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

IEA EBC Technical Day 24.6.2020

Simon Schneider

Competence team for liveable Positive Energy Districts

Research group Sustainable buildings and cities

Projects

Zukunftsquartier

Exploration project

Duration: 12 months (07/18 – 06/19)

Funding: Bundesministerium Verkehr, Innovation und Technologie

Partners: urban innovation vienna, FH Technikum Wien, Institute of Building Research & Innovation ZT-GmbH

Zukunftsquartier 2.0

Demonstration

Duration: 36 months (09/19 – 08/21)

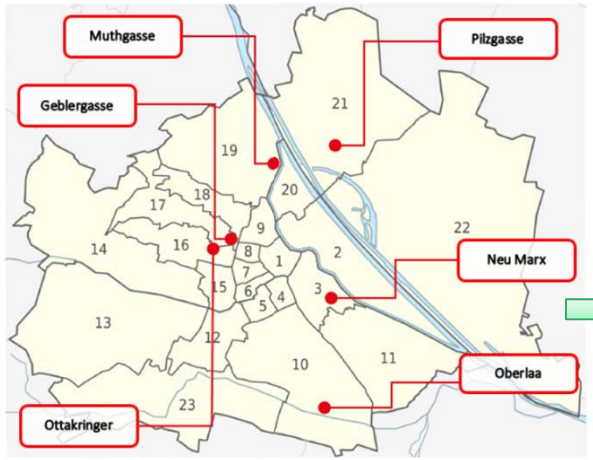
Funding: Bundesministerium Verkehr, Innovation und Technologie

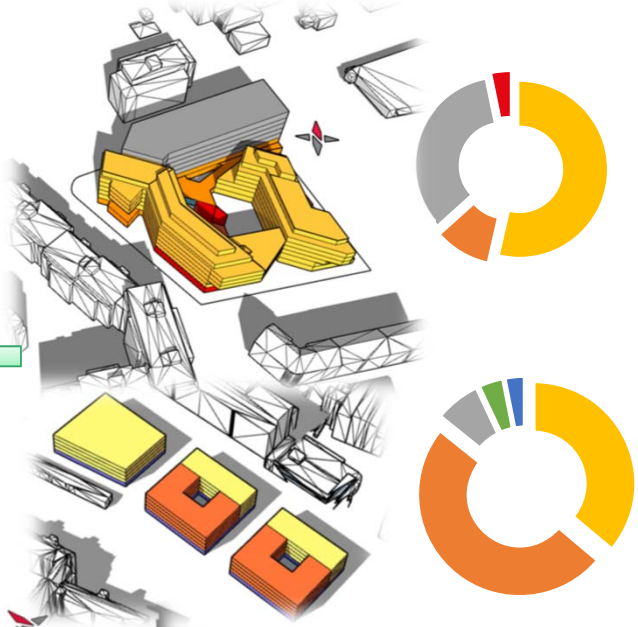
Partners: urban innovation vienna, FH Technikum Wien, Institute of Building Research & Innovation ZT-GmbH, SUBA, BÖHM, HaCon

Project goals

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

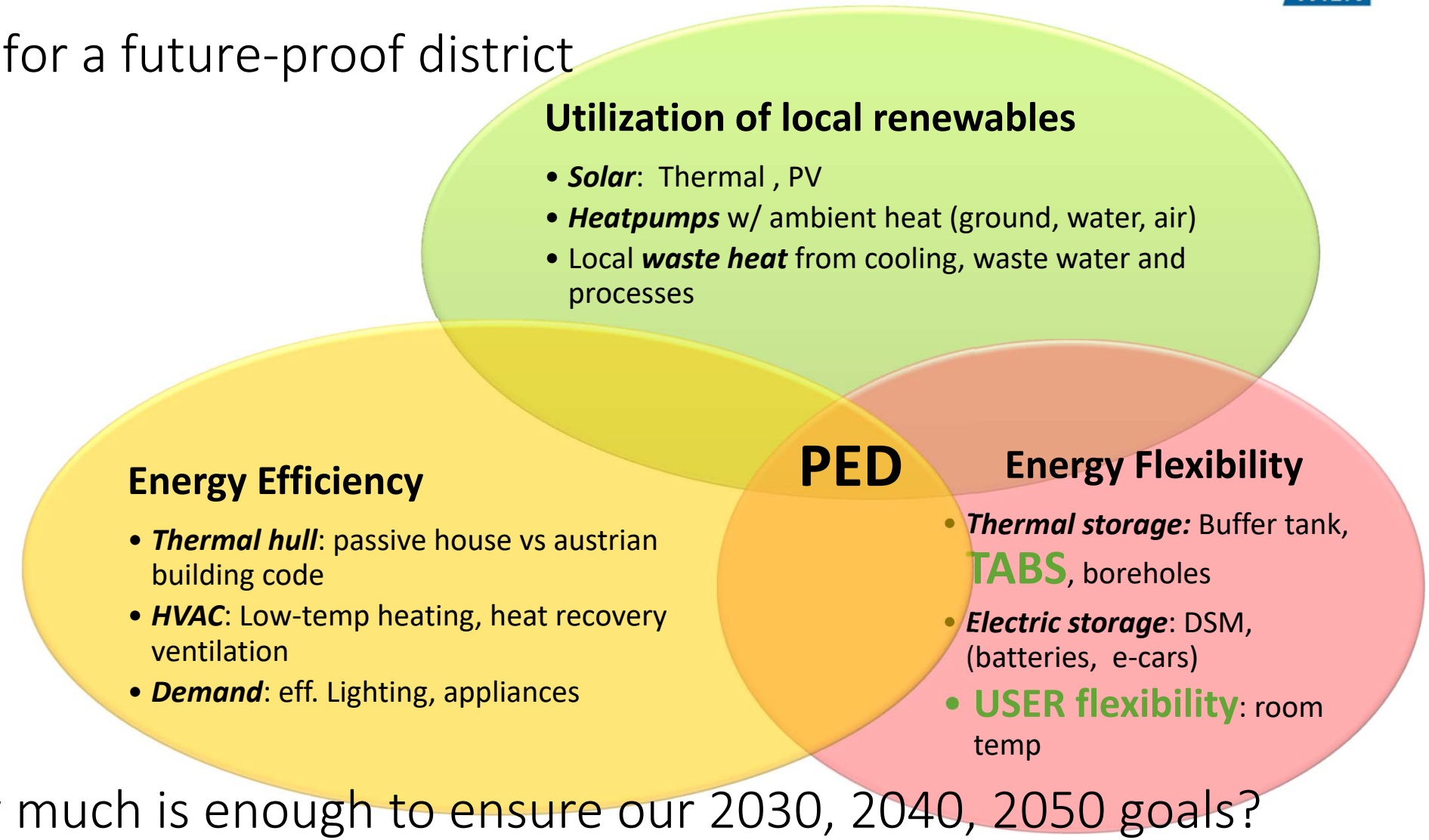
Exploration of **5 possible sites** with 20 – 32.000 m² useable floor area w/ mixed use





Usage mix:

