

Future Quarter 2.0 – Grid-Supportive Conception of (Positive Energy) Districts

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Research group Sustainable buildings and cities



Institute of
**Building Research
& Innovation** ZT-GmbH

KolPEQ – Competence team for liveable Positive Energy Districts

Projects

Zukunftsquartier
Exploration project

Zukunfts Quartier

Duration: 12 months (07/18 – 06/19)

Funding:  Bundesministerium
Verkehr, Innovation
und Technologie

Partners:



Zukunftsquartier 2.0
Demonstration

Duration: 36 months (09/19 – 08/21)

Funding:  Bundesministerium
Verkehr, Innovation
und Technologie

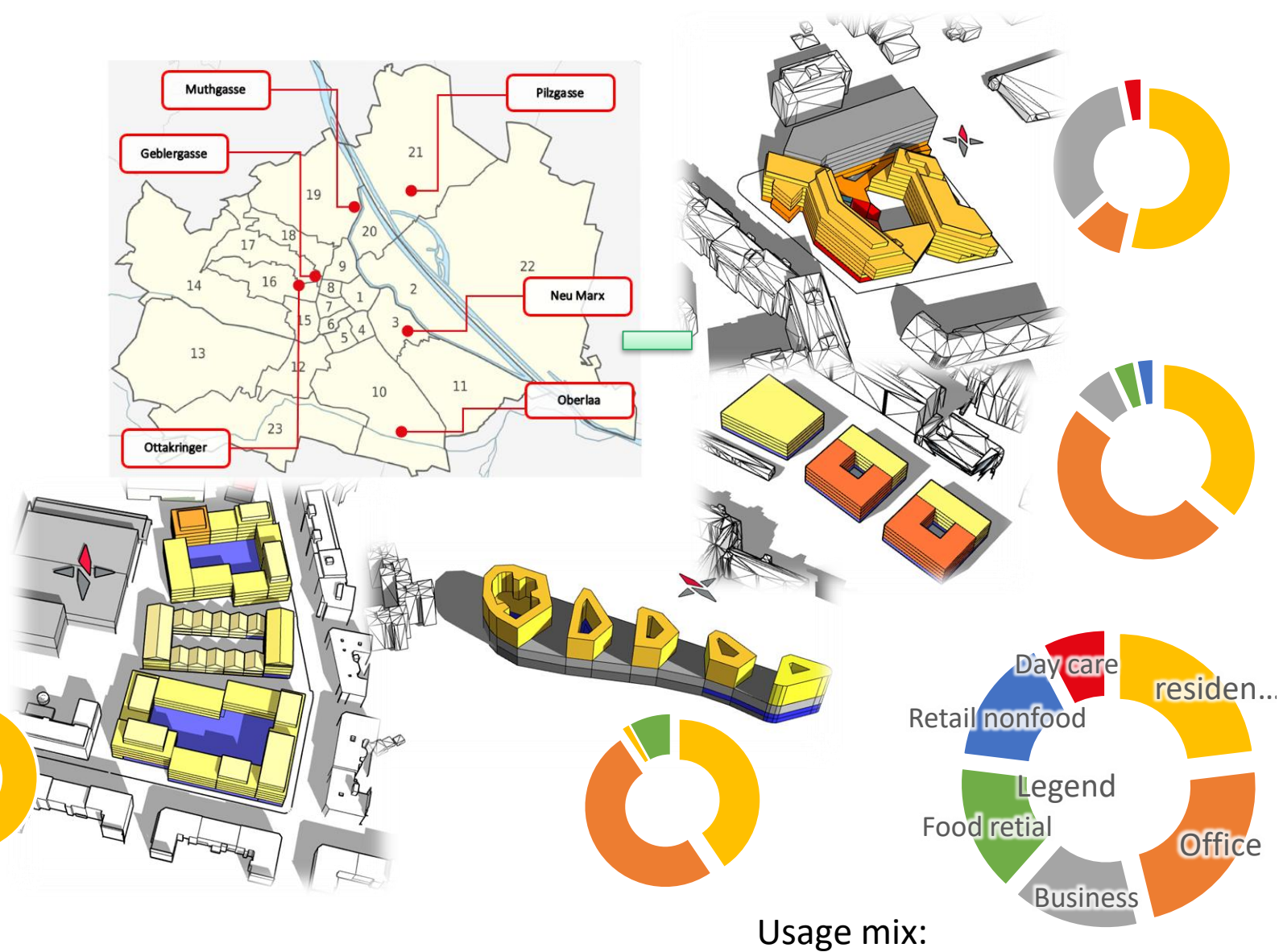
Partners:



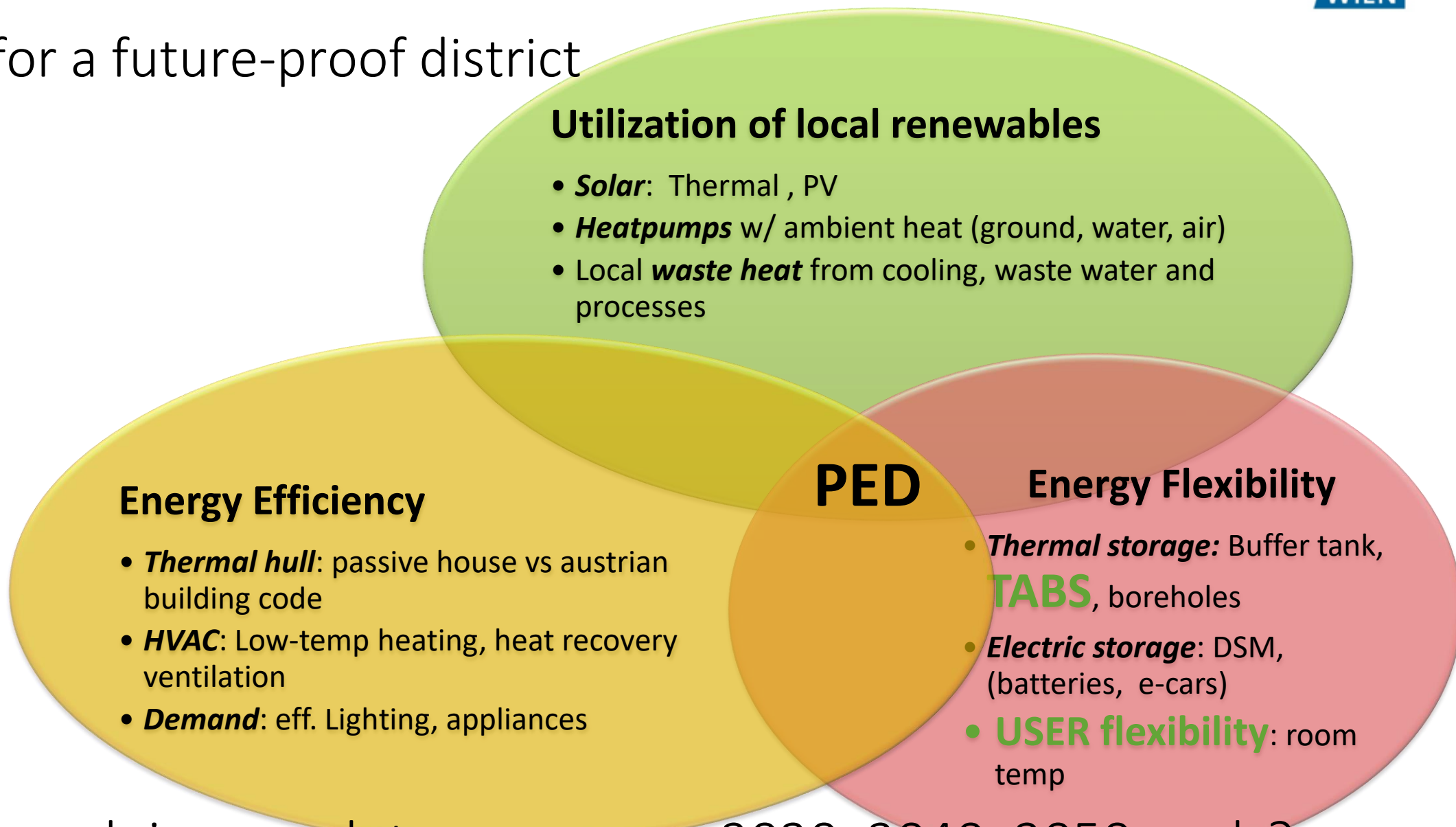
Project goals

Sustainable energy concepts for urban quarters, as part of a future carbon free energy system 2050

Exploration of **5 possible sites** with 20 – 32.000 m² useable floor area w/ mixed use



3 Pillars for a future-proof district

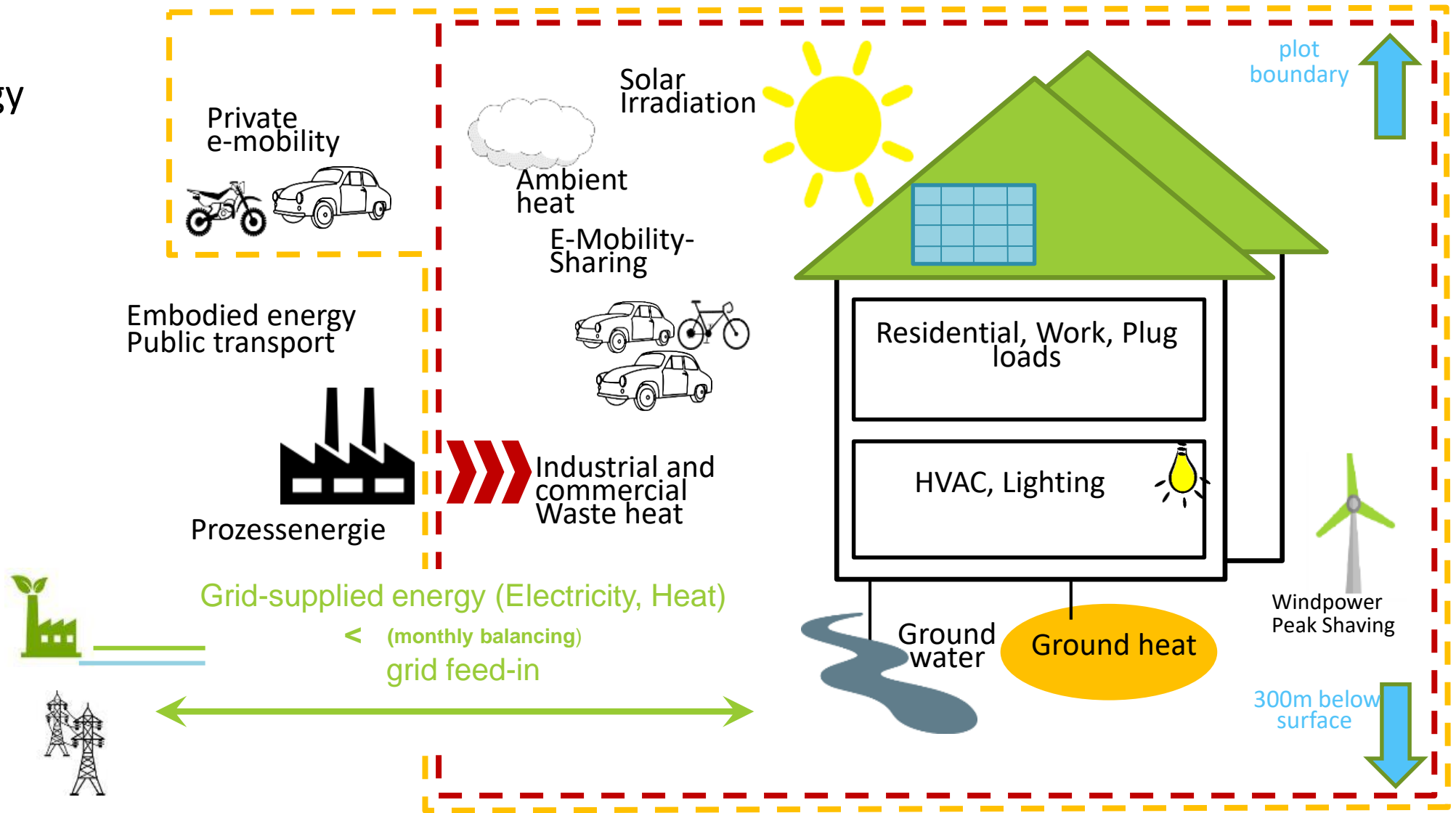


But how much is enough to ensure our 2030, 2040, 2050 goals?

