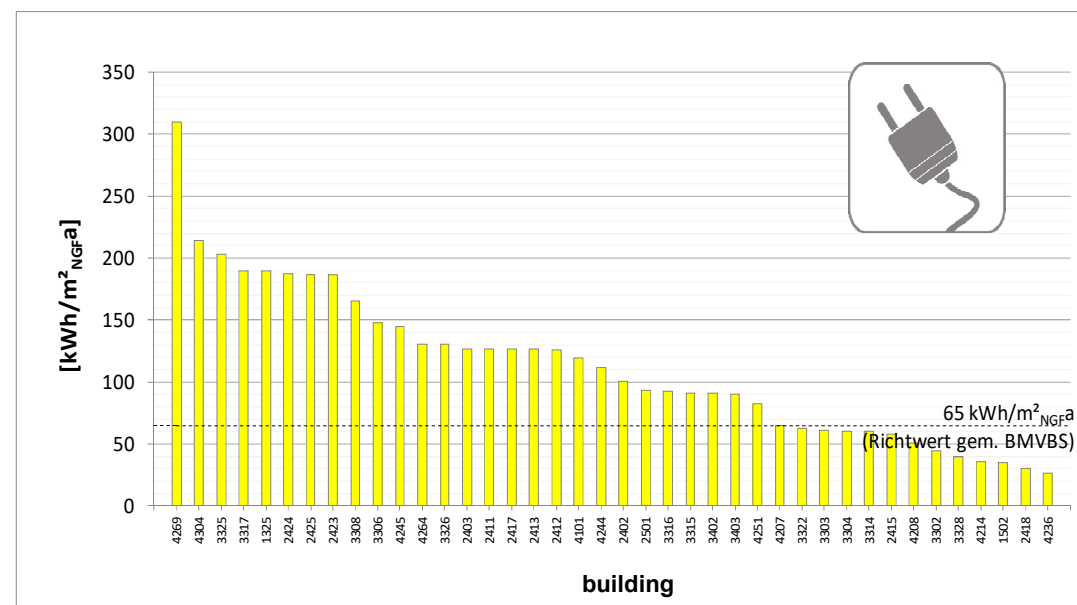
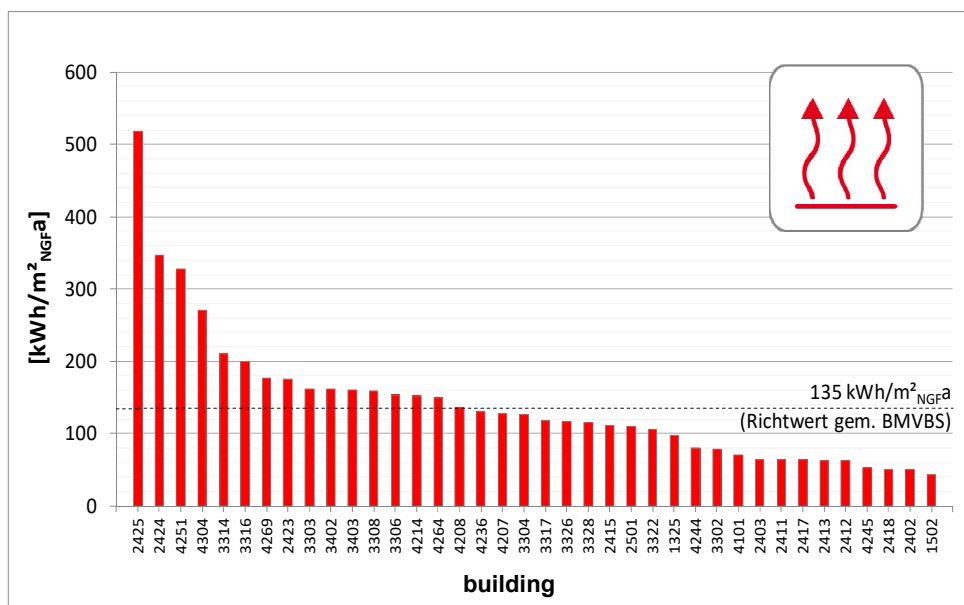
TU Hochhaus „Scheibe“