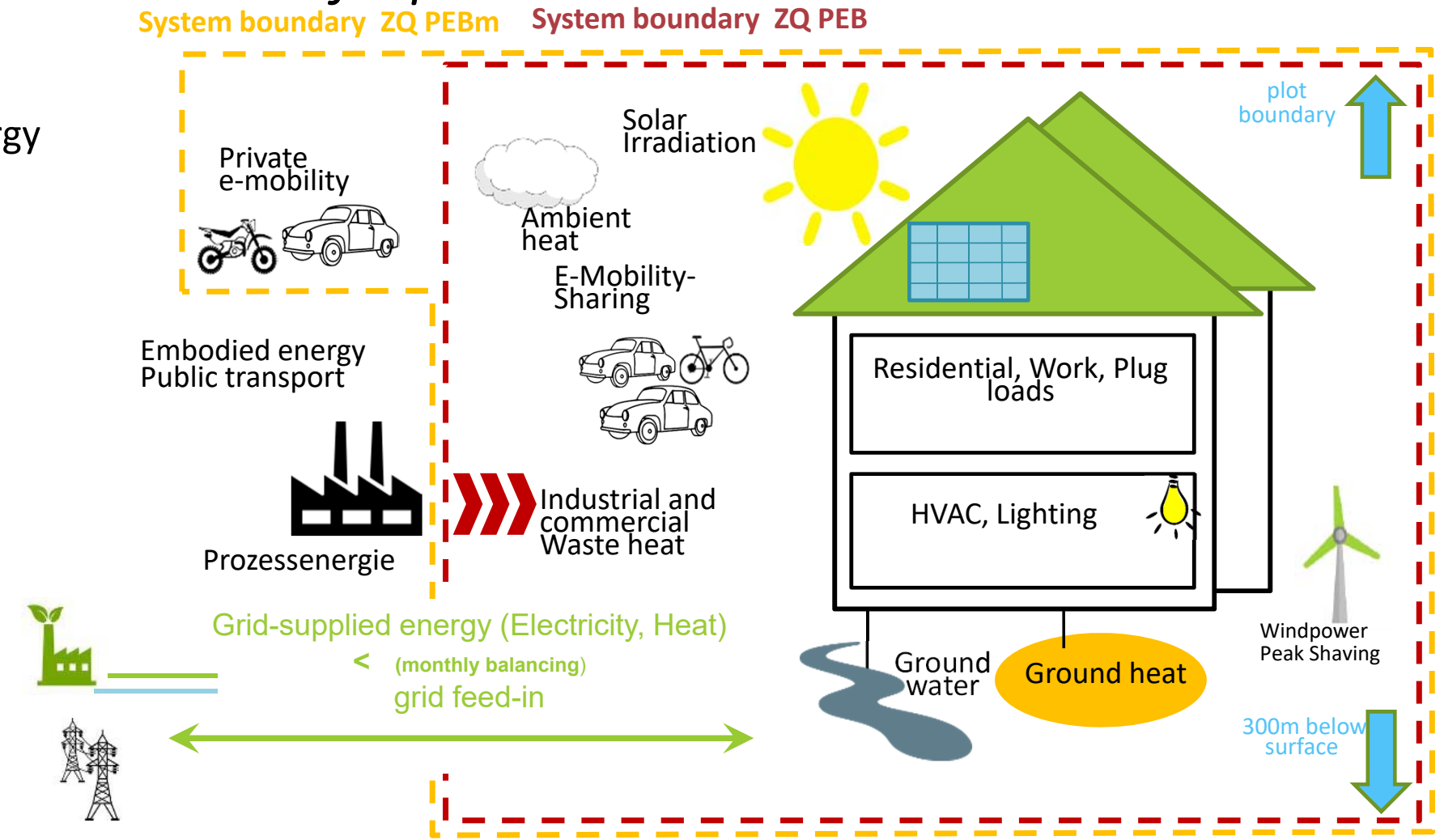
3 Pillars for a future-proof district



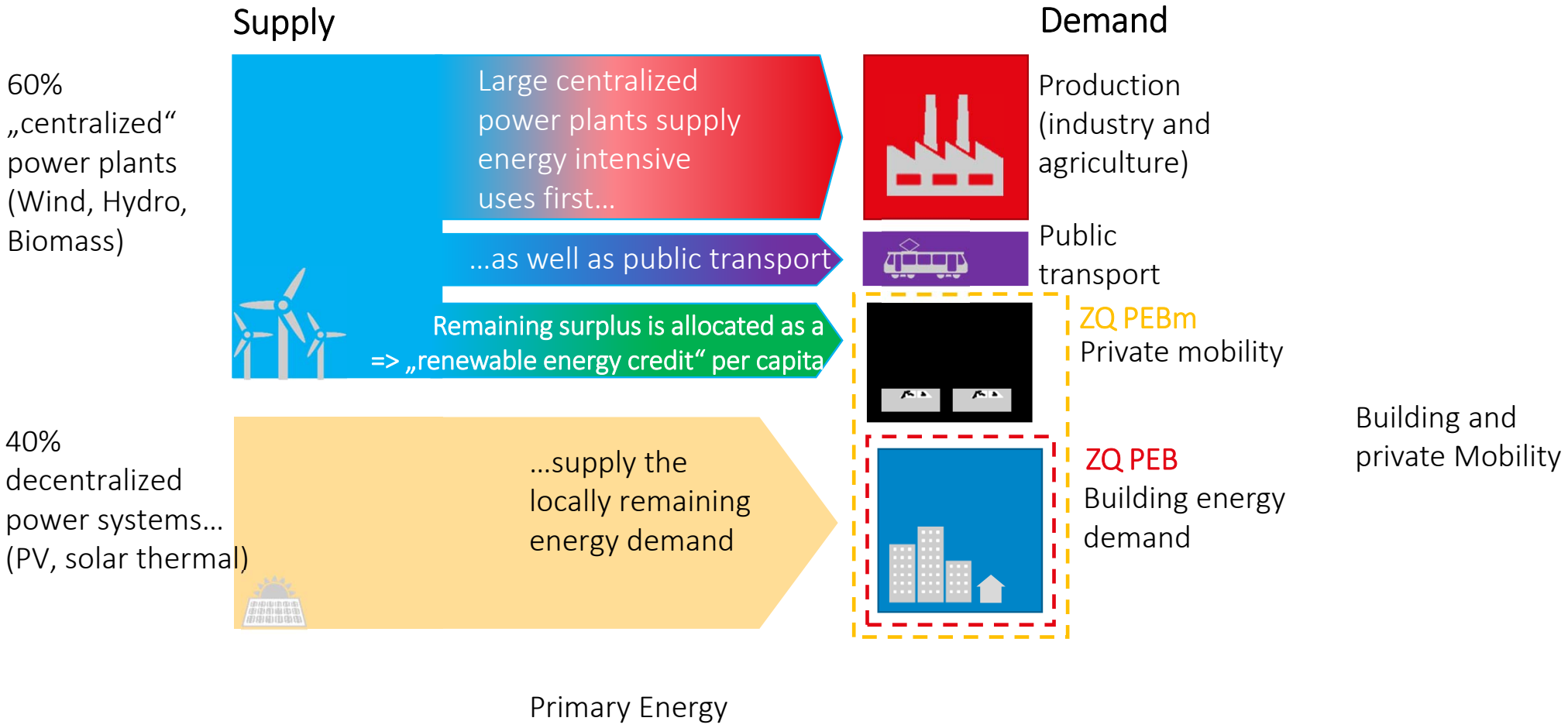
But how much is enough to ensure our 2030, 2040, 2050 goals?

System boundaries *Zukunftsquartier*

Includes all energy services onsite

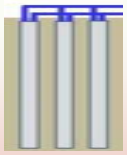


Attempting to combine top-down and bottom-up targets



Development and simulation of grid supportive energy management

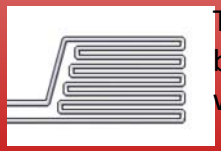
Storage capabilities provided by components:



Borehole field
„Earth coffer “

Centralized
buffer tank

Decentralized
domestic hot
water tank



Thermalyl activated
building system
w/floor heating

Thermal

Battery

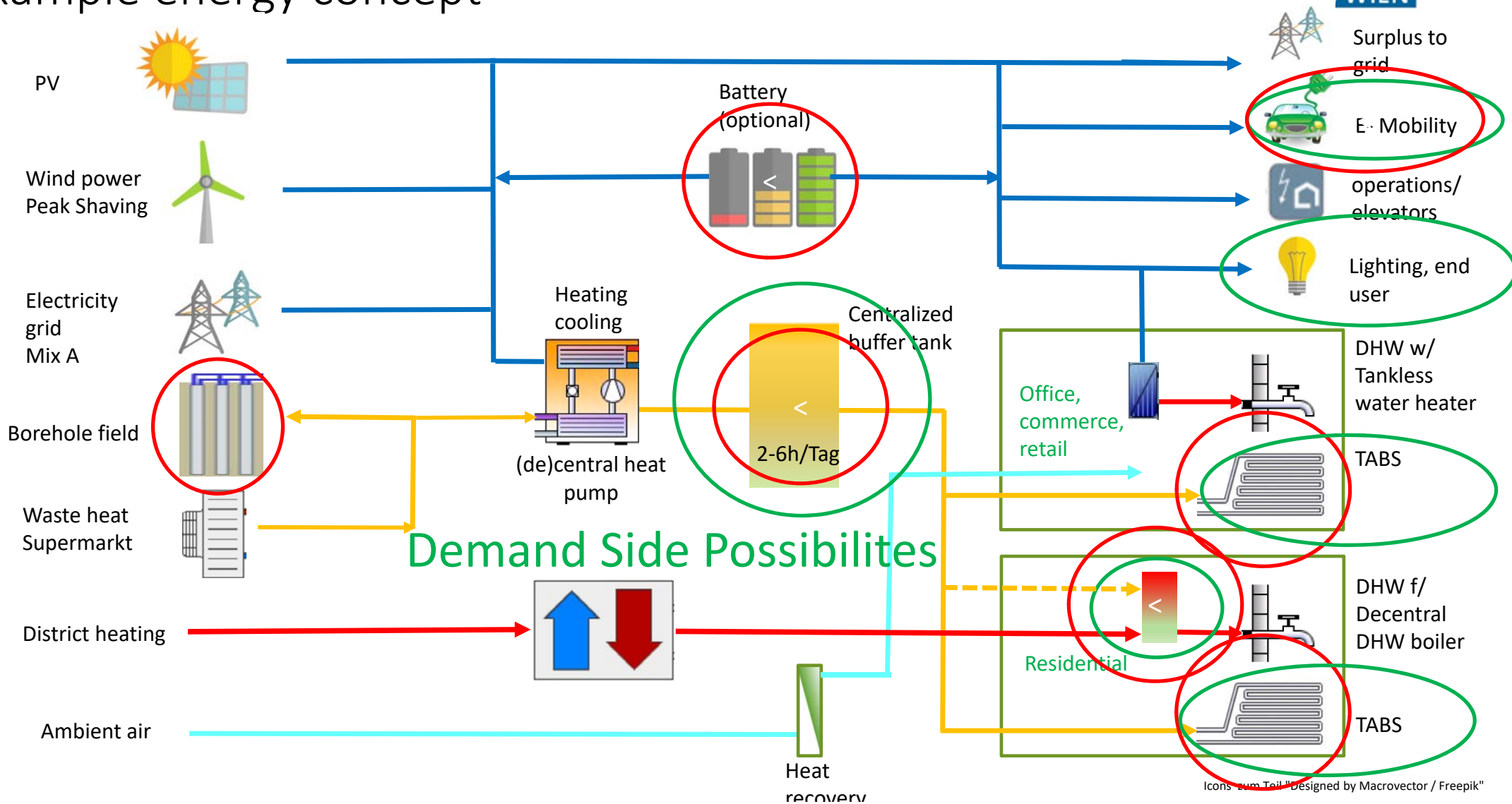
E- Mobility

Electrical

Hydrogen

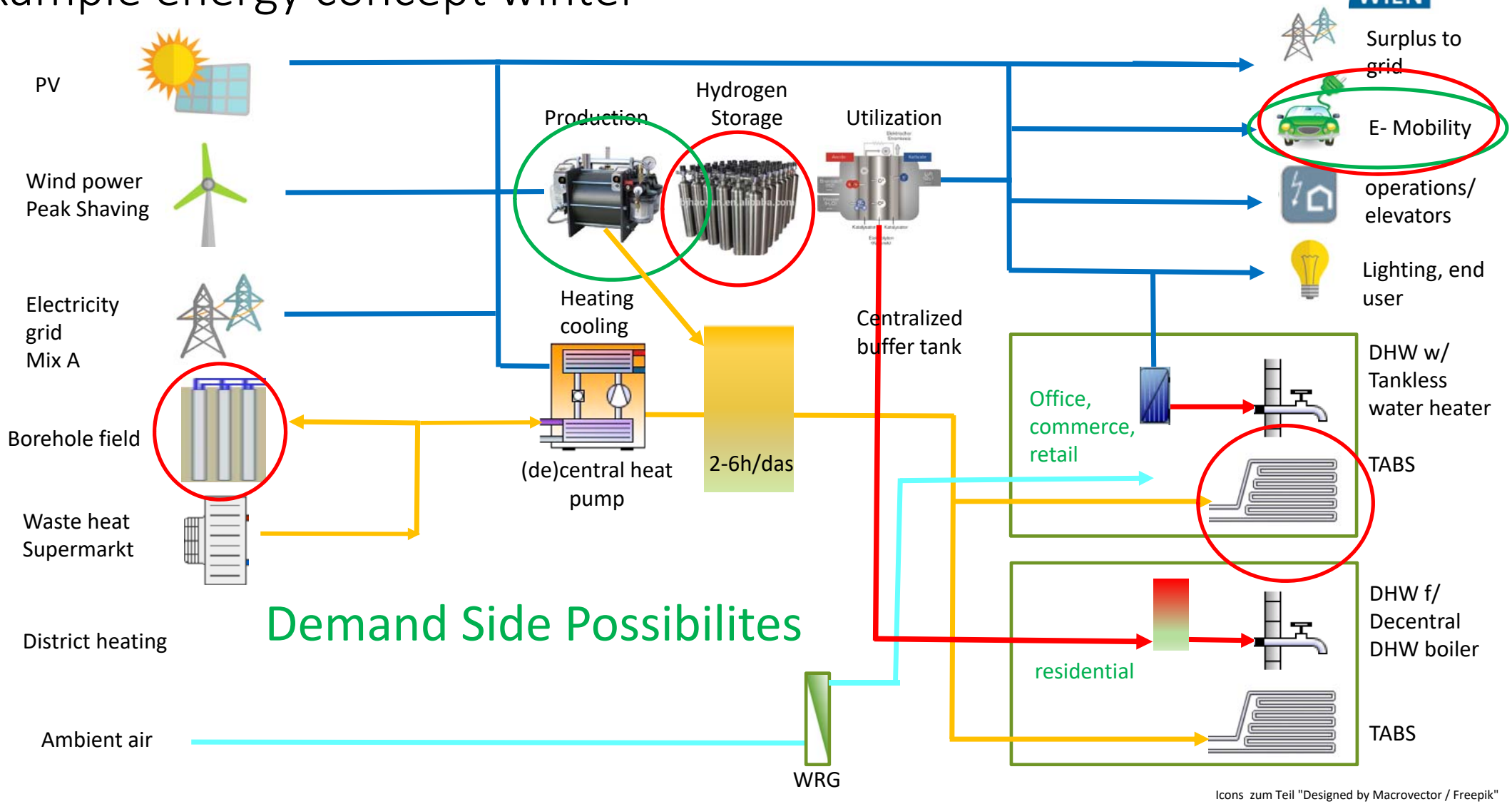
Chemical

Example energy concept



Icons zum Teil "Designed by Macrovector / Freepik"