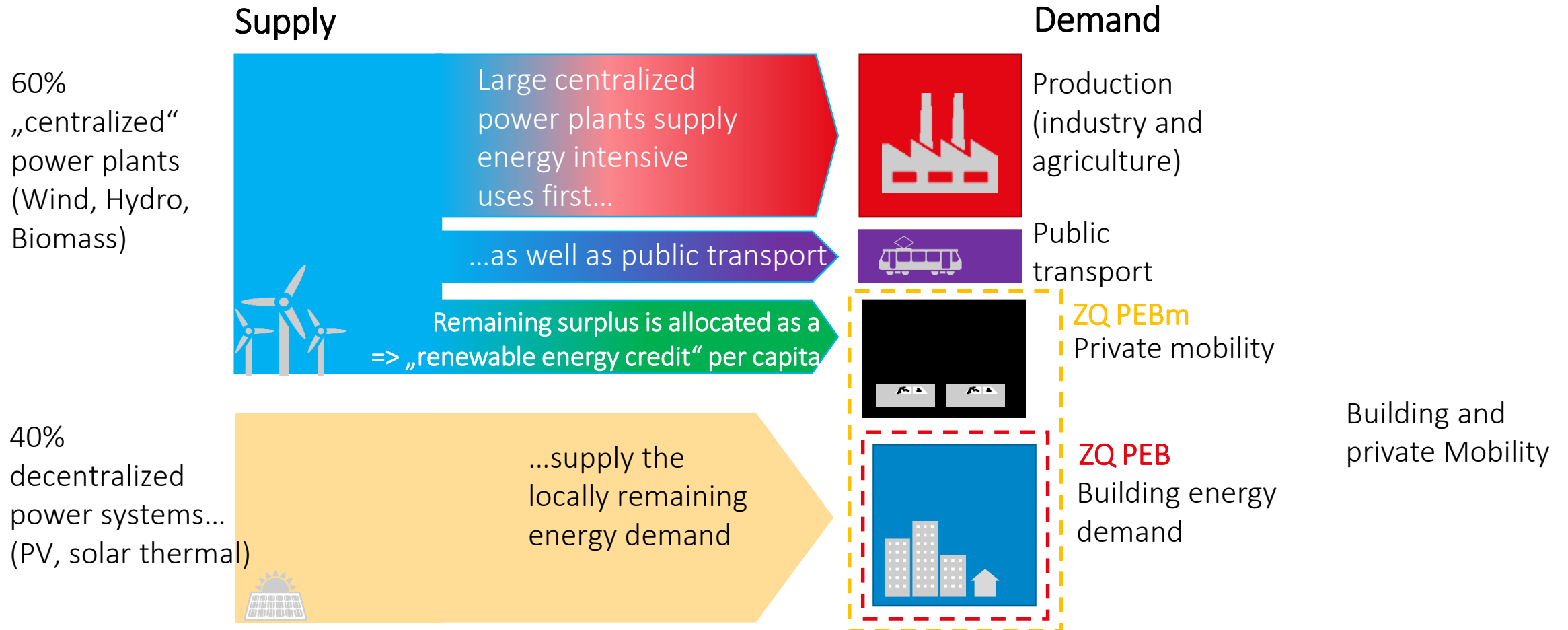
System boundaries *Zukunftsquartier*

System boundary ZQ PEBm System boundary ZQ PEB

Includes all energy services onsite



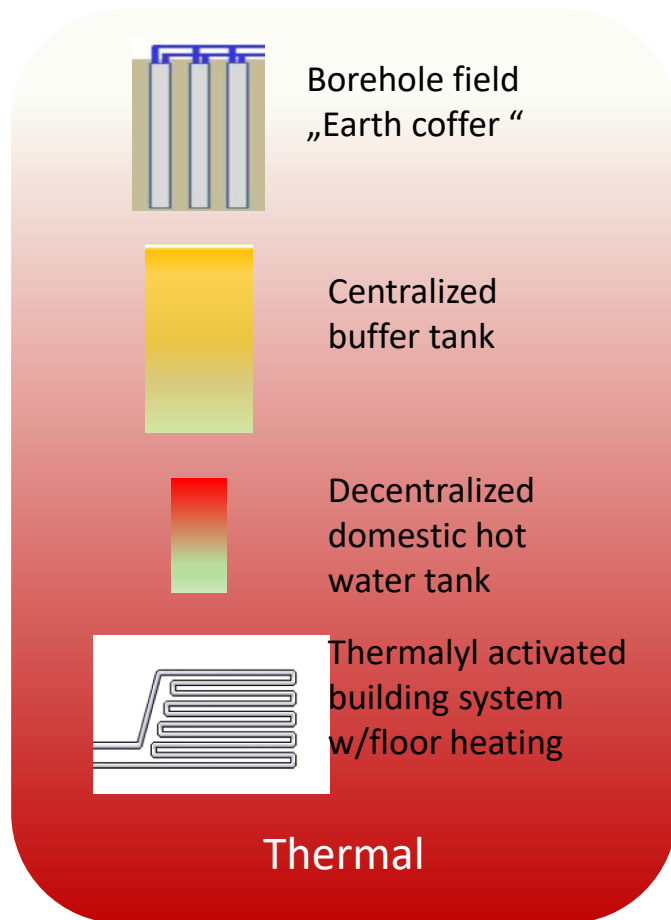
Attempting to combine top-down and bottom-up targets



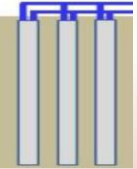


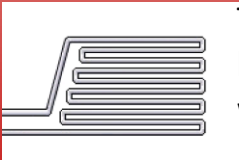
Primary Energy

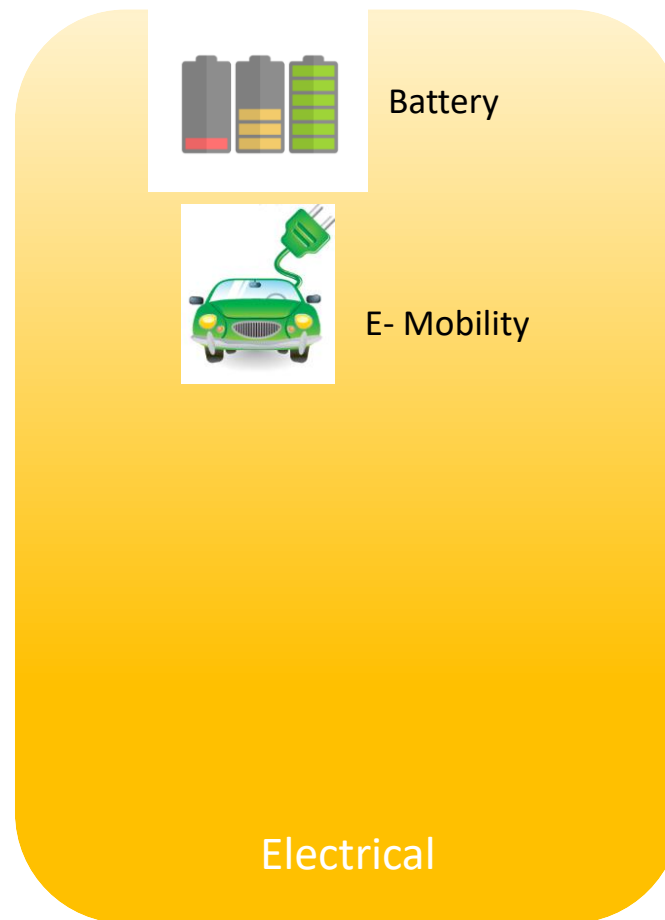
Development and simulation of grid supportive energy management

🏠 Storage capabilities provided by components:



Thermal

-  Borehole field „Earth coffer“
-  Centralized buffer tank
-  Decentralized domestic hot water tank
-  Thermally activated building system w/floor heating