Neubau Informatikzentrum (NIZ)

end energy consumption heat and electricity

using group – research (DIN 277)



energy cadastre

Campus TU BS



classification

**type of
construction**

**year of
construction**

use

**energy
consumption
(heat /
electricity)**

typification

Type 01

Type 02

Type 03

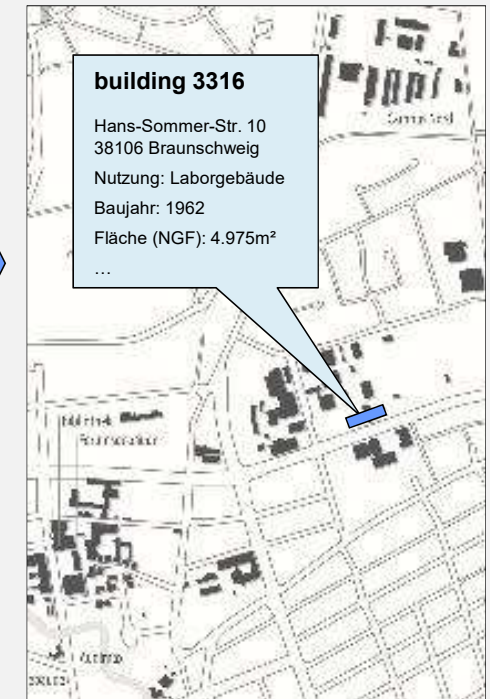
Type ...

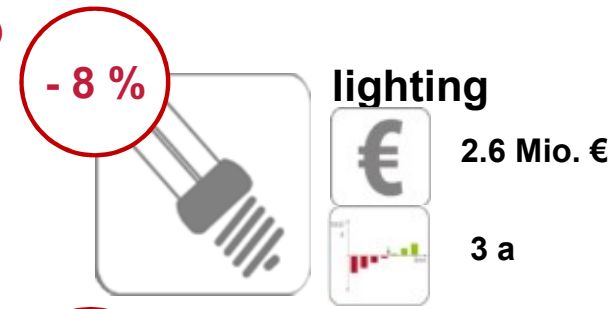
Type ...