Example energy concept winter

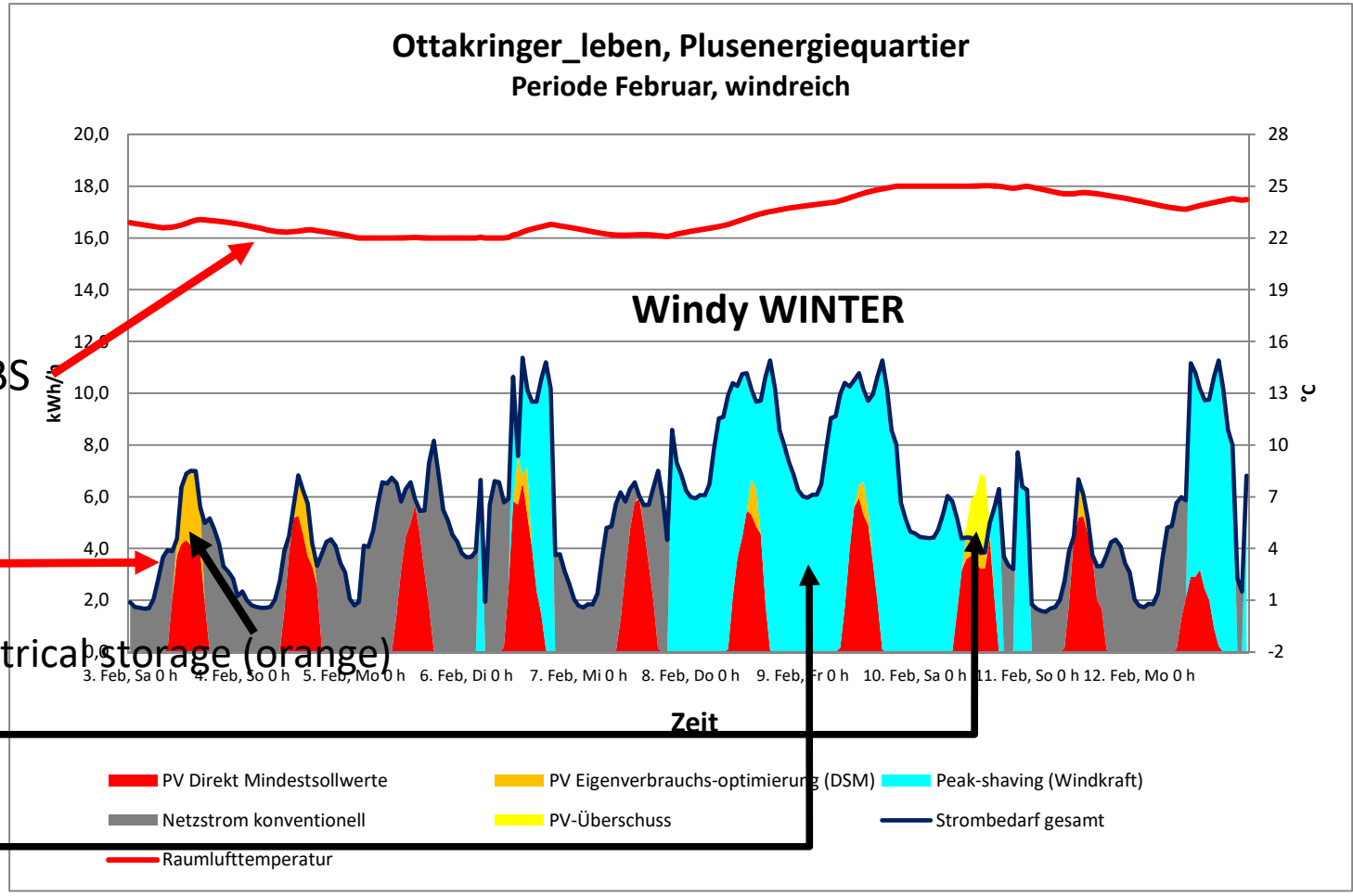


Icons zum Teil "Designed by Macrovector / Freepik"

Zukunftsquartier approach

Direct utilization of otherwise unuseable RES power peaks (DSM)

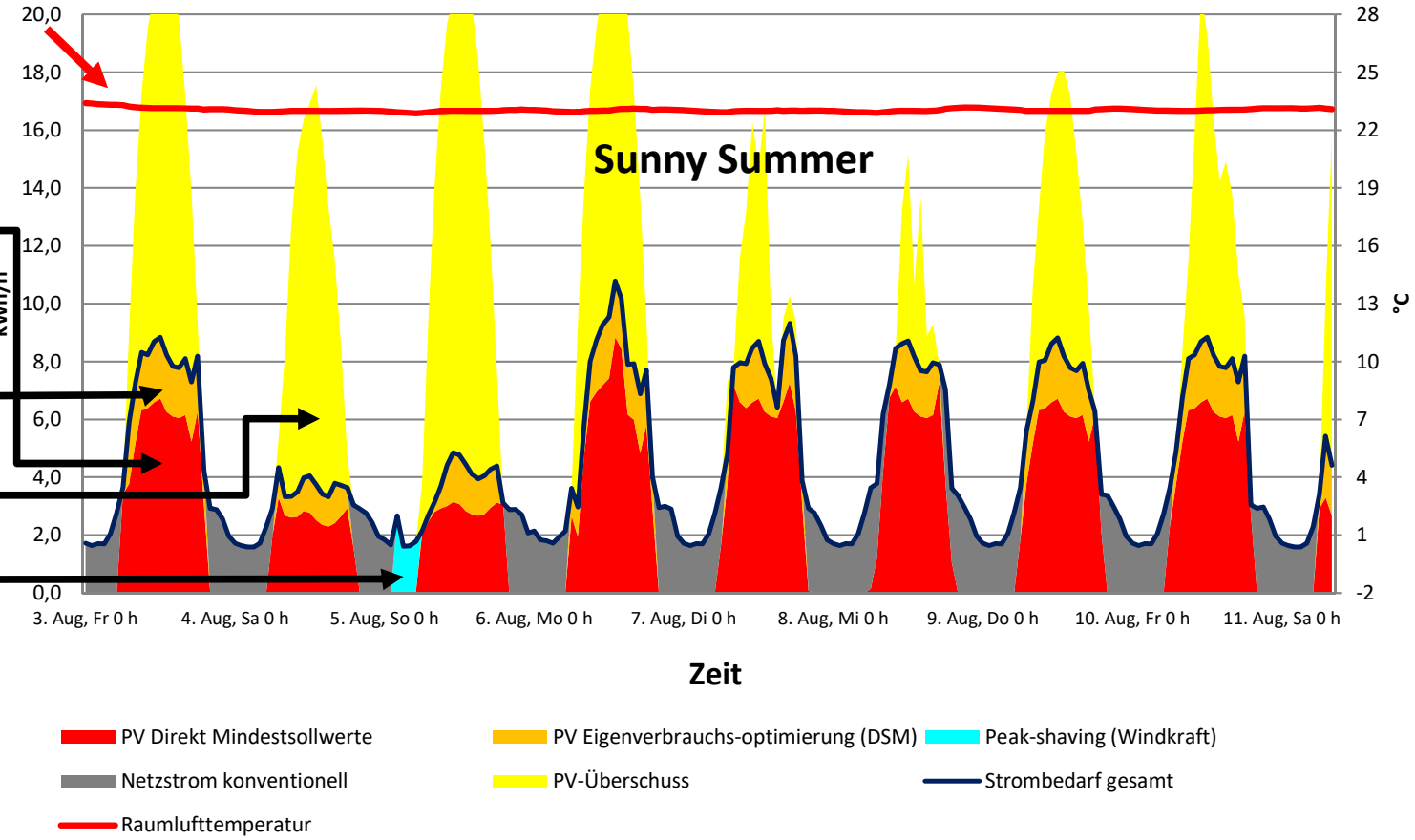
- USER FLEXIBILITY:
  - Max. 25°C in winter
  - Min. 23°C in summer
  - Over-Heating/cooling of TABS
- RES sources
  - PV Direct use (red)
  - PV Loading of thermal and electrical storage (orange)
  - PV Grid infeed (yellow)
  - Wind peak shaving (cyan)



Zukunftsquartier approach

Utilization of PV excess instead of grid infeed

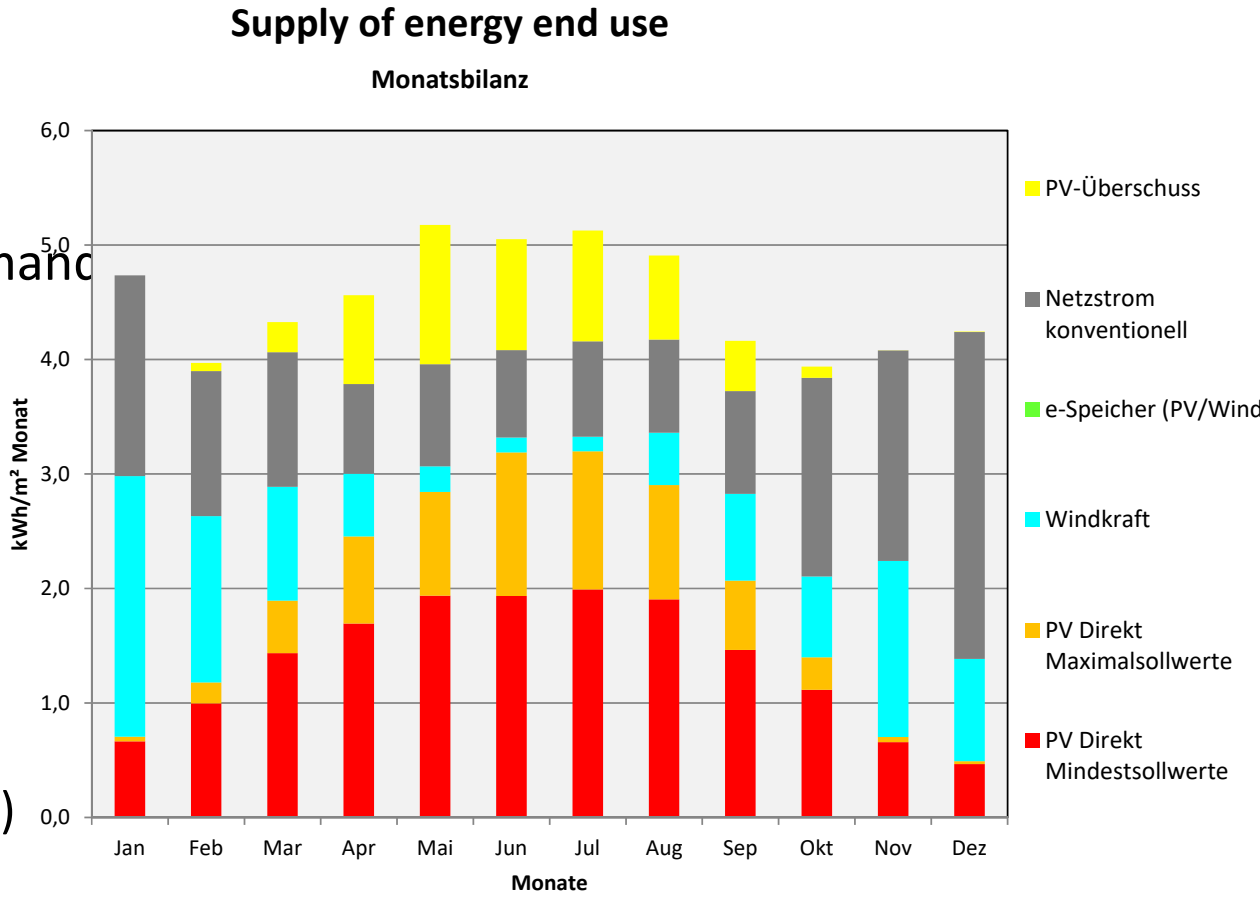
- Room temp (thermal storage)
- RES DSM
  - PV Direct use (red)
  - PV Loading of thermal and electrical storage (orange)
  - PV Grid infeed (yellow)
  - Wind peak shaving (cyan)