Electrical

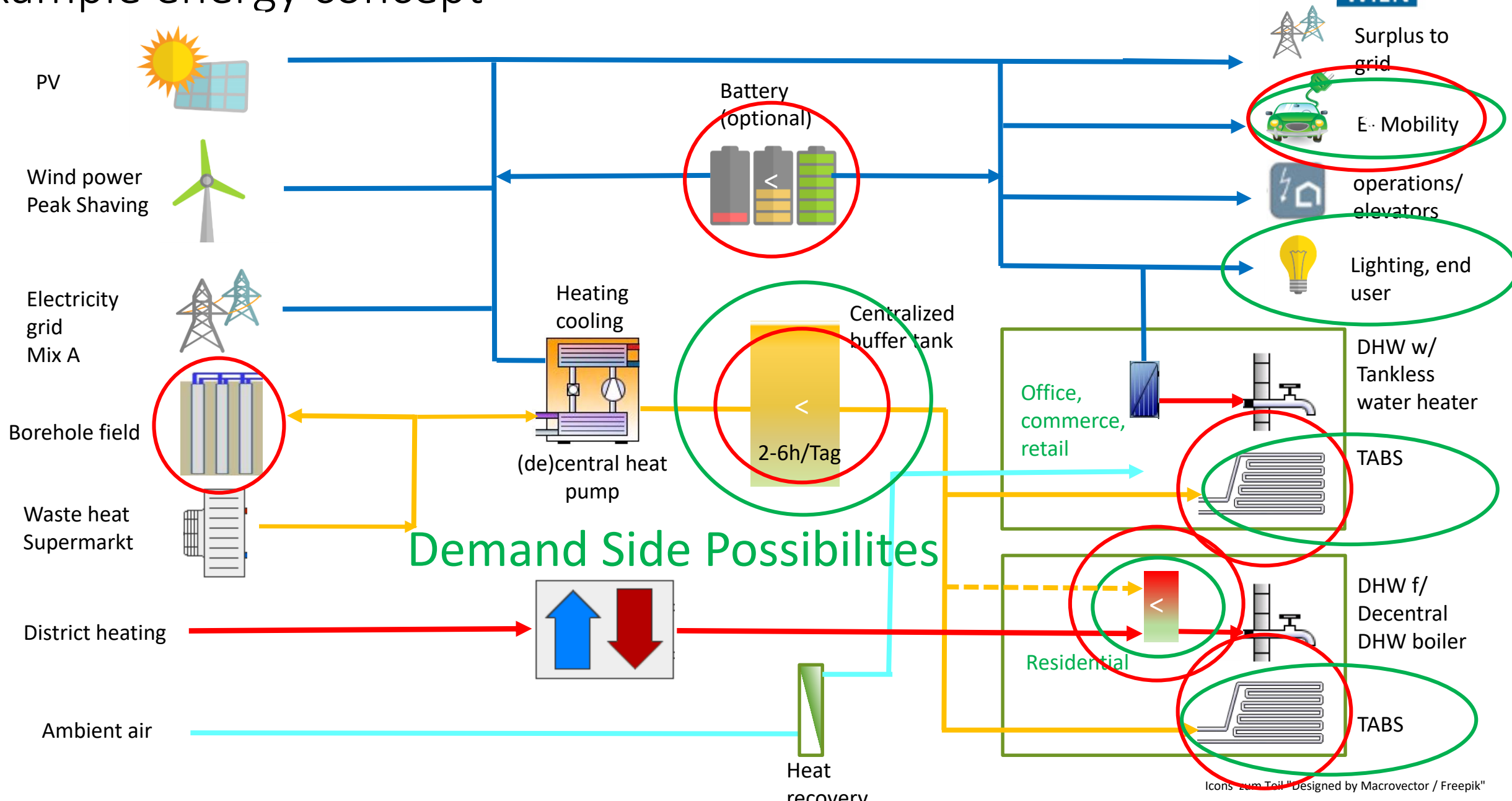
-  Battery
-  E- Mobility



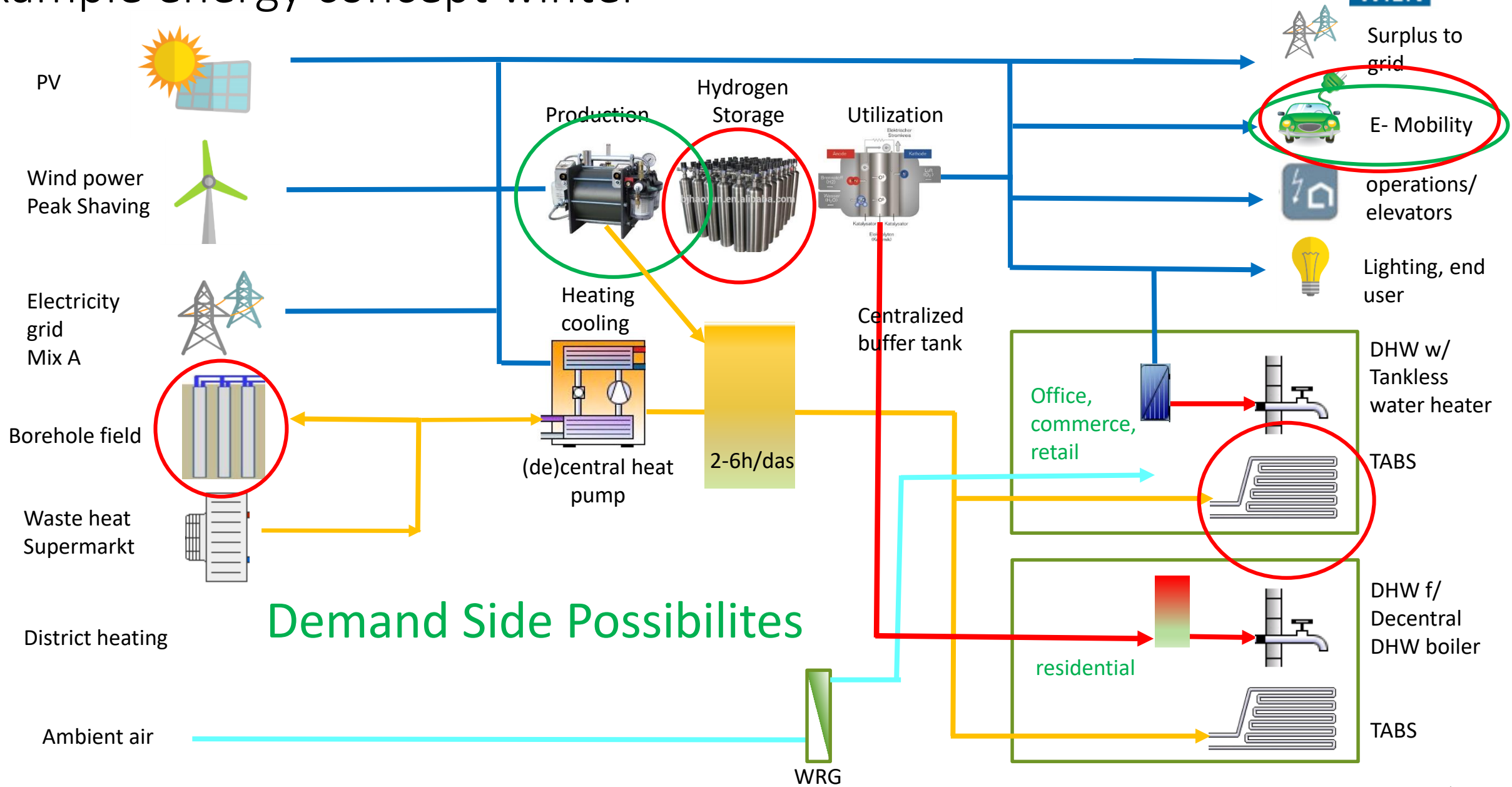
Chemical

-  Hydrogen
- 

Example energy concept



Example energy concept winter



Zukunftsquartier approach

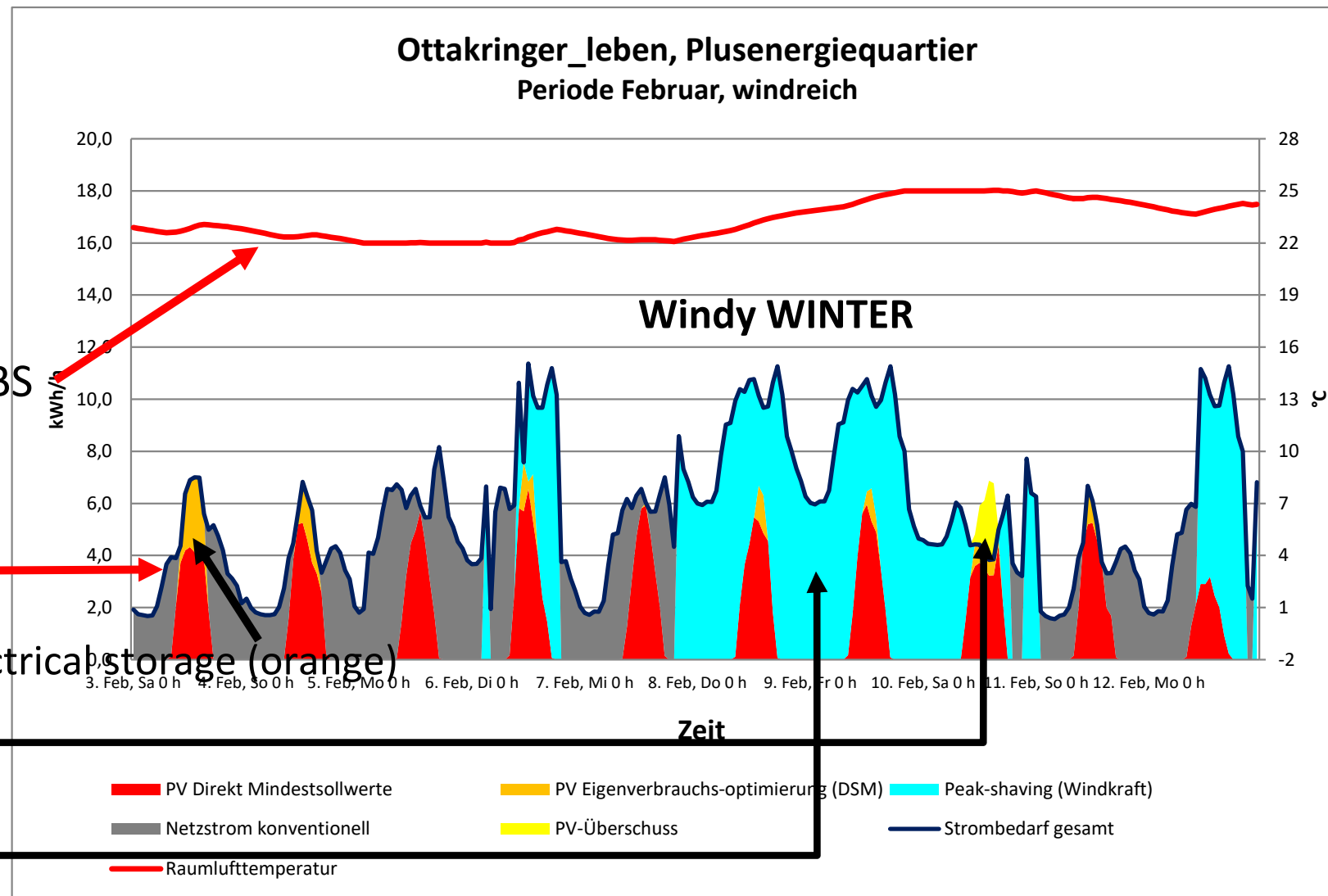
Direct utilization of otherwise unuseable RES power peaks (DSM)

USER FLEXIBILITY:

- ▶ Max. 25°C in winter
- ▶ Min. 23°C in summer
- ▶ Over-Heating/cooling of TABS

RES sources

- ▶ PV Direct use (red)
- ▶ PV Loading of thermal and electrical storage (orange)
- ▶ PV Grid infeed (yellow)
- ▶ Wind peak shaving (cyan)



Zukunftsquartier approach

Utilization of PV excess instead of grid infeed

🏠 Room temp (thermal storage)

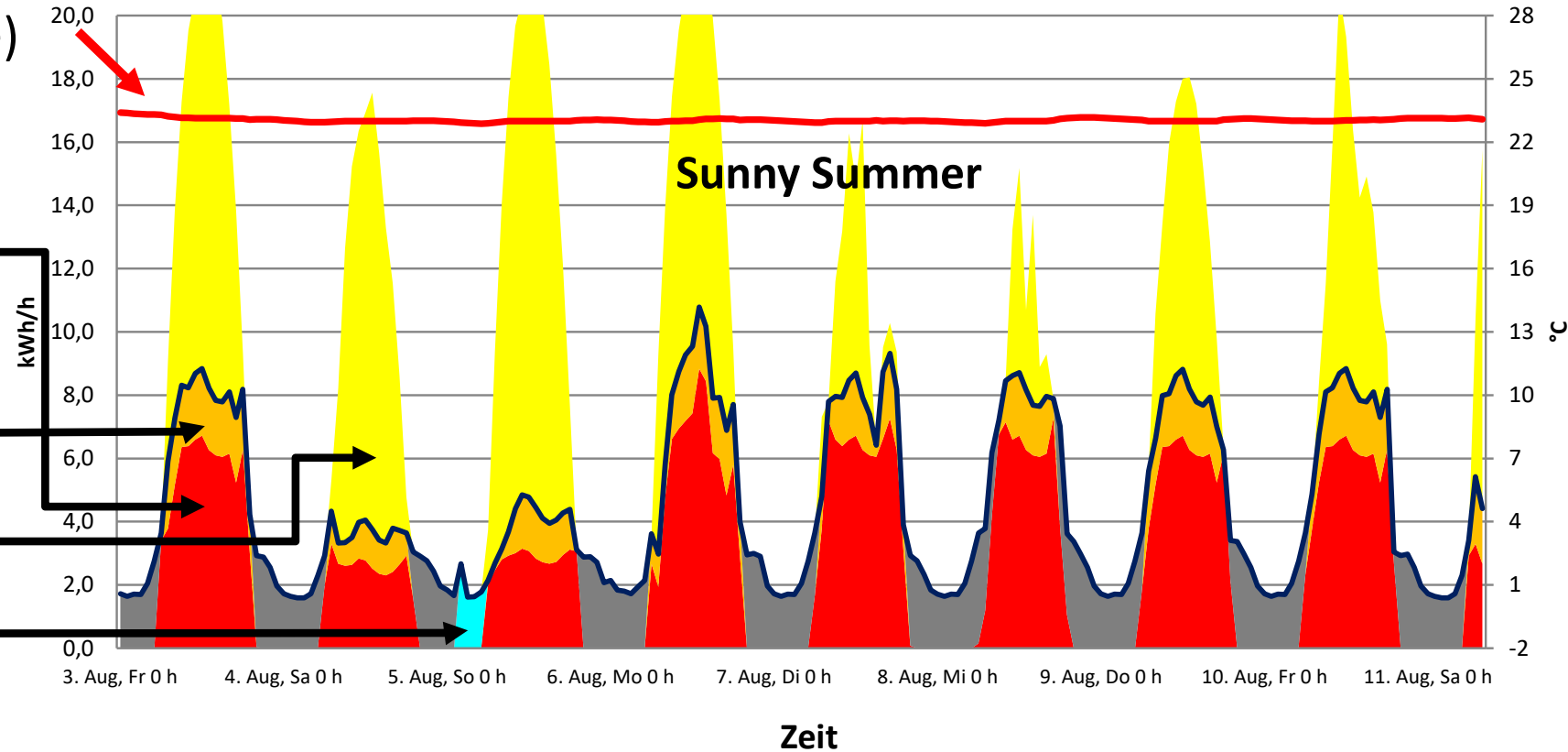
🏠 RES DSM

▶ PV Direct use (red)

▶ PV Loading of thermal and electrical storage (orange)

▶ PV Grid infeed (yellow)

▶ Wind peak shaving (cyan)



■ PV Direkt Mindestsollwerte

■ PV Eigenverbrauchs-optimierung (DSM)

■ Peak-shaving (Windkraft)

■ Netzstrom konventionell

■ PV-Überschuss

— Strombedarf gesamt

— Raumlufttemperatur

Zukunftsquartier approach

Direct utilization of otherwise unuseable RES power peaks (DSM)

- 🏠 Reduction of required grid electricity and surplus infeed of 30-70% (but overall slightly higher energy demand)