type 1

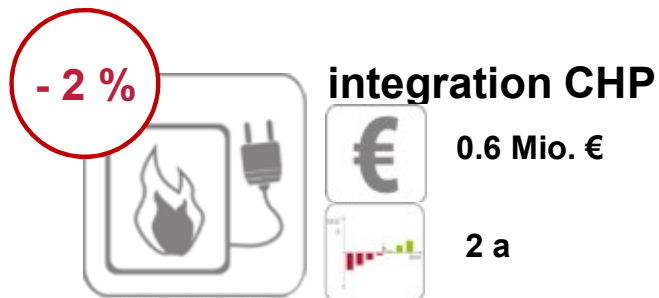


energy register

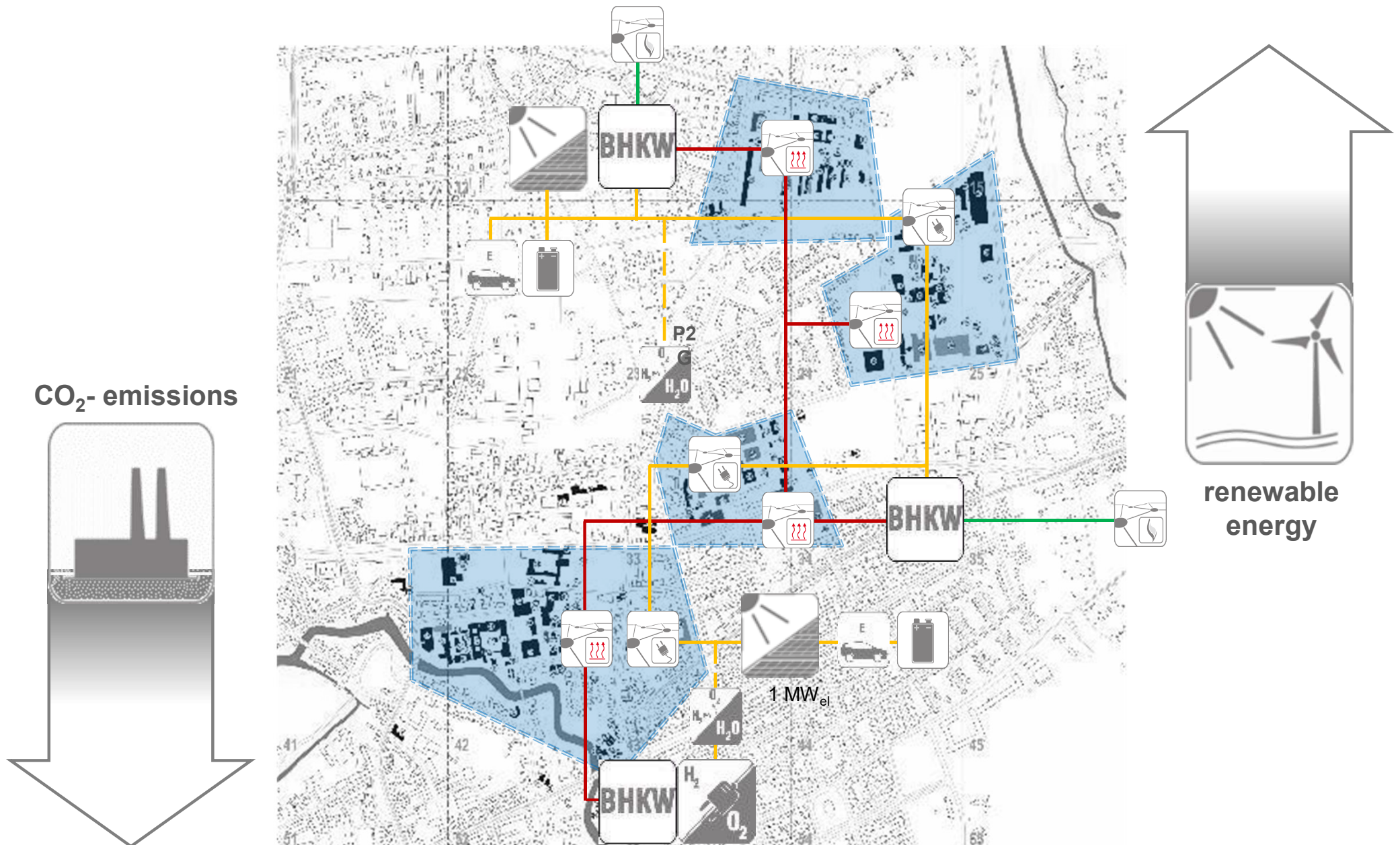




- 40 % Primary Energy