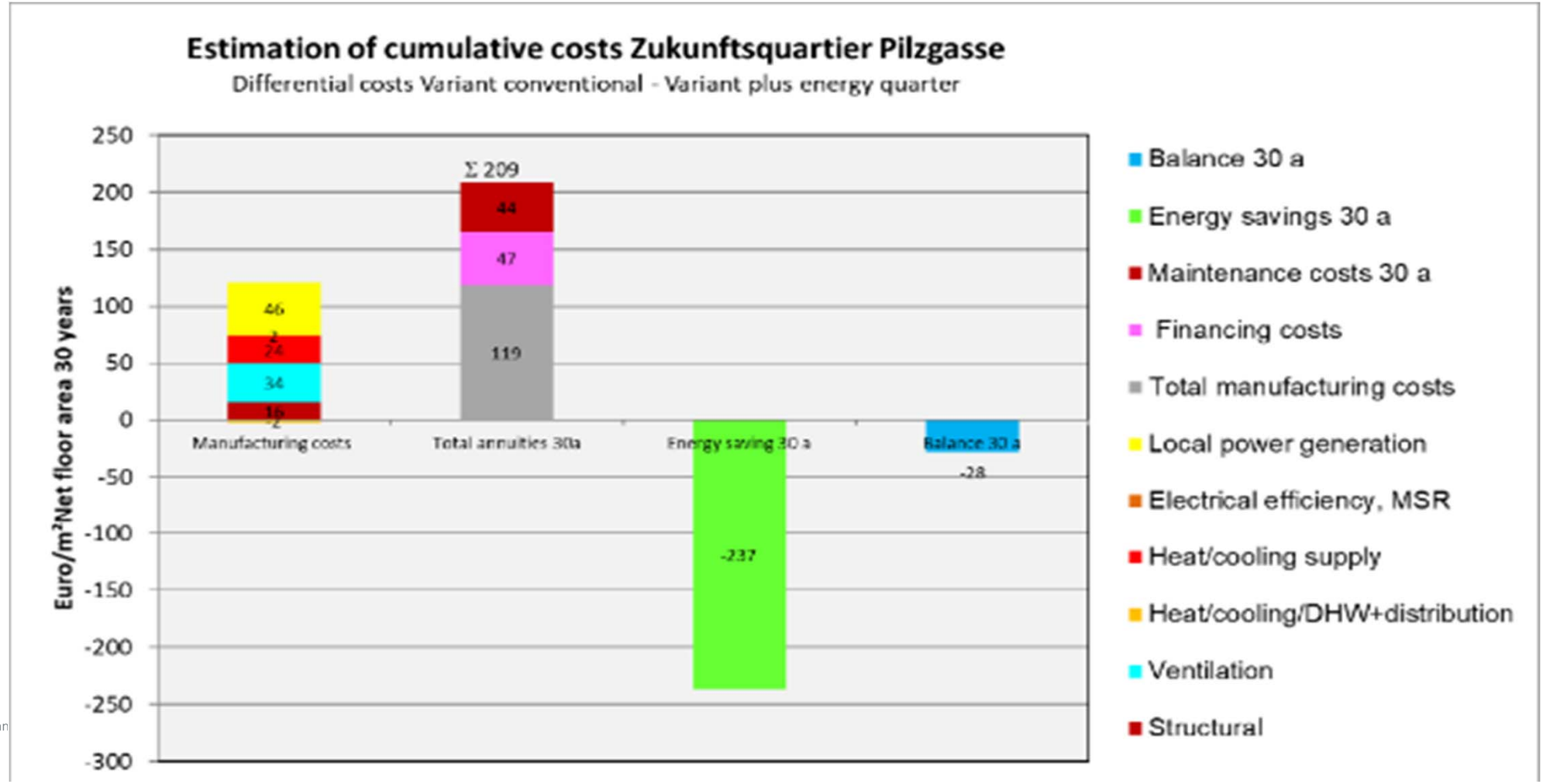
Zukunftsquartier approach

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)



Differential life cycle costs o/ 30 years are positive!



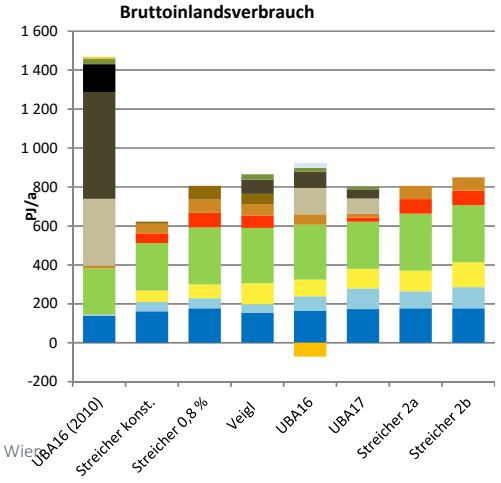
Conclusions (i)

- 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.

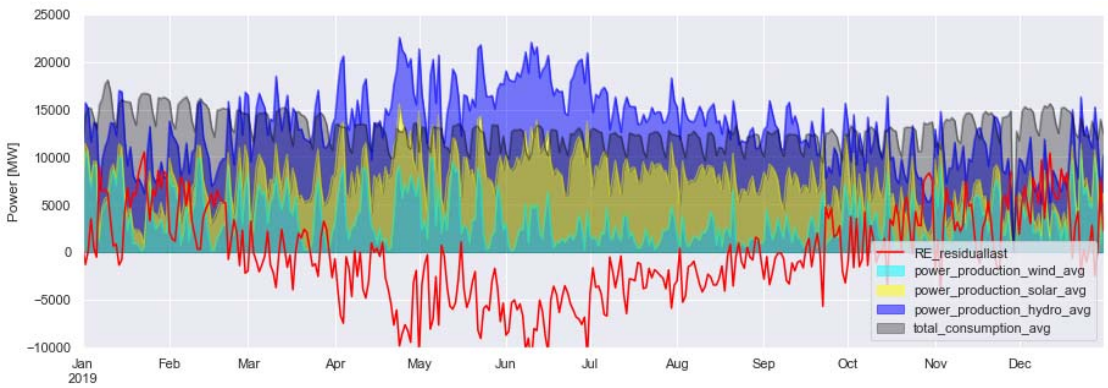
Next step: Hourly resolution of future scenarios:
Flucco+ research project
Future carbon and grid-supporting signals for hourly positive energy districts

- 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



Subhourly Supply, demand and carbon emission signals



Thank you for your attention!

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Research group Sustainable buildings and cities

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Further Information

Project Zukunftsquartier

Projekct Zukunftsquartier 2.0

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Team

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

Zukunfts Quartier 2.0

FFG Forschung wirkt.

klima+ energie fonds

HaCon

BÖHM

SUBA

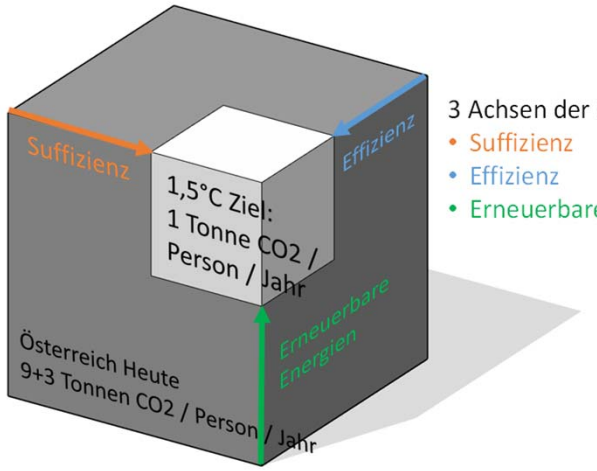
Zukunfts Quartier

urban innovation vienna

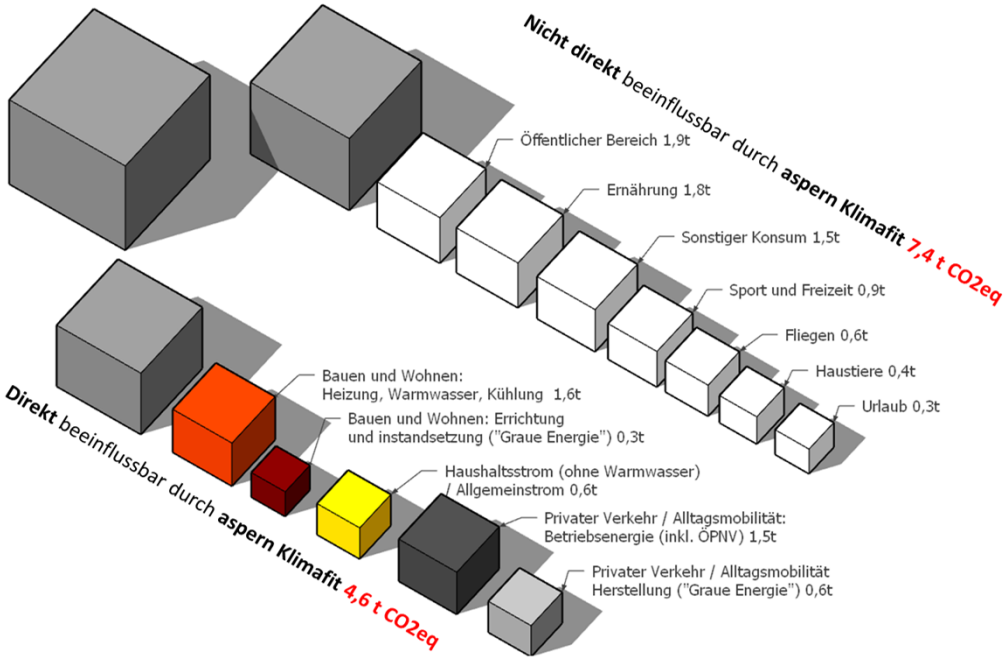
Institute of Building Research & Innovation ZT-GmbH