- 🏠 Wind overproduction in winter

- ▶ NOT wind power itself

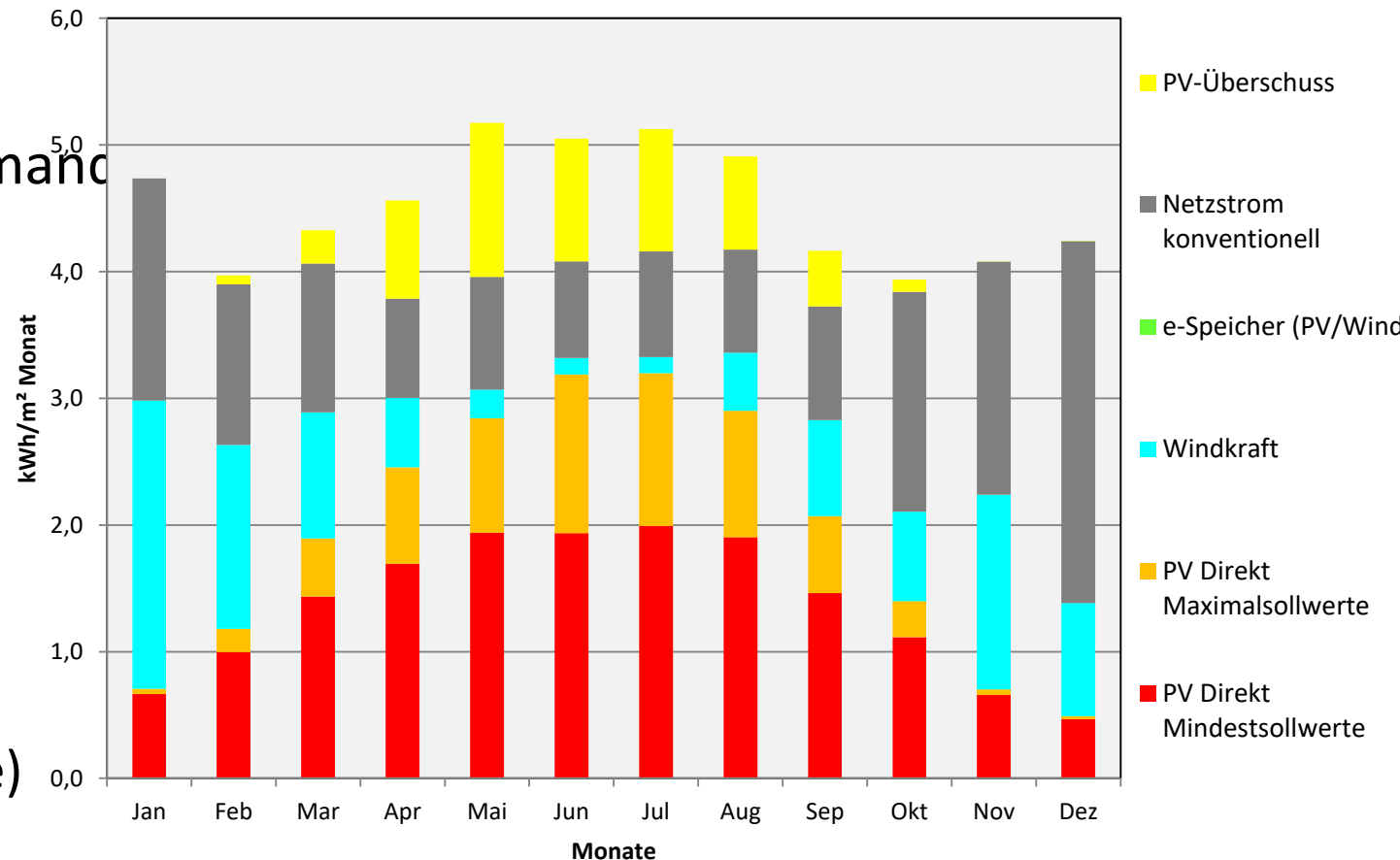
- 🏠 PV in Summer

- ▶ Direct utilization

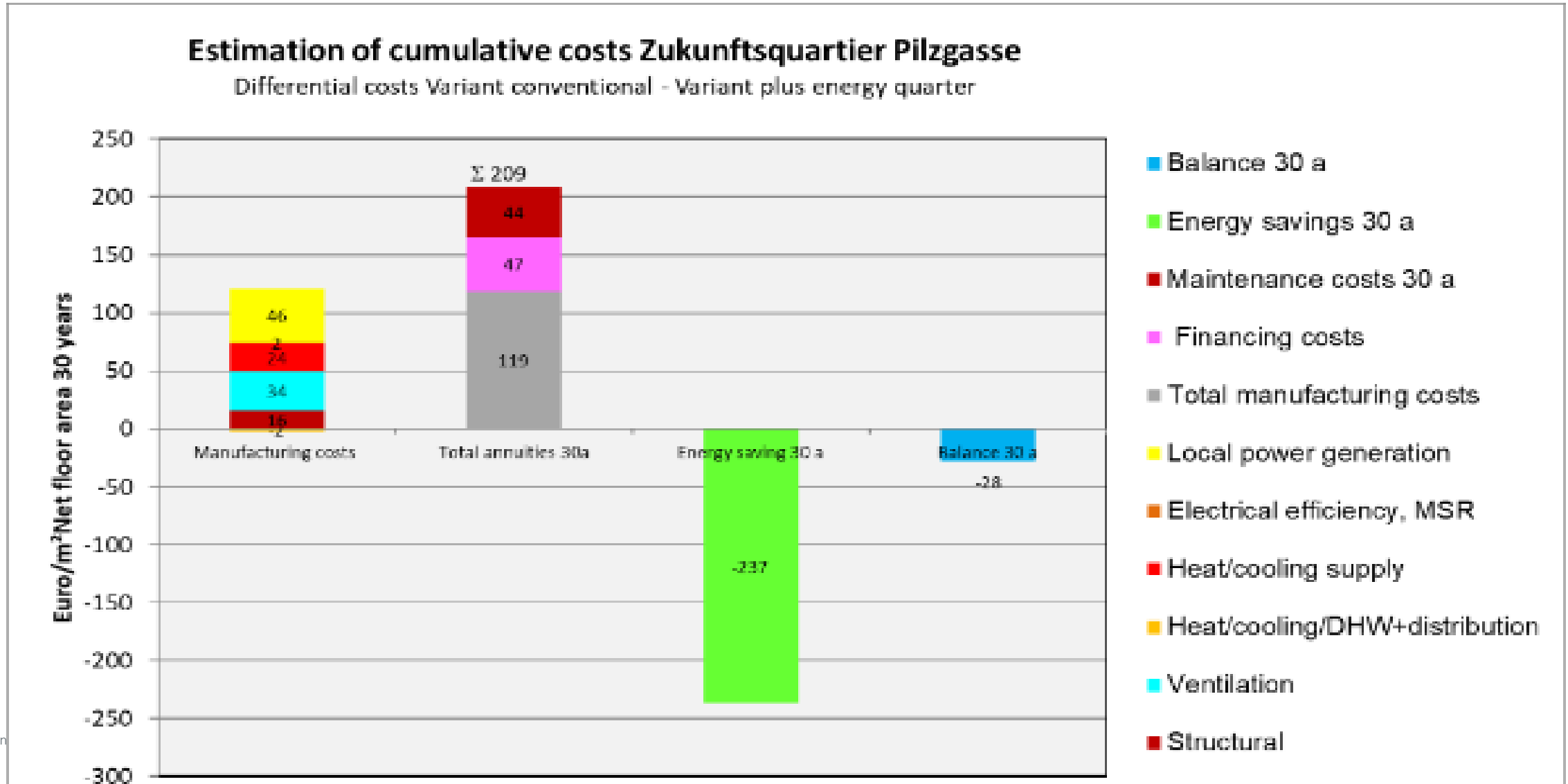
- ▶ Utilization of thermal storage (orange)

Supply of energy end use

Monatsbilanz



Differential life cycle costs o/ 30 years are positive!



Conclusions (i)

- 🏠 High **energy efficiency** of thermal hull and HVAC system is a **critical requirement** for an urban PED
- 🏠 The use of local resources groundwater and geothermal energy for heating and cooling is required. Regeneration must be taken into account. Ambient air should only be used if no other potential can be used.
- 🏠 The use of solar energy (mostly PV) has to be **integrated in the planning process from the beginning**. This way, possible conflicting goals (greening, etc.) can be addressed proactively.
- 🏠 The optimal use of different storage facilities and user elasticity (borehole storage, buffer storage, battery storage, building mass, load shift) is crucial for maximizing self-consumption and thus for economic efficiency.
 - ▶ PV's own consumption rates of 60% and 70% can be achieved. The PV surpluses can largely be absorbed by the process energy requirements of businesses and future e-mobility.

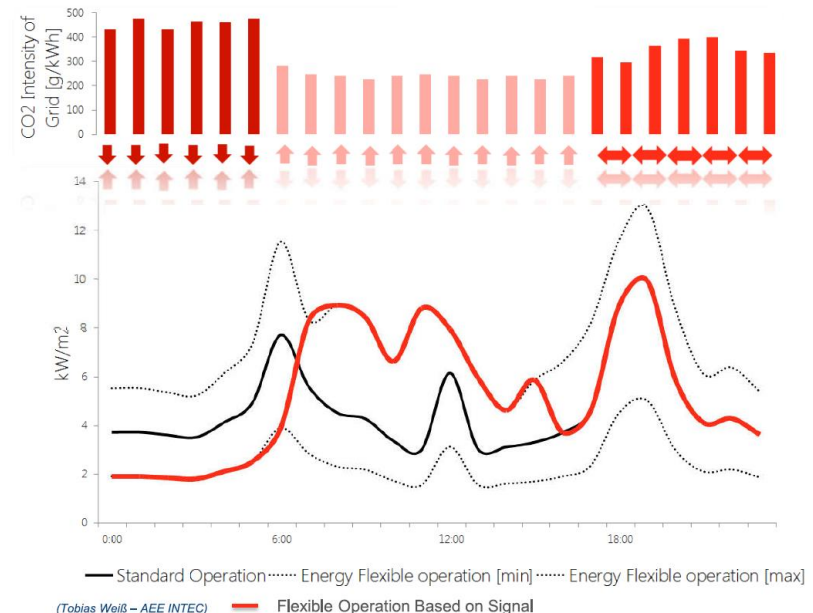
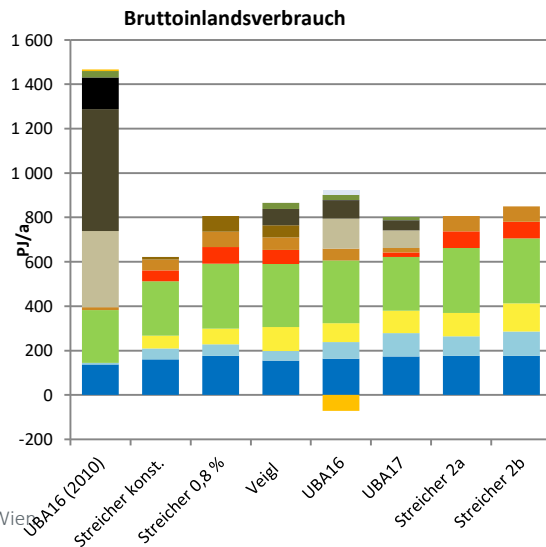
Next step: Hourly resolution of future scenarios:

Flucco+ research project

Future carbon and grid-supporting signals for hourly positive energy districts

- ▶ Securing robust scenarios for the Austrian power grid 2030 and 2050
- ▶ Modelling of an aggregated grid-support signal based on subhourly Carbon intensities

Gross domestic supply 2050 according to scenarios



Thank you for your attention!

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Further Information

[Project Zukunftsquartier](#)

[Projekt Zukunftsquartier 2.0](#)

FH Technikum @

res.technikum-wien.at/kolpeq/ www.technikum-wien.at/forschung/forschungsschwerpunkte/

Team

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- Jens Leibold (FHTW)
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- Petra Schöfmann (UIV)
- Momir Tabakovic (FHTW)
- Thomas Zelger (FHTW)

Zukunfts Quartier 2.0



Zukunfts Quartier



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Context: Paris 2050, Viennese version (GHG p.C. -35% by 2035, -80% by 2050 vs 1990)

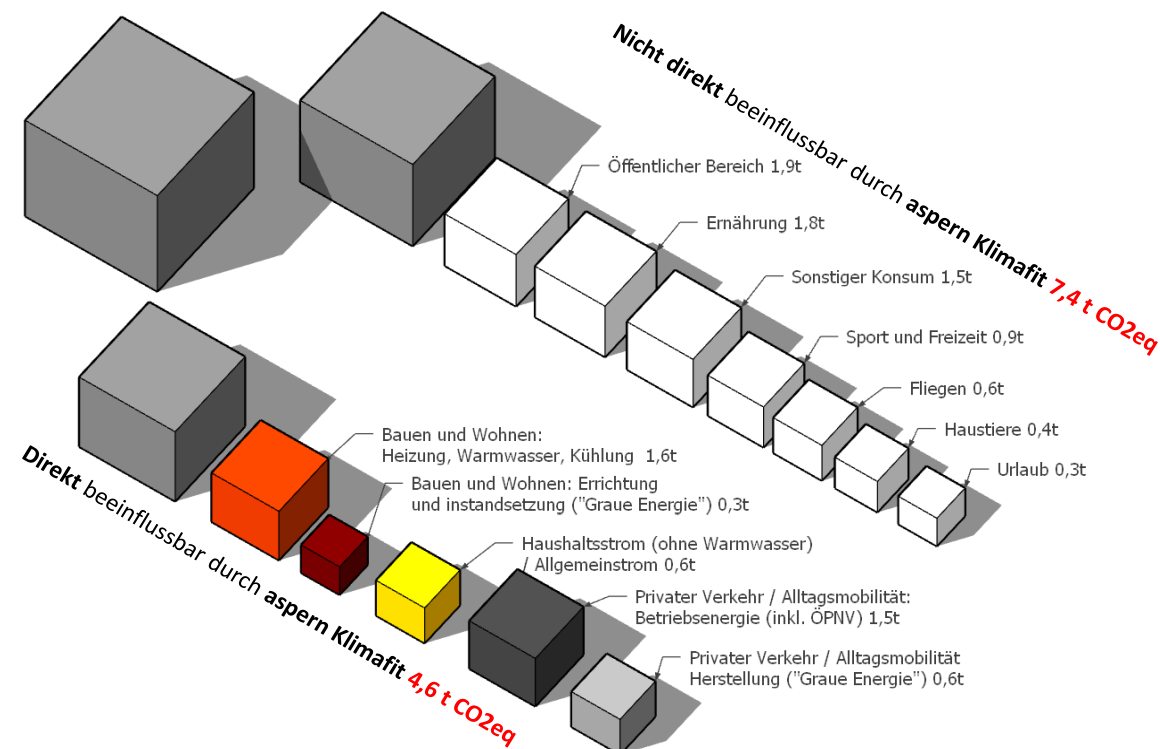
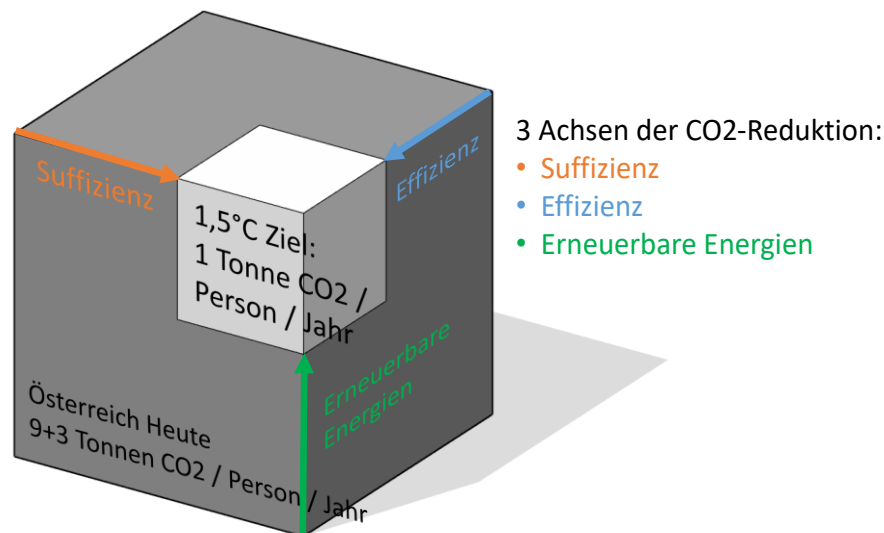
What is a „climate fit“ and „future proof“ building or district?