13 Mio. € (35 € / m²) investment
< 10a ROI



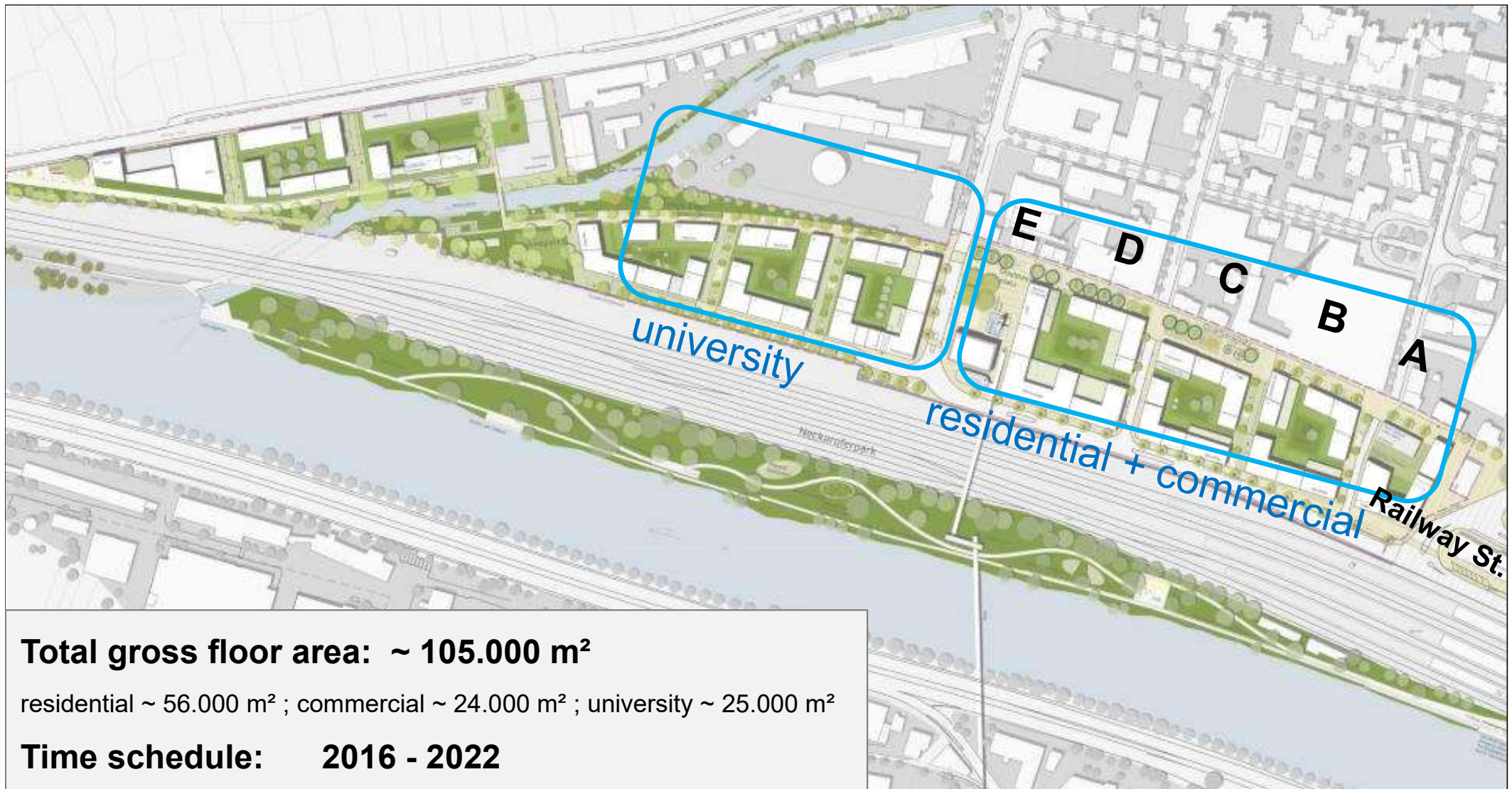
Campus 2035 realization „climate neutral urban quarter“