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)



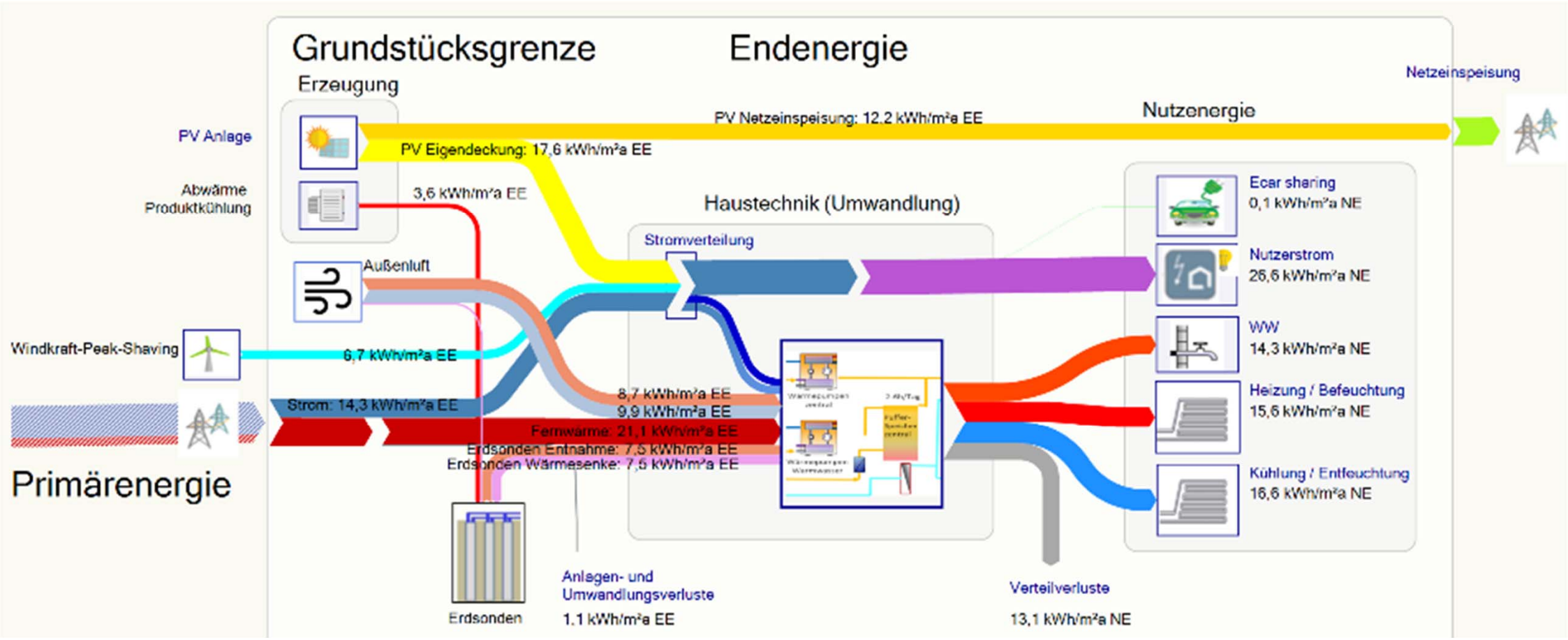
3 Achsen der CO2-Reduktion:
- Suffizienz
- Effizienz
- Erneuerbare Energien



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)

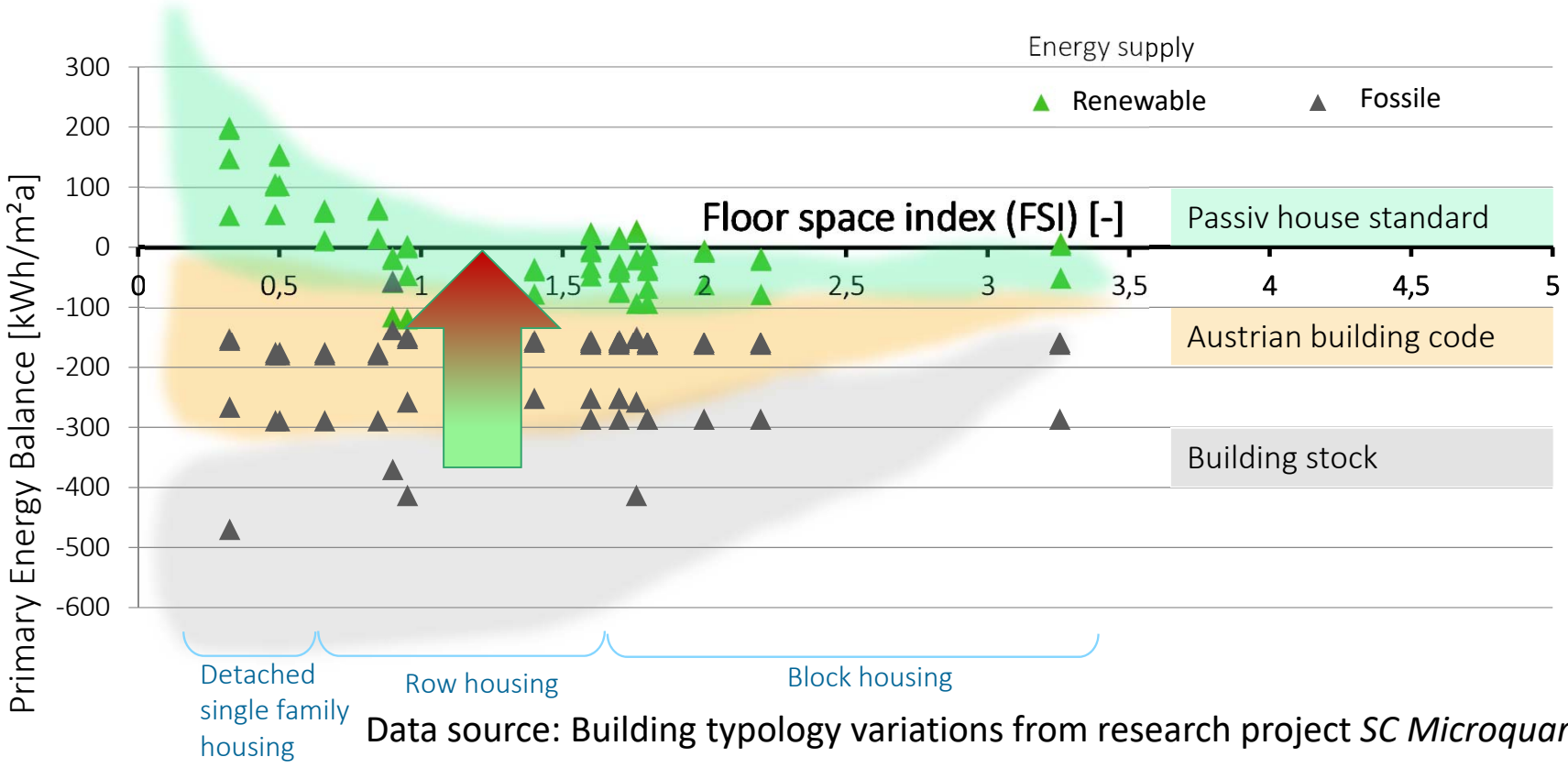
Example energy flow and system boundary



Zukunftsquartier approach

„Density“ modulation of primary energy balance target

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



Data source: Building typology variations from research project *SC Microquartiere*

Zukunftsquartier approach

„Density“ modulation of primary energy balance target

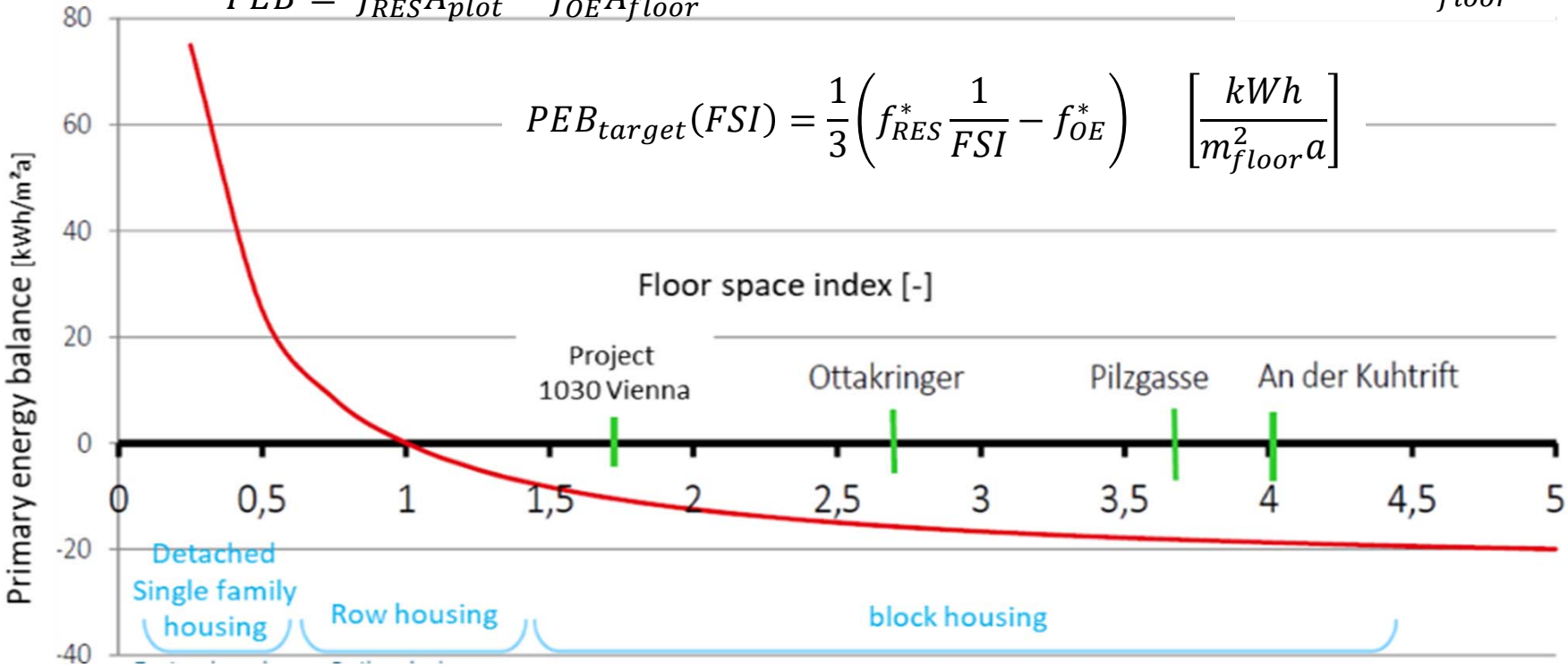
$$f^*_{RES} = 75 \frac{kWh}{m^2_{plot} a}$$