🏠 Global warming < 2°C (compared to pre-industrial levels)

🏠 Global emission budget 2016-2100 < 850 Gt CO₂e

▶ (initially 2010-2100 < 1000 Gt Co₂)

(source: Klimaschutzbericht 2017, Umweltbundesamt)



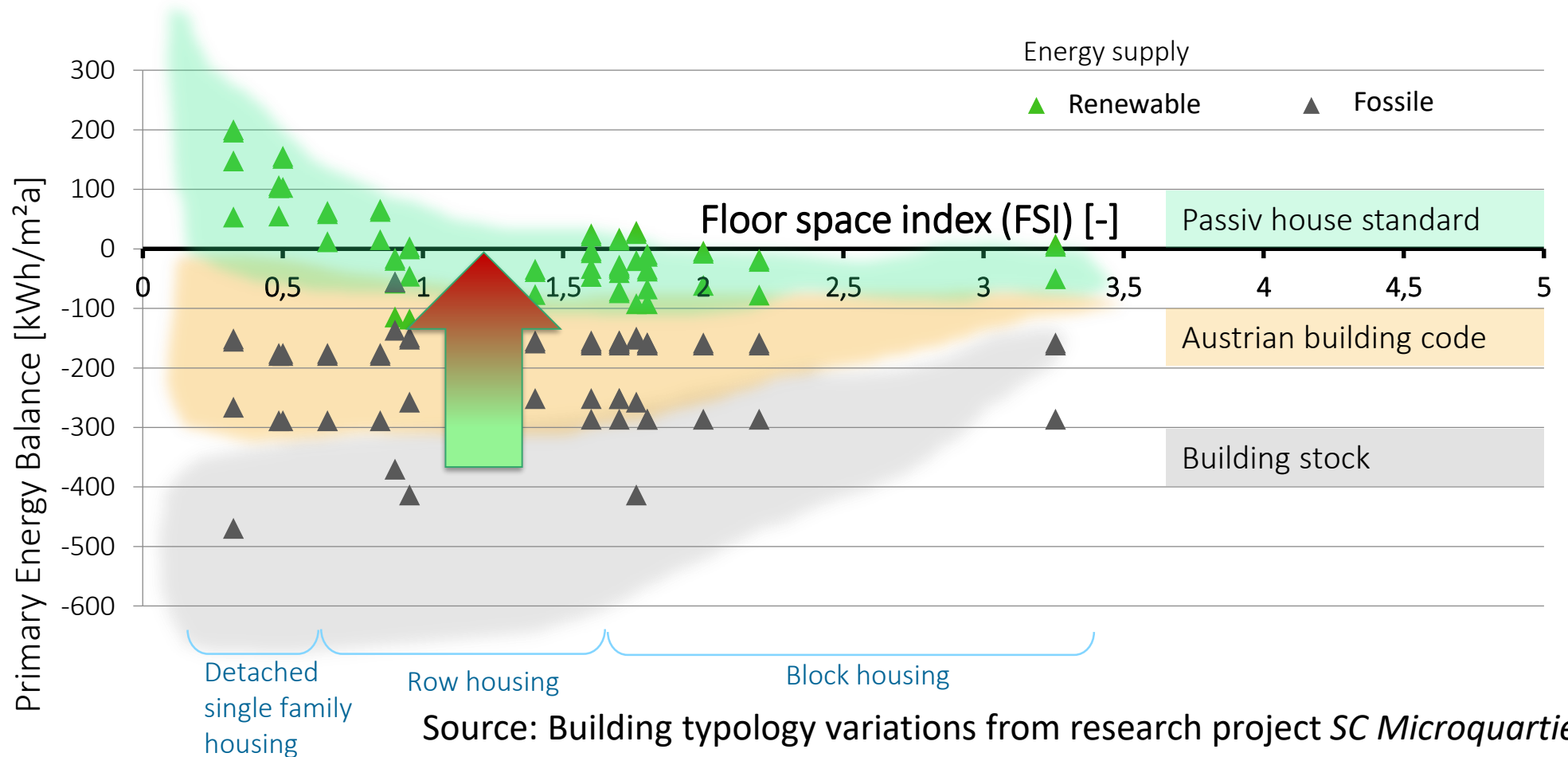
Methods

- 🏠 Stationary energy balance calculation (PHPP) for the expected mixed use (residential, office, retail, ...) and with superstructures in two variants (OIB standard valid from 2021 and passive house construction);
- 🏠 Potential assessment of the usable solar energy for photovoltaics (PV) in four variants of different size and cost;
- 🏠 Comparison of conventional (legal req) and *positive energy* concept including local renewable potentials (solar, geothermal, ambient & waste heat);
- 🏠 Dynamic simulation of energy demand and supply, including DSM and storage utilization (PV self-consumption (thermal storage) and peak-shaving of future renewable volatile electricity supply (wind));
- 🏠 Differential LCC for all differing measures between variants (construction, maintenance and operation over a 30-year observation period)

Zukunftsquartier approach

„Density“ modulation of primary energy balance target

🏠 Best-practice PE-balance is a function of FSI



Zukunftsquartier approach

„Density“ modulation of primary energy balance target

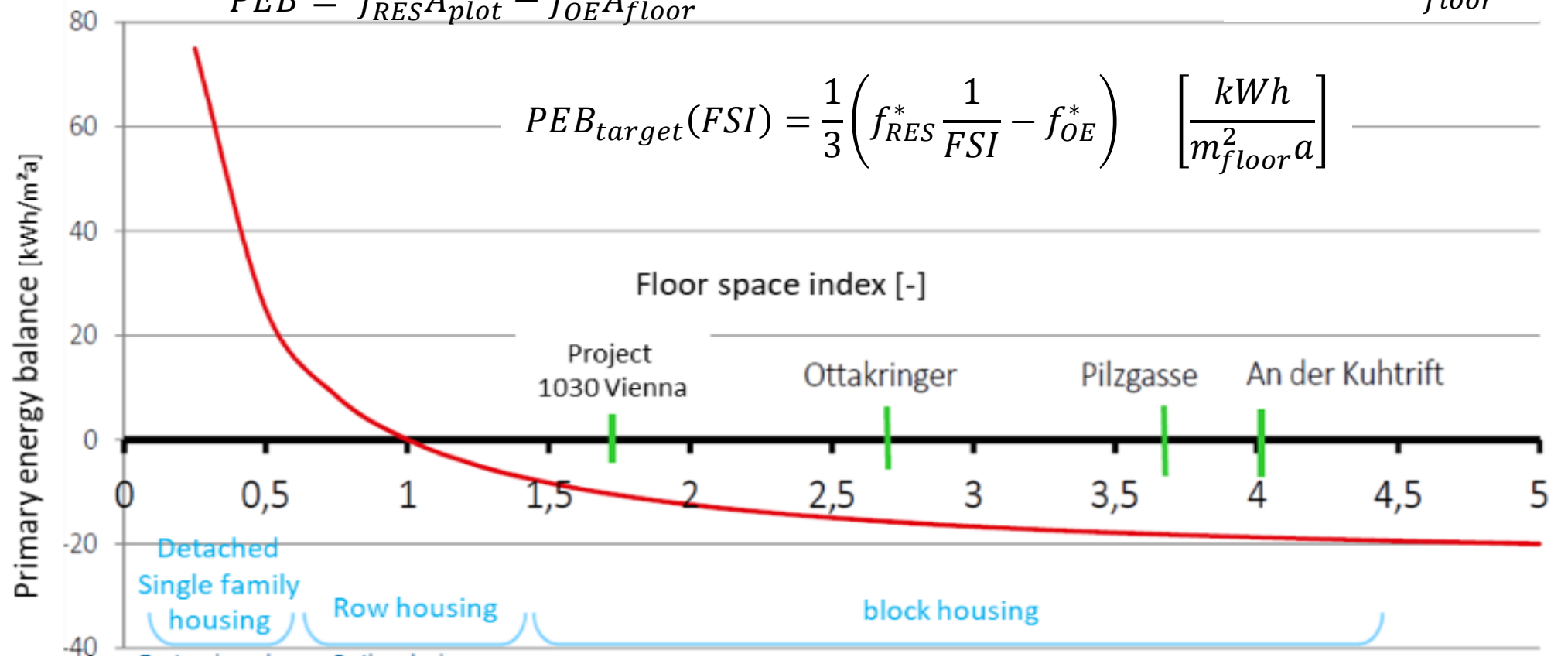
🏠 Target value as a function of the floor space index

$$f_{RES}^* = 75 \frac{kWh}{m_{plot}^2 a}$$

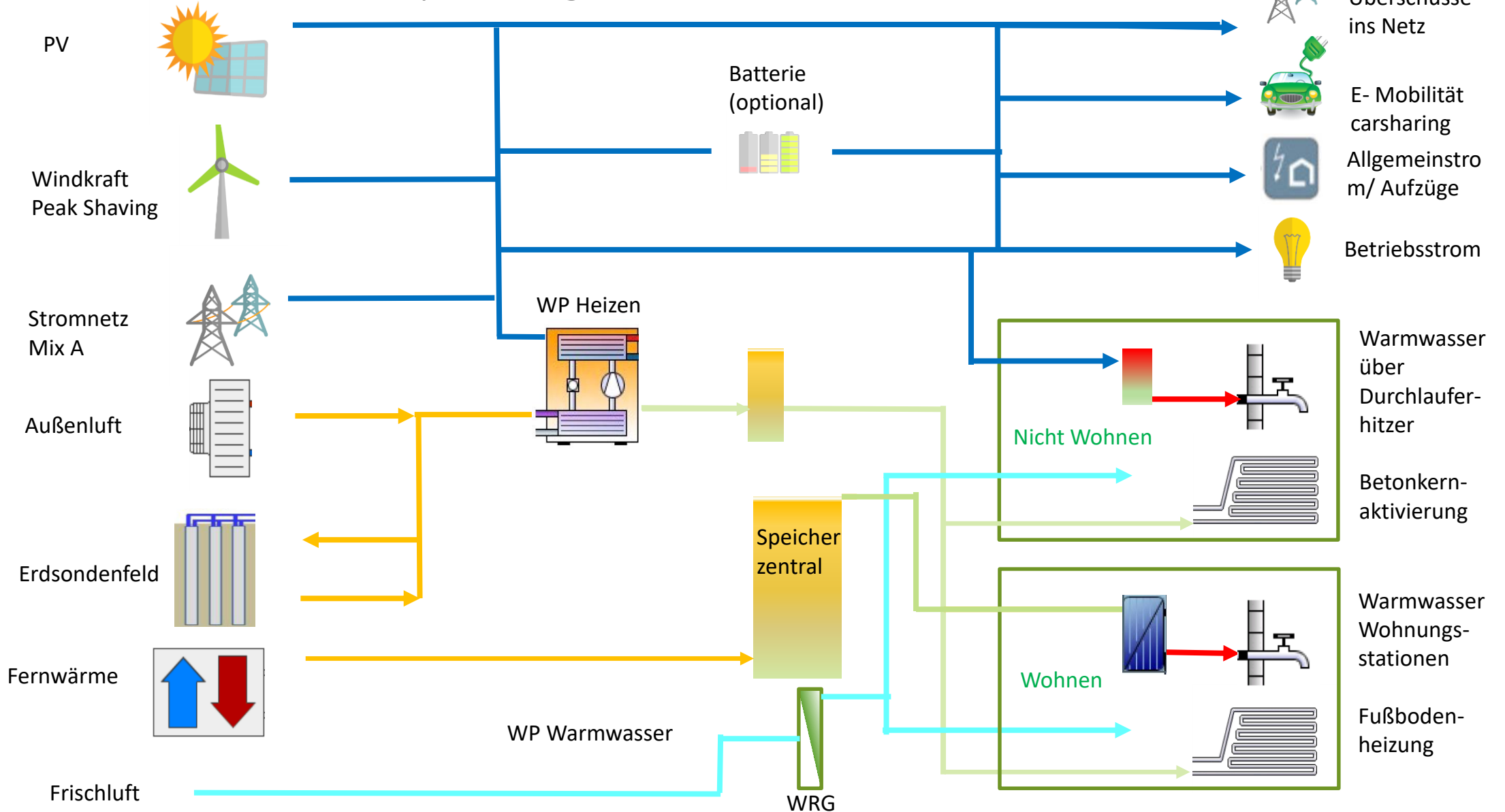
$$f_{OE}^* = 75 \frac{kWh}{m_{floor}^2 a}$$