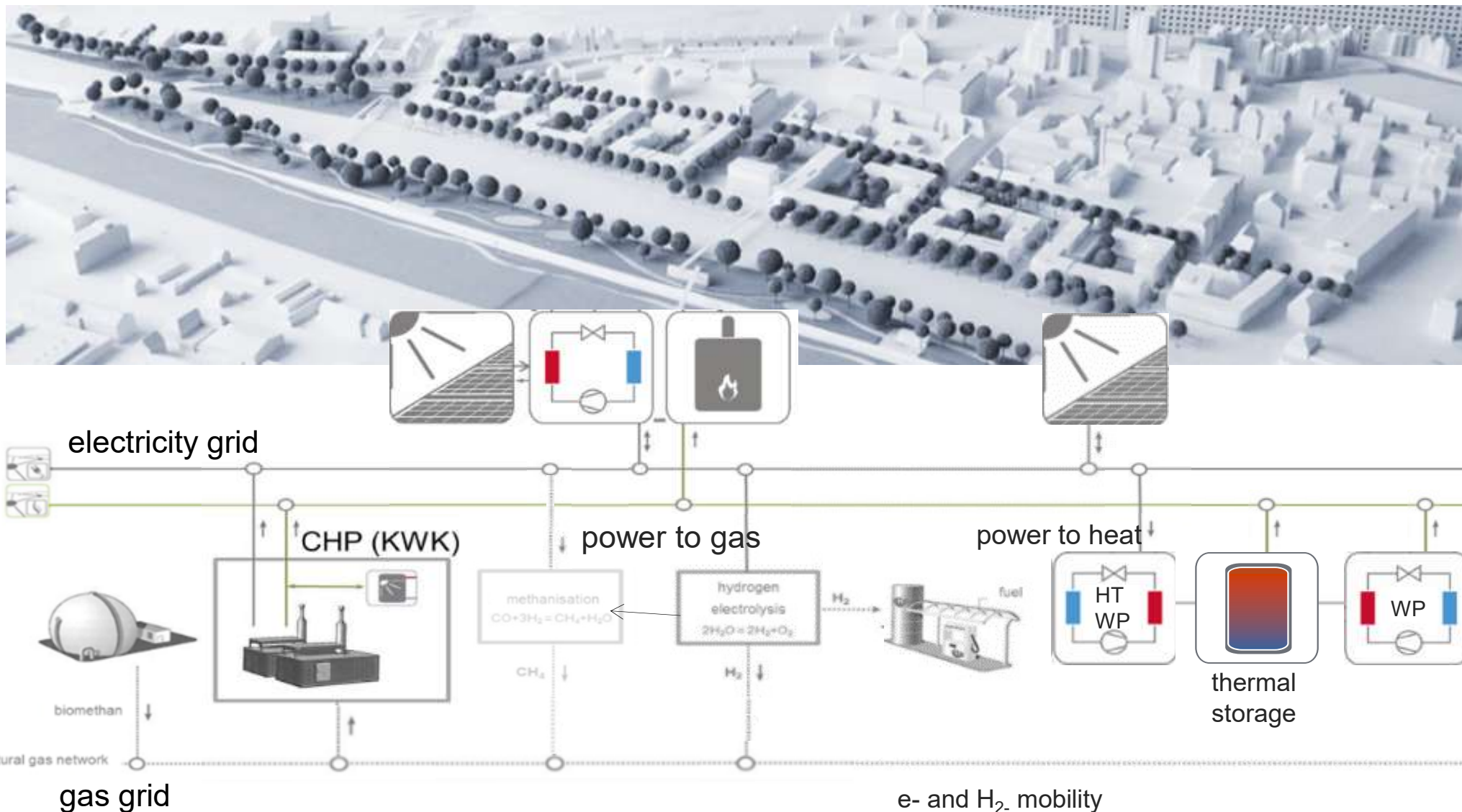
... Neue Weststadt Esslingen

„CO₂- neutral city district“

Esslingen Weststadt „CO₂- neutral city district“



smart city district „Esslingen Weststadt“ 2014 - 2025

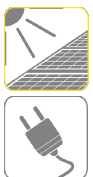


parkade
~ 250 kWp

university
~ 1.000 kWp

resid. + commercial
~ 1.250 kWp

total
~ 2.500 kWp



PV production ~ 2.250 MWh/a

Electricity consumption ~ 4.500 MWh/a



~ 50% solar coverage!

Additional generation of „green“ electricity necessary!

(CHP, additional PV area, **regional production** of electricity and biomethane)

„Neue Weststadt Esslingen“ 1st building block

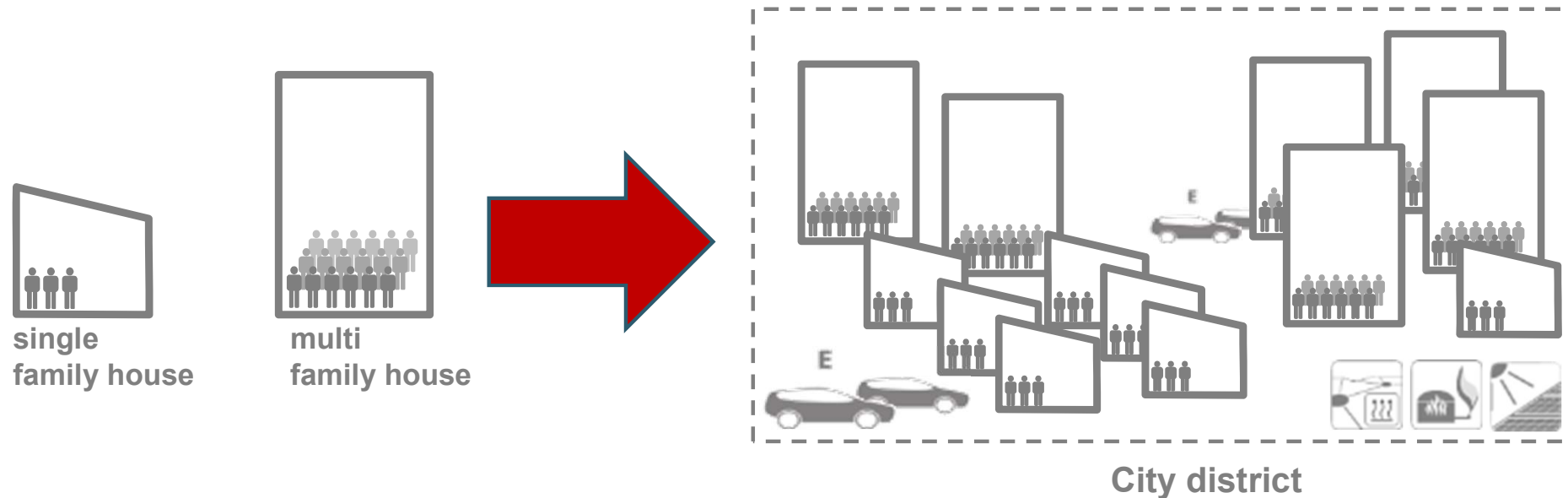
Büro Graf+Graf, Montabaur



„Neue Weststadt Esslingen“ 1st building block



conclusions - from buildings to district



- investigations on districts requested!
- various ownerships – challenge!
- more technical flexibility for cogeneration and implementation of renewable energy

EnergyPLUS – design construction operation



2012



2013



2014

We believe in solar energy ...