$$f^*_{OE} = 75 \frac{kWh}{m^2_{floor} a}$$

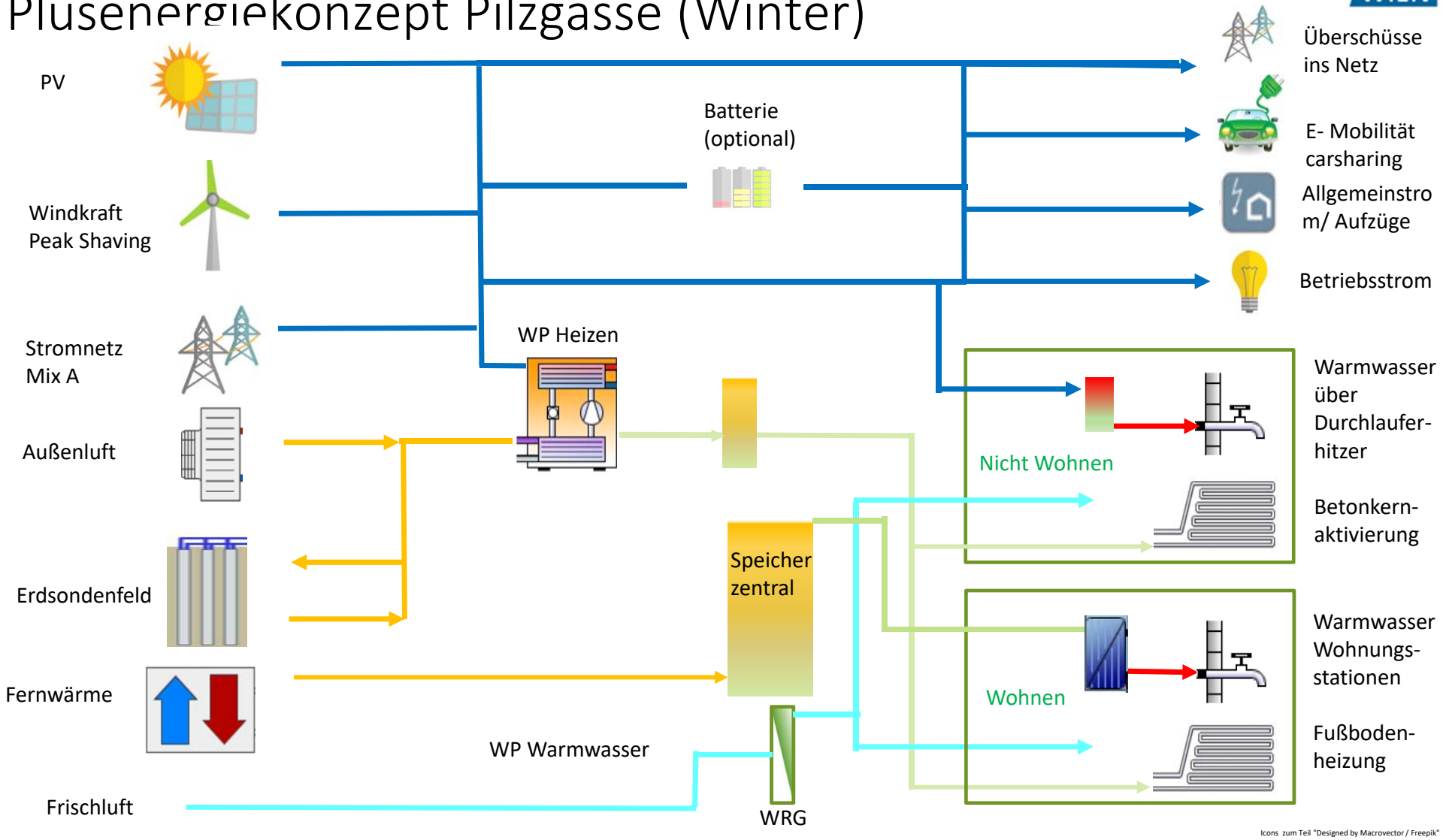
- Target value as a function of the floor space index

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

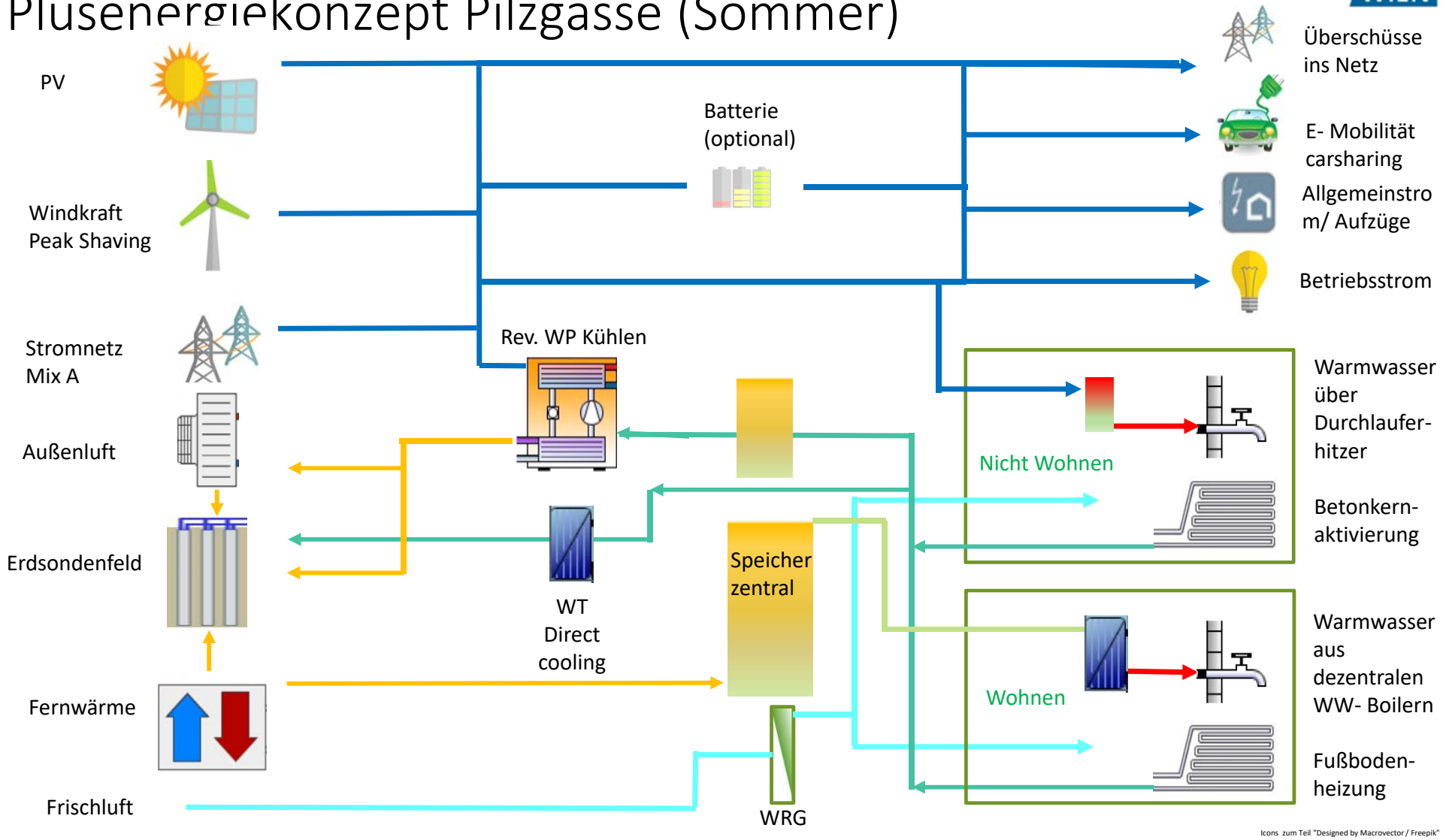
$$PEB_{target}(FSI) = \frac{1}{3}\left(f^*_{RES} \frac{1}{FSI} - f^*_{OE}\right) \quad \left[\frac{kWh}{m^2_{floor} a}\right]$$



Plusenergiekonzept Pilzgasse (Winter)



Plusenergiekonzept Pilzgasse (Sommer)