$$PEB = f_{RES}^* A_{plot} - f_{OE}^* A_{floor}$$

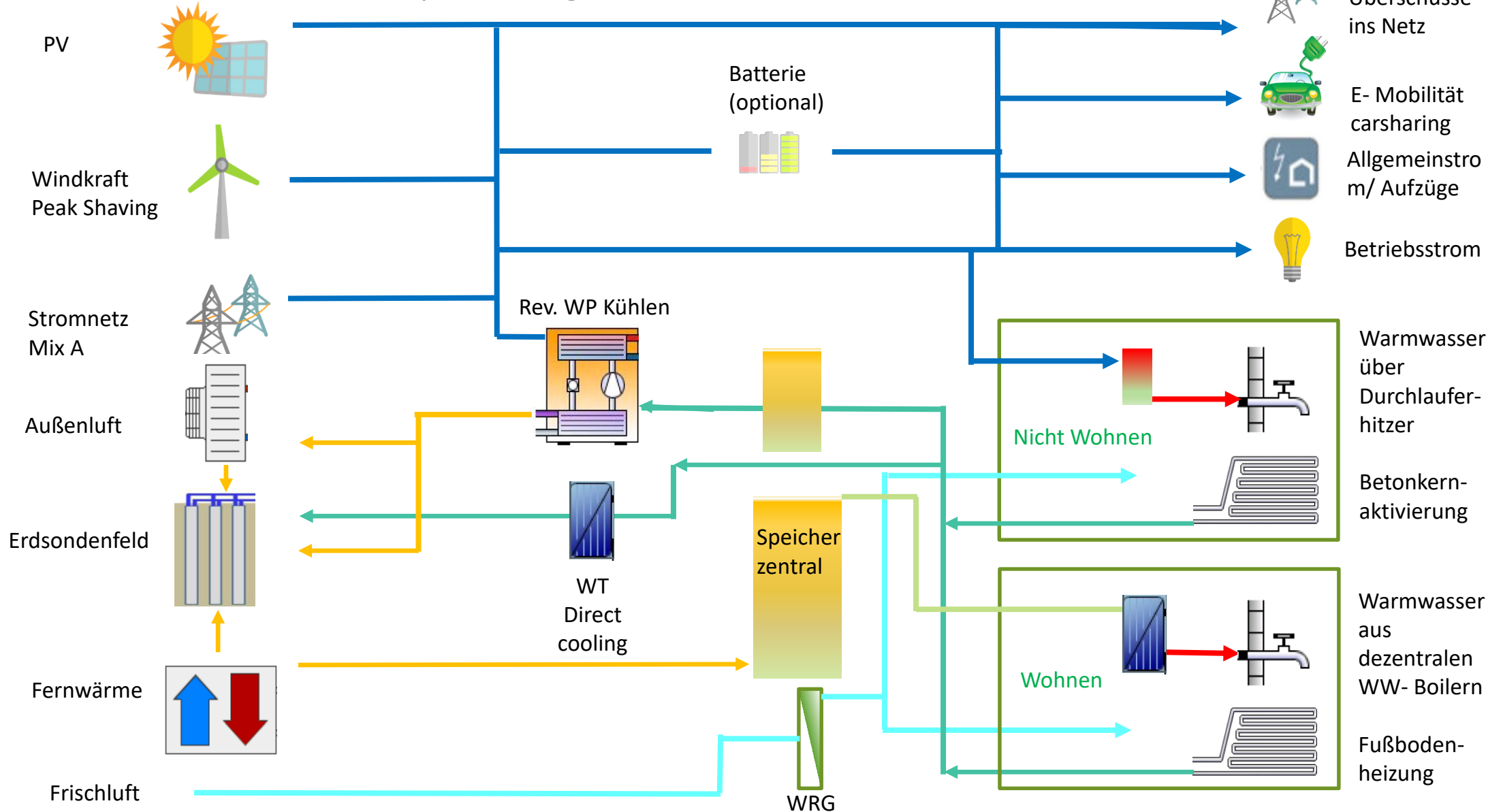
$$PEB_{target}(FSI) = \frac{1}{3} \left(f_{RES}^* \frac{1}{FSI} - f_{OE}^* \right) \left[\frac{kWh}{m_{floor}^2 a} \right]$$



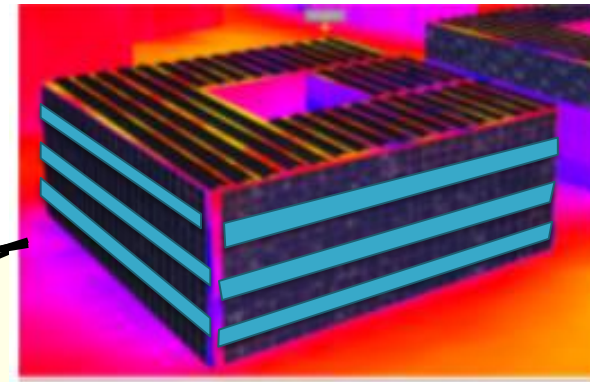
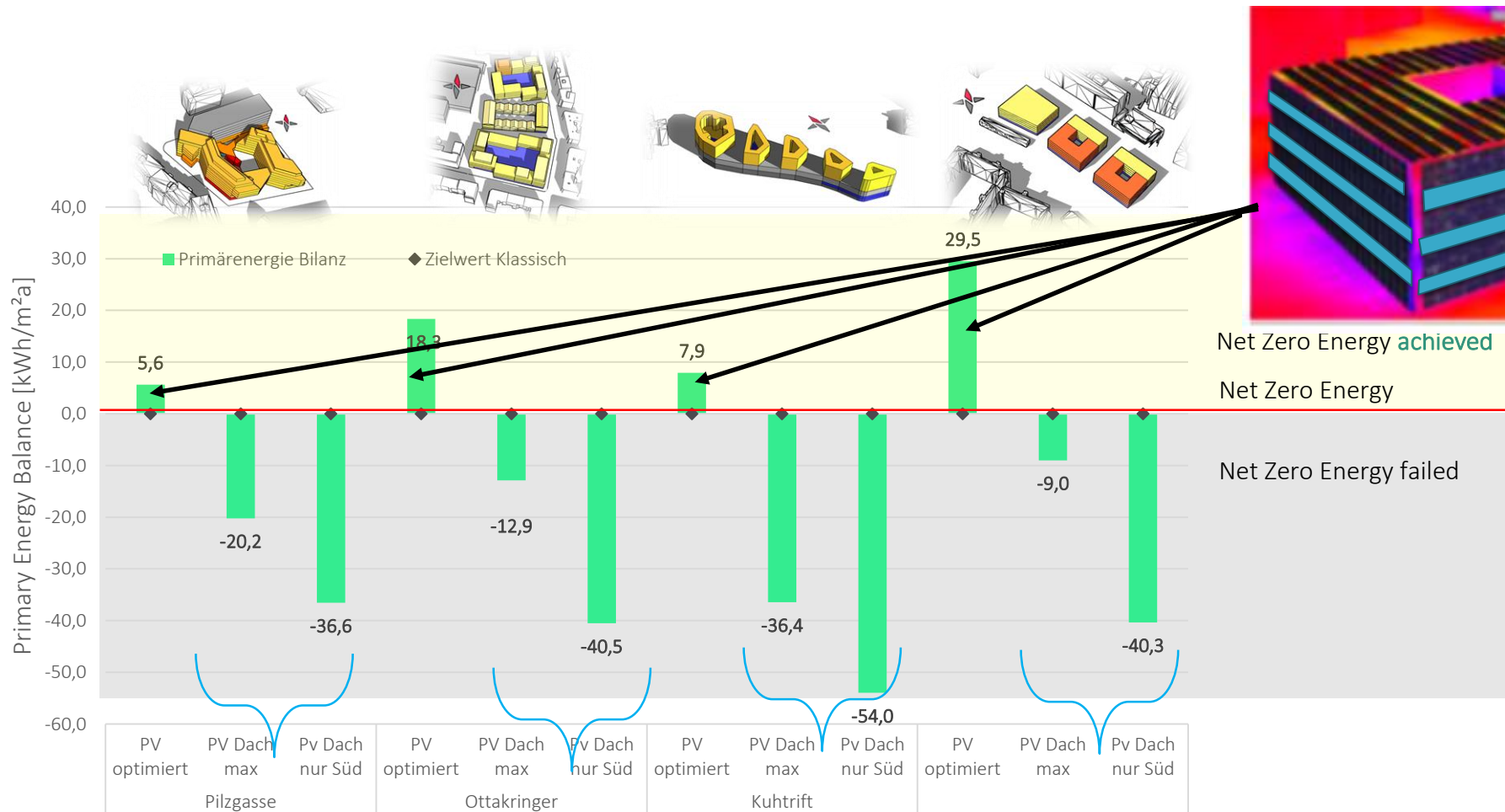
Plusenergiekonzept Pilzgasse (Winter)



Plusenergiekonzept Pilzgasse (Sommer)



However: „Classic“ Net zero energy balance remains unfeasible for dense projects for all but „pv-enveloped“ buildings



Entire building Envelope needs to be **Photovoltaic**

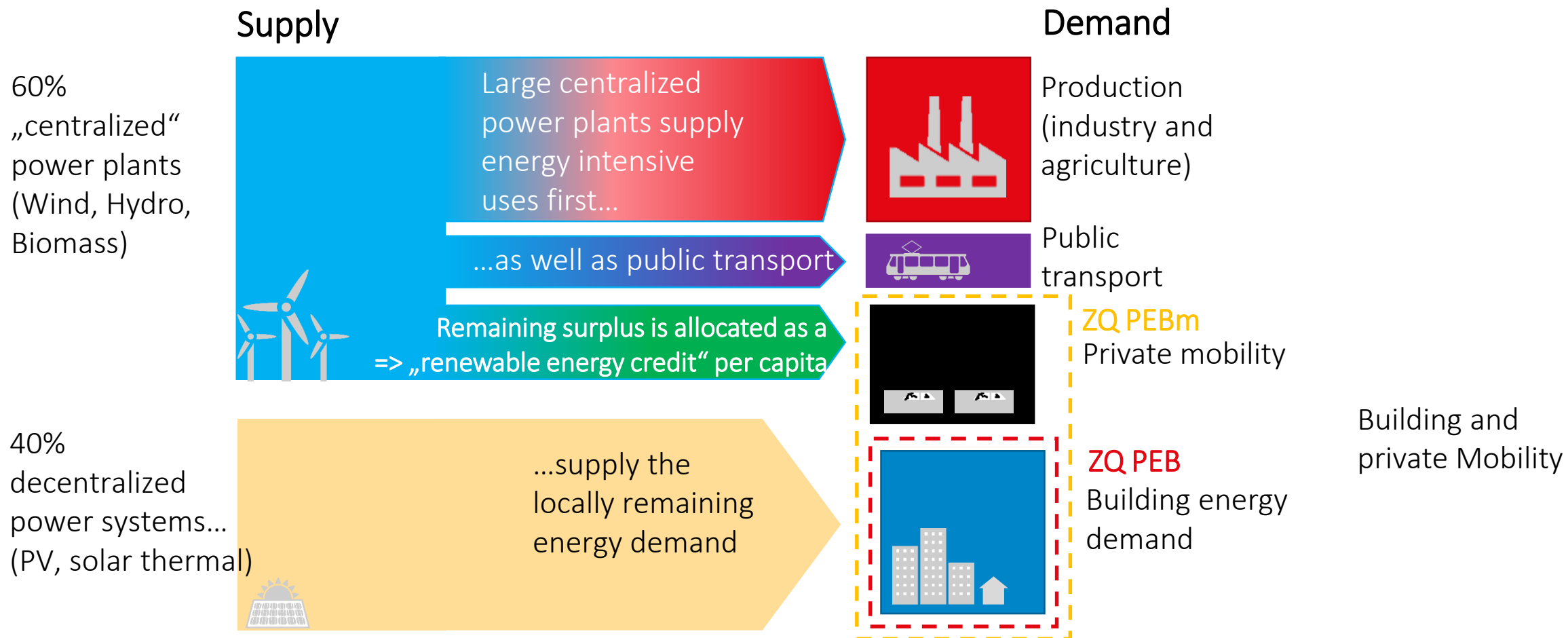
Net Zero Energy **achieved**

Net Zero Energy

Net Zero Energy failed

Feasibility of moderate PV utilization (50 – 100% of roof surfaces)