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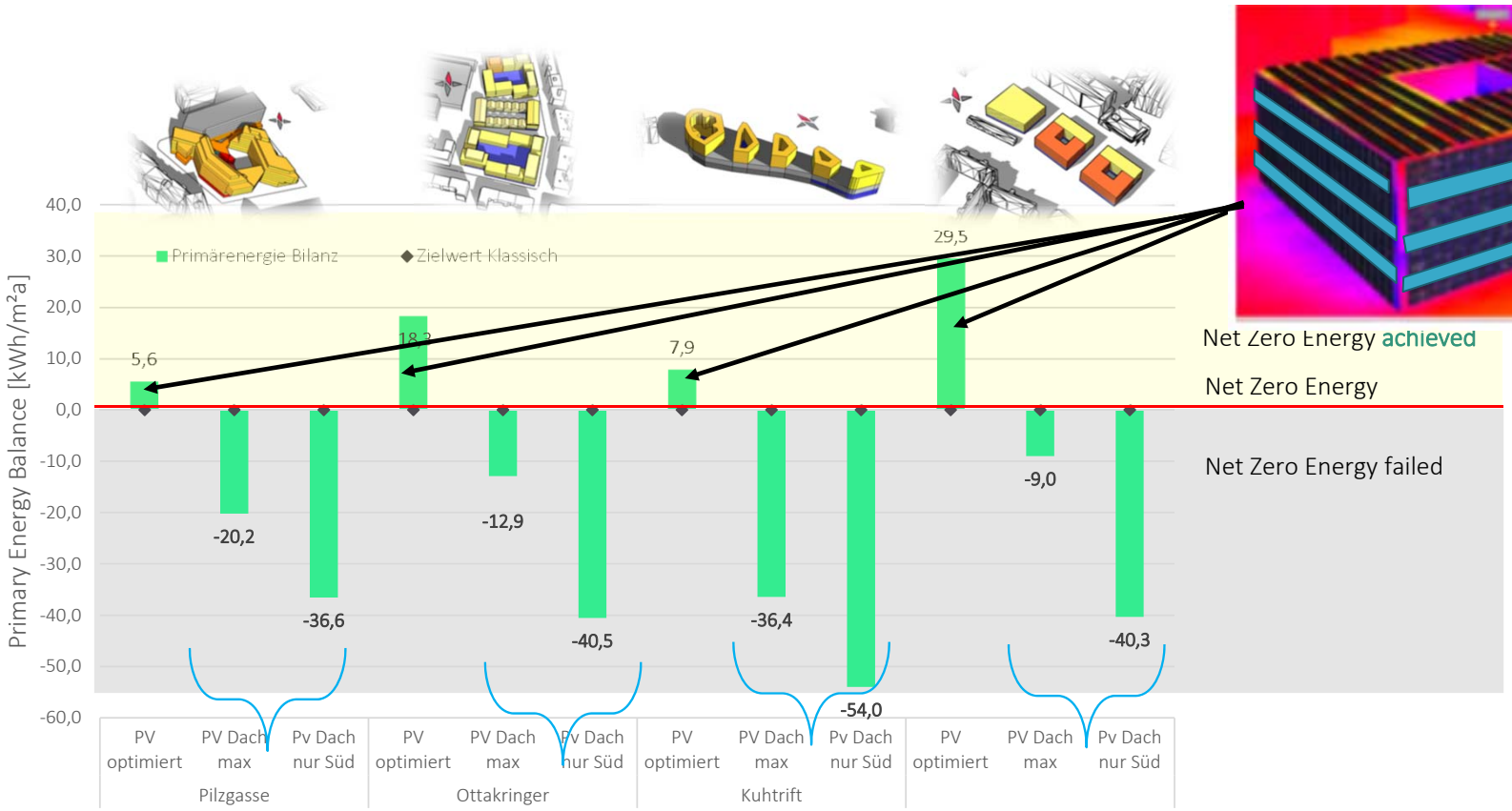
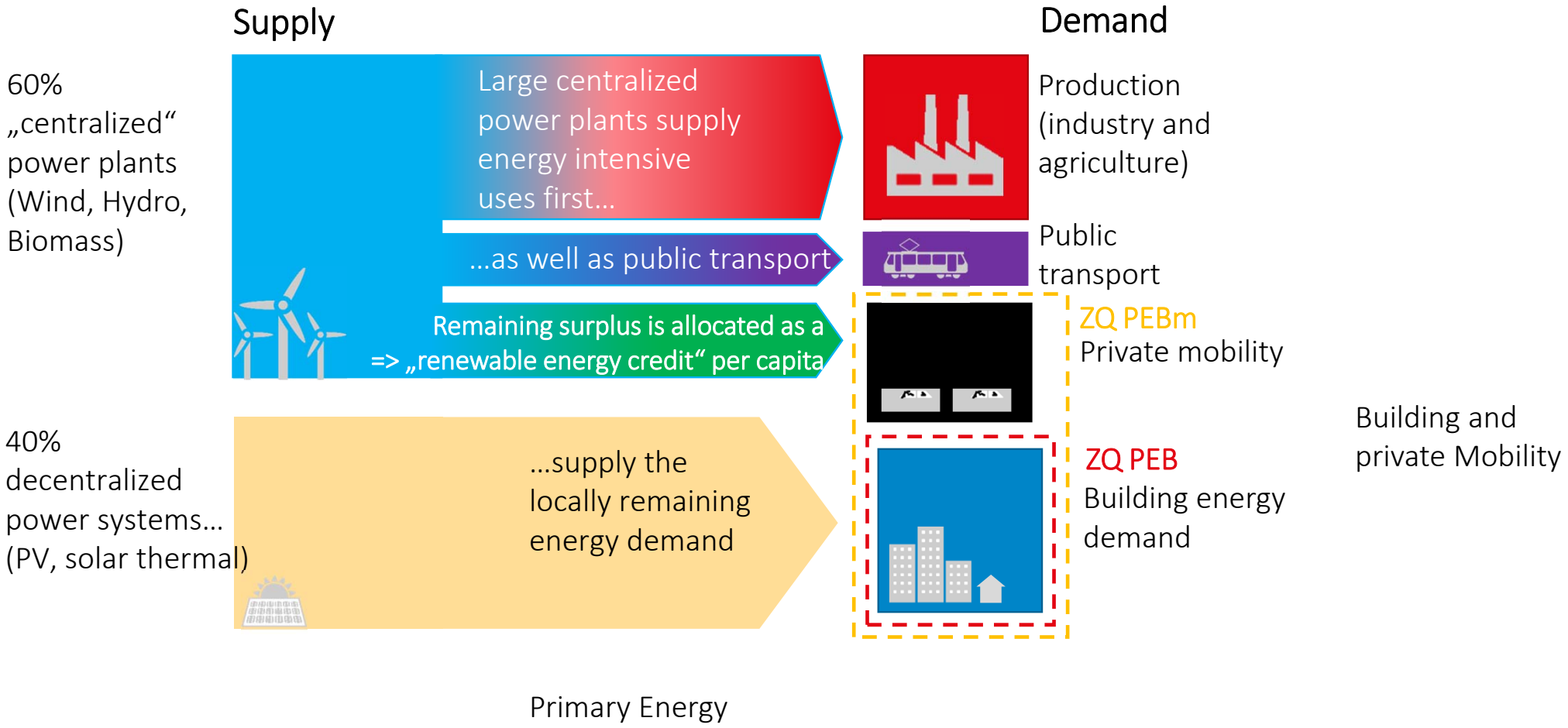
However: „Classic“ Net zero energy balance remains unfeasible for dense projects for all but „pv-enveloped“ buildings



Entire building Envelope needs to be **Photovoltaic**

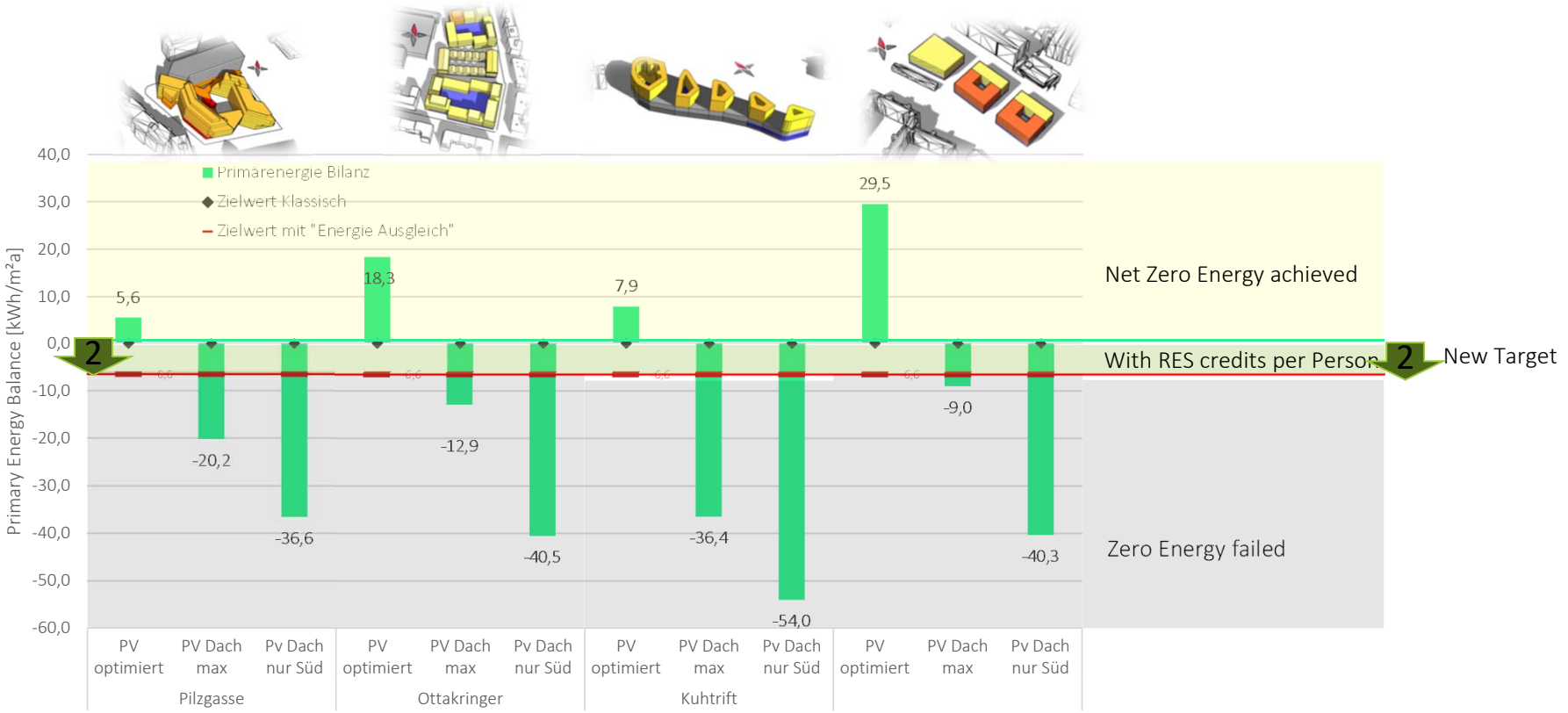
Feasibility of moderate PV utilization (50 – 100% of roof surfaces)