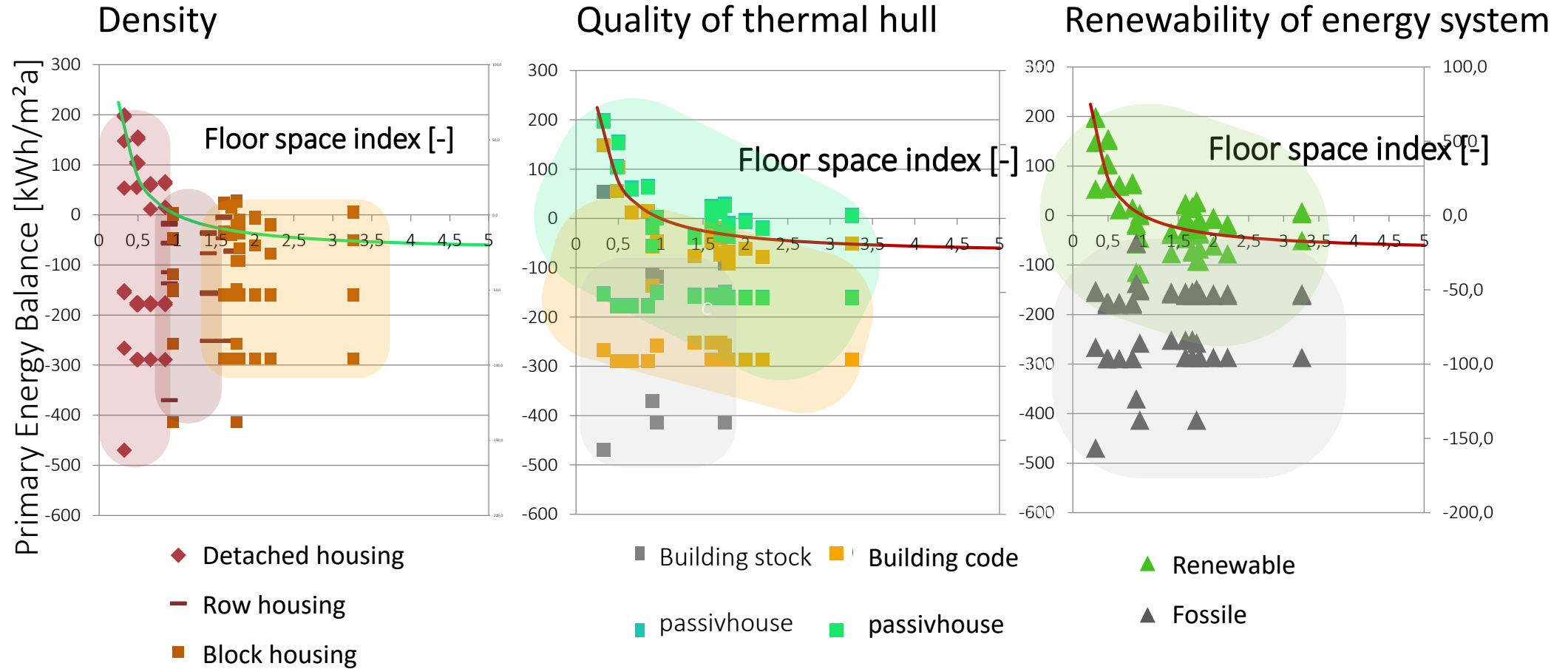
Attempting to combine top-down and bottom-up targets



Primary Energy

Zukunftsquartier approach

Predictors of building energy balance

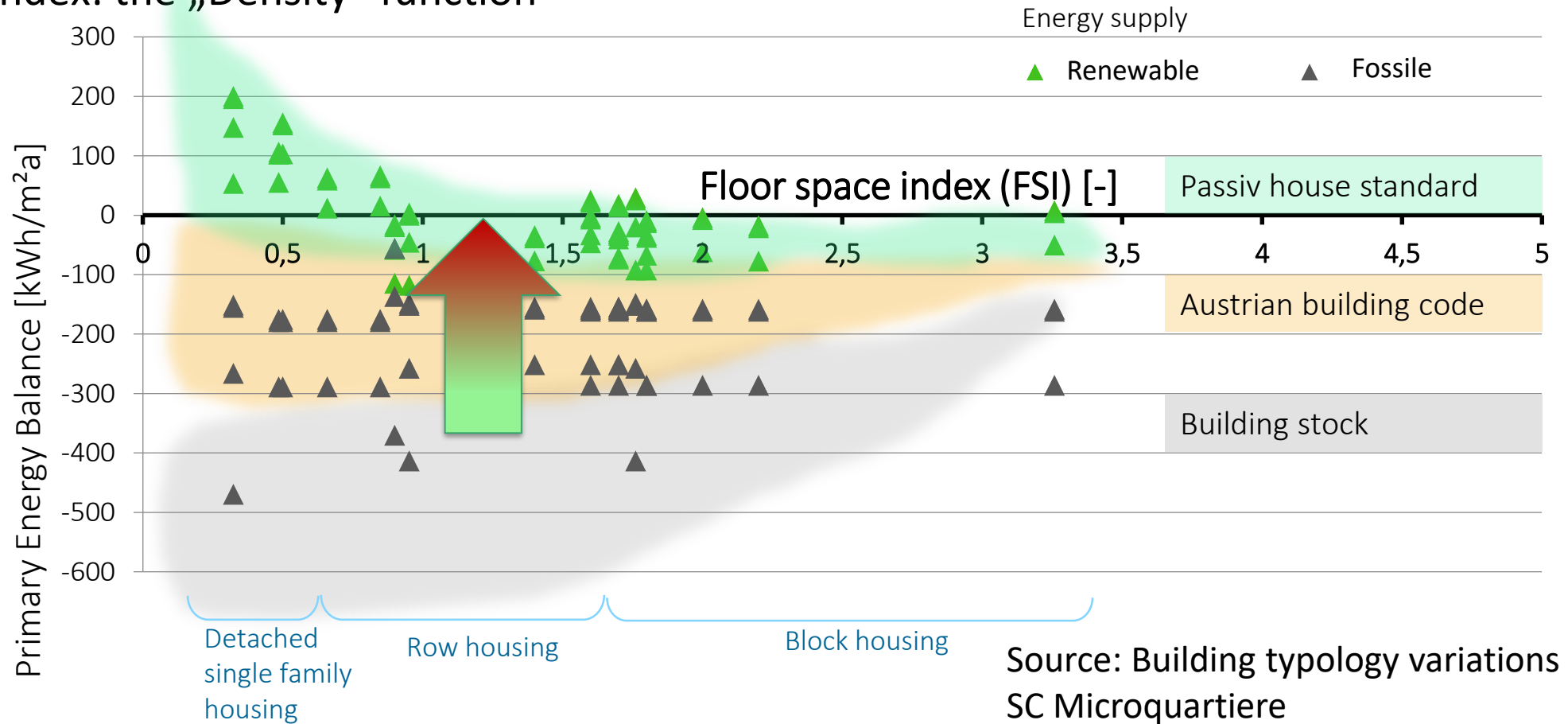


Source: Building typology variations from SC Microquartiere

Zukunftsquartier approach

3. „Density“ modulation of primary energy balance target

🏠 Floor space index: the „Density“ function



Zukunftsquartier approach

3. „Density“ modulation of primary energy balance target

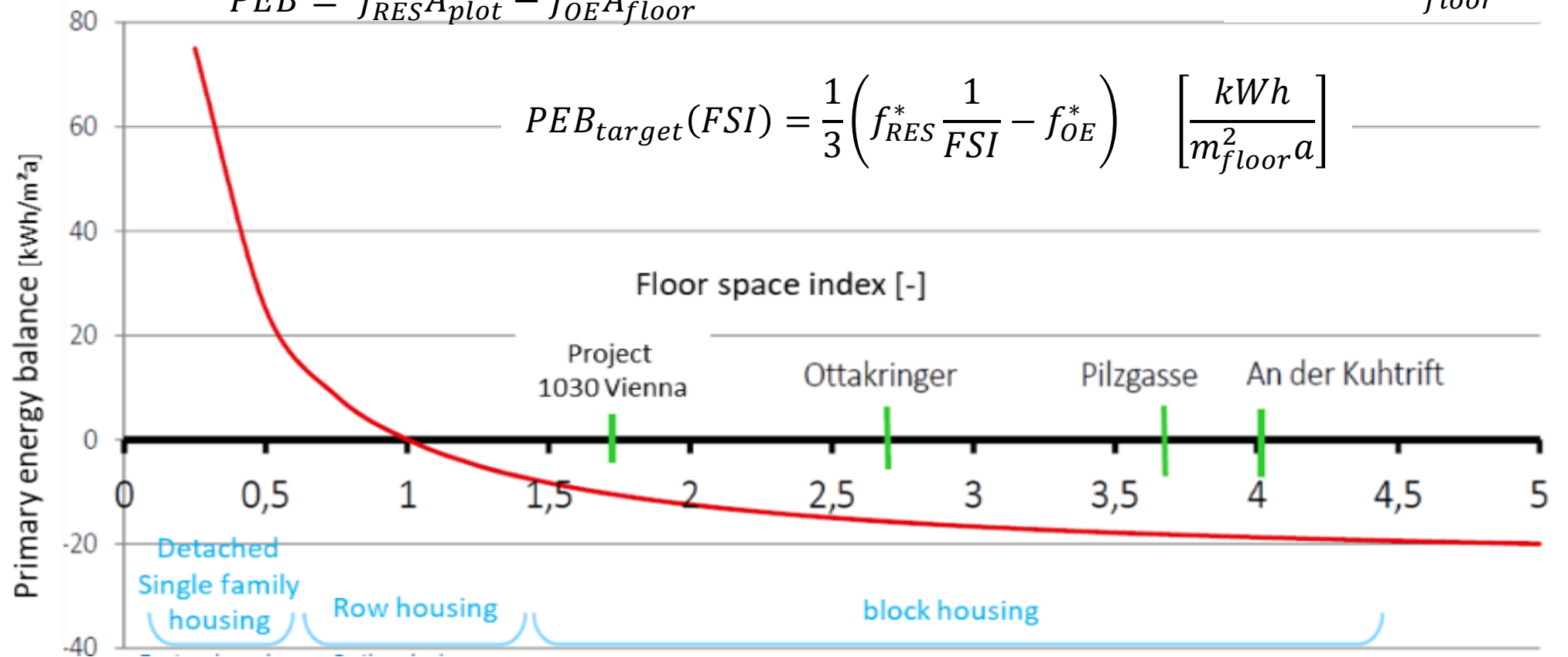
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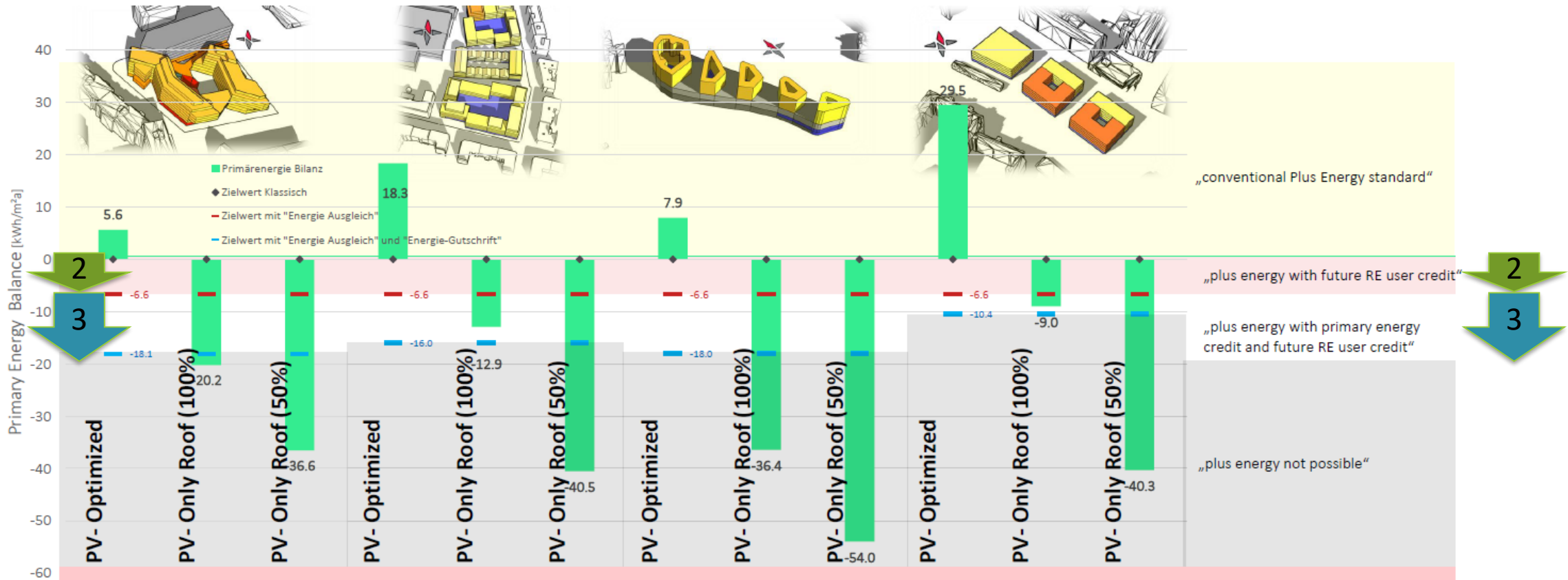
$$f_{OE}^* = 75 \frac{kWh}{m_{floor}^2 a}$$

$$PEB = f_{RES}^* A_{plot} - f_{OE}^* A_{floor}$$

$$PEB_{target}(FSI) = \frac{1}{3} \left(f_{RES}^* \frac{1}{FSI} - f_{OE}^* \right) \left[\frac{kWh}{m_{floor}^2 a} \right]$$

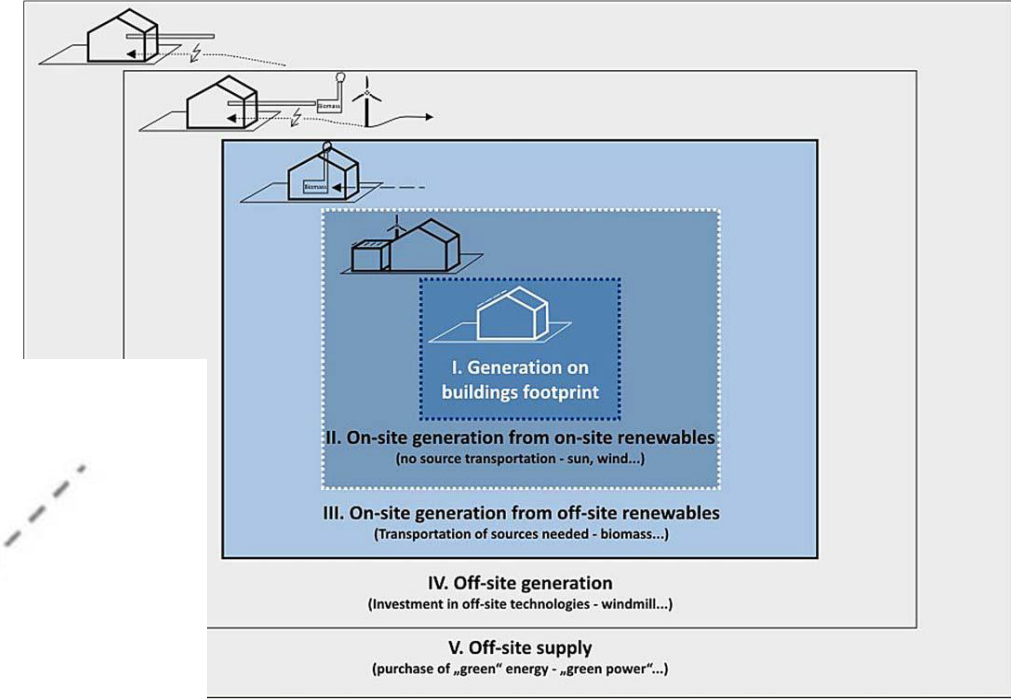
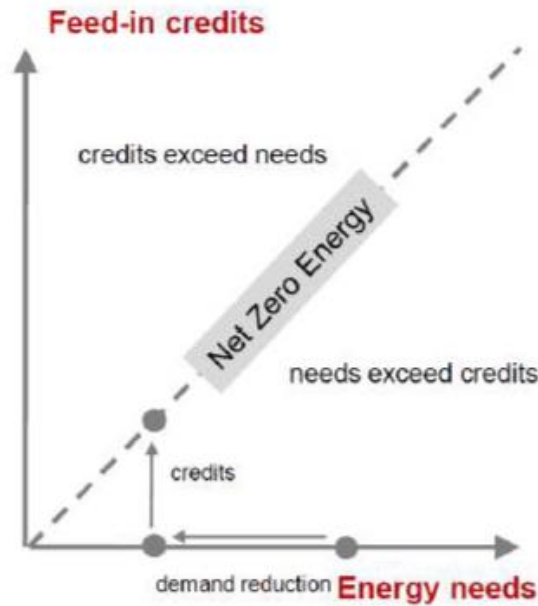
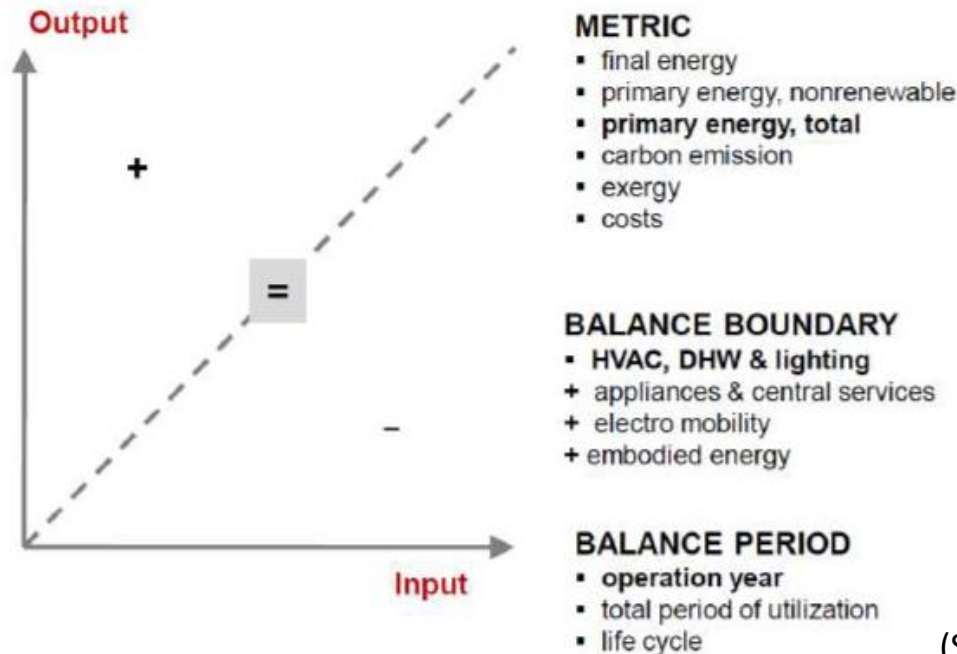


Application of modulations 1 (windpeak DSM), 2 (central RES credits per person) and 3 (PEB as function of density)



What is „positive energy“?

NZEB, PED: NO uniform /default metrics, balancing system boundary and balancing period



(Marszal et al., 2011: Varying system boundaries)

(Source: Net-Zero-Energy Solar Buildings SHC Position Paper, 2015)

Quantification: Net Zero Energy Building

🏠 System boundary: Plot

- Target value **POSITIVE** Primary Energy (PE-) balance within a year
- Mobility **NOT** included
- Plugloads & Process energy **NOT** included

Advantages:

- Clear system boundary
- Comprehensible definition
- In principal easy to measure
- Clear objective for demand and supply optimization

Disadvantages:

- Dense urban quarters **heavily disadvantaged**
- **Demand-supply mismatch** in yearly energy balance not accounted for
- No consideration of **Energy Flexibility**

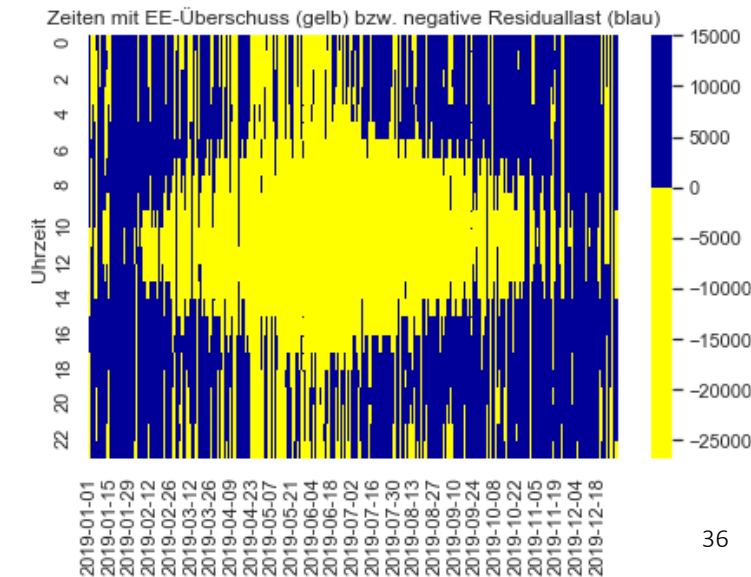
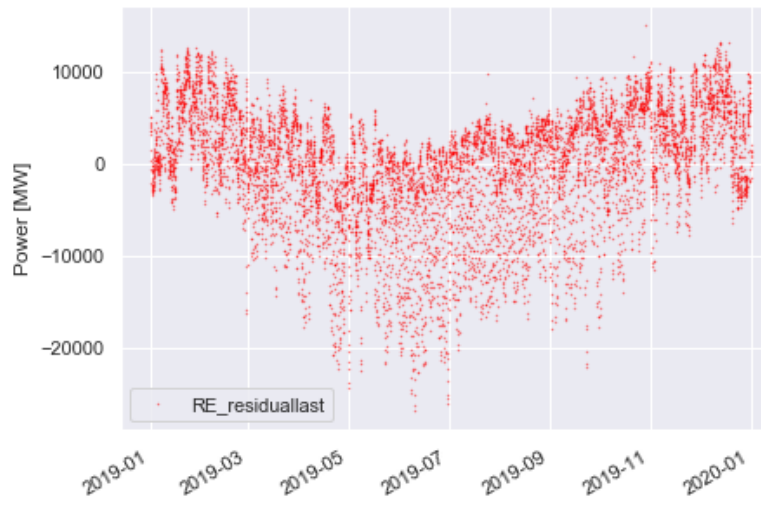
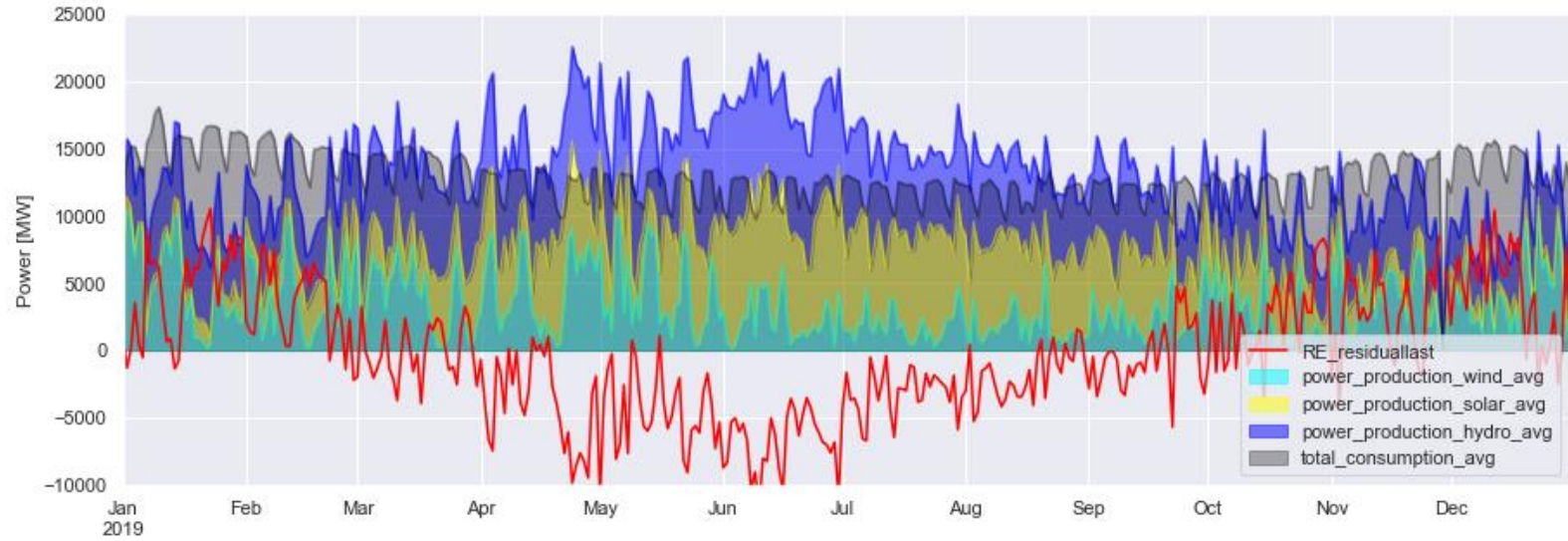
Residual load 2050

🏠 Depends on

- ▶ Future energy flexibility measures
- ▶ Future storage capacities

🏠 Correlates with CO2 Emissions

More Information @ flucco+ project



Conclusions (ii)

- 🏠 Classic Definition of Net Zero Energy Quarters in urban areas are **unfeasible**, or omit important parts of the energy balance.
- 🏠 Positive energy concepts are possible for all districts with very large PV areas that make maximum use of the roof areas and are located on the facades to a small extent.
- 🏠 Interpretated as „sustainable components of future carbon-free energy system 2050“ quarters are feasible with
 1. RES peak shaving demand side management and storage management
 2. National RES accounting and crediting for individual use
 3. Remaining primary energy target value depending on building density
- 🏠 Consideration of CO₂ eq leads to similar results.