Attempting to combine top-down and bottom-up targets



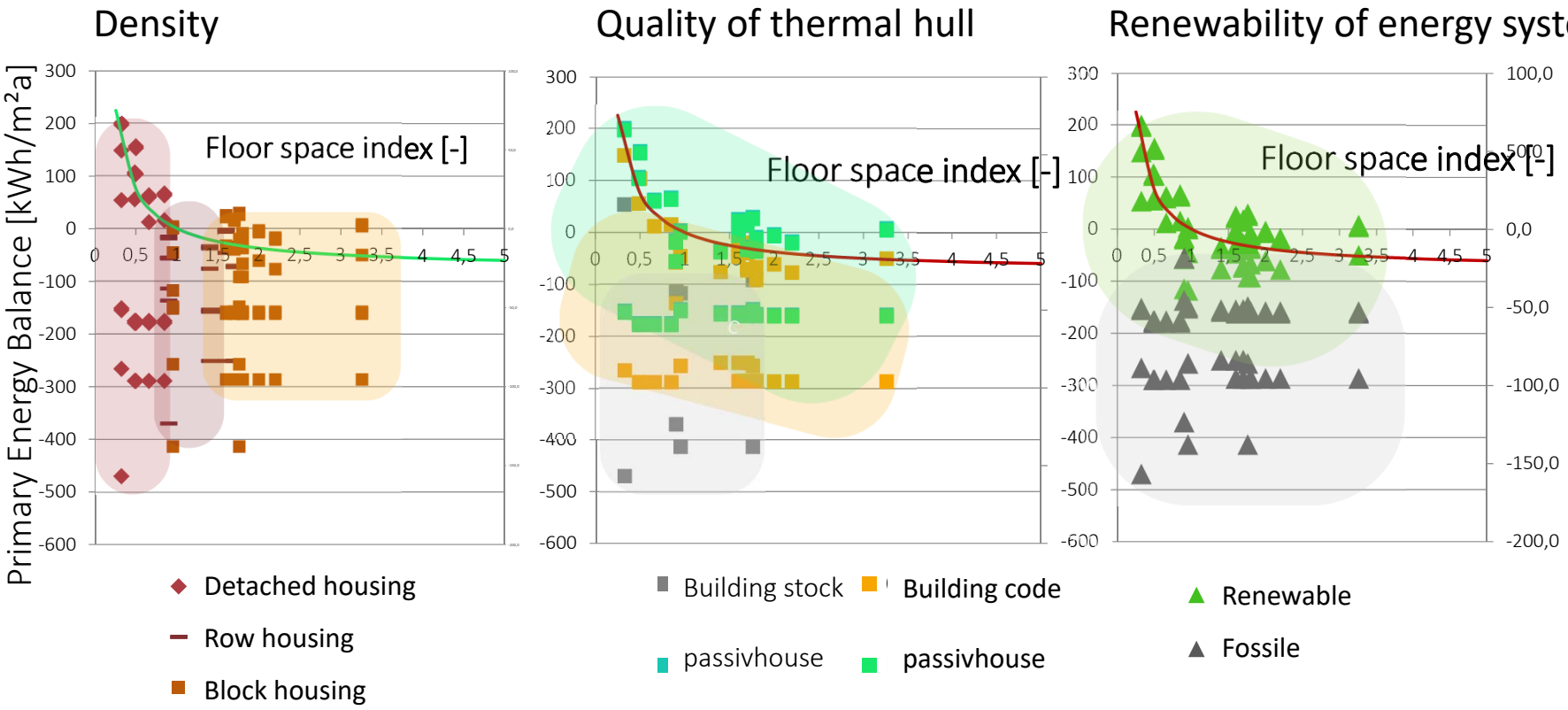
Zukunftsquartier approach

2. RES credits per Person (rather than per area) promotes density



Zukunftsquartier approach

Predictors of building energy balance

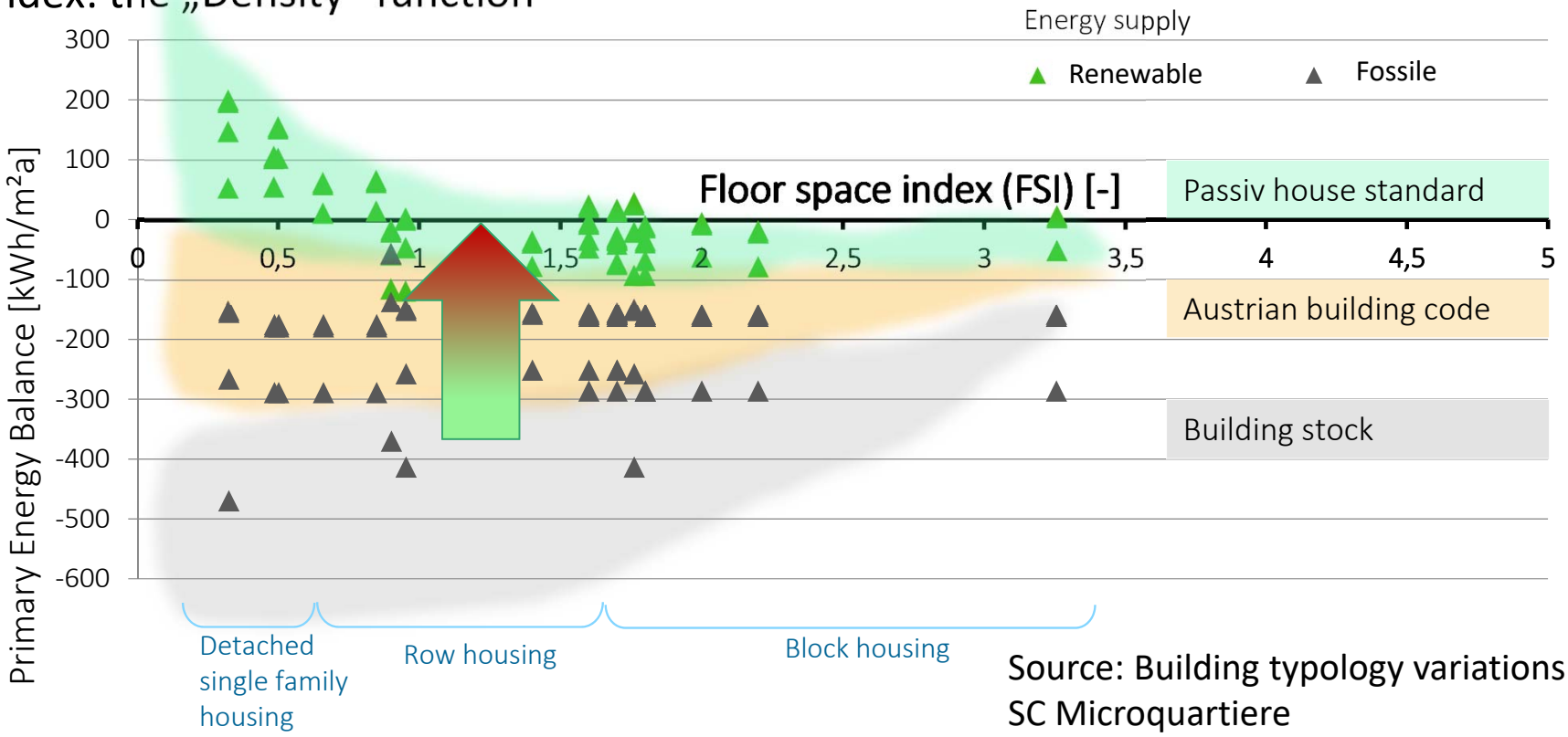


Source: Building typology variations from SC Microquartiere

Zukunftsquartier approach

3. „Density“ modulation of primary energy balance target

- Floor space index: the „Density“ function



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Zukunftsquartier approach

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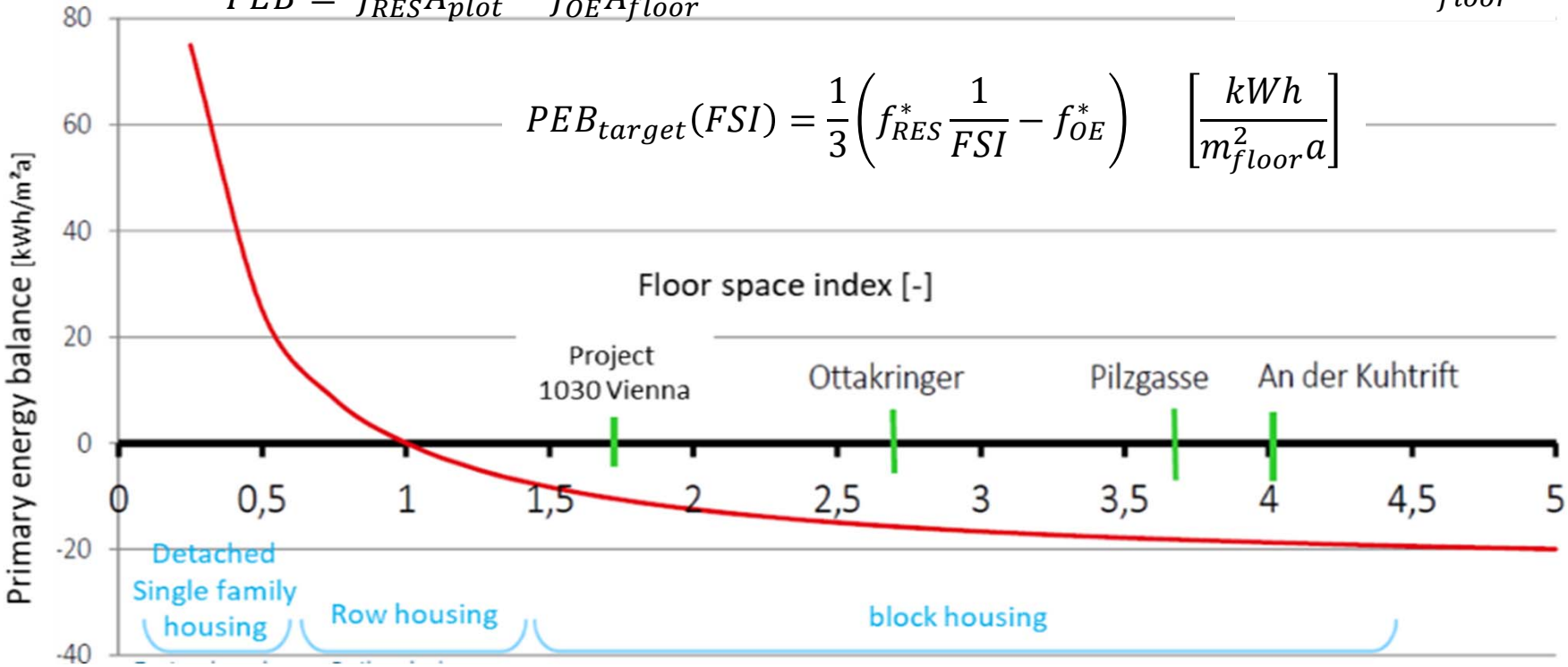
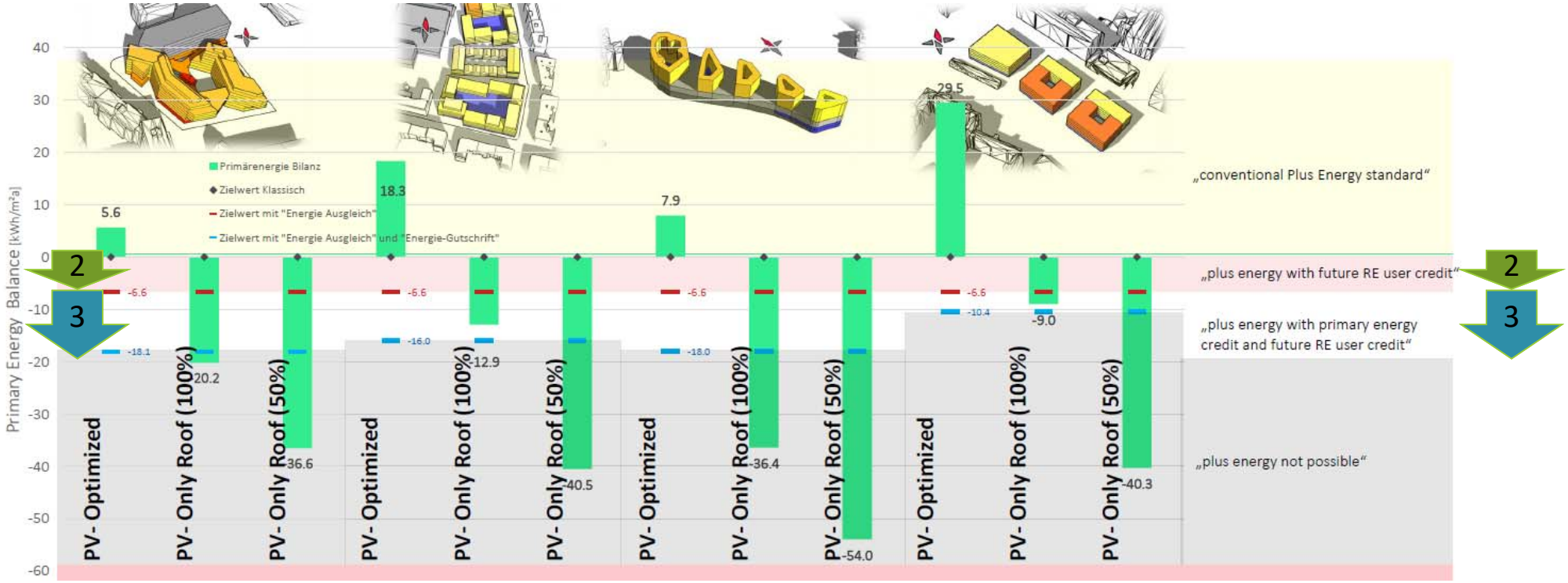


Application of modulations 1(windpeak DSM),2(central RES credits per person) and 3(PEB as function of density)



Refining the ped definition: the *Zukunftsquartier* approach

- Adapted system boundary relating to a carbon free future
  - Target value: Primary Energy (PE-) balance **depending on density, with monthly PE-Factors**
  - Mobility: **Sharing e-mobility only**
  - Plugloads: **Plugloads included** (Adaption 2)
  - Process energy: Covered by large scale RES 2050 (Adaption 2)

1. **Include Energy flexibility** with Carbon-free direct utilization of renewable power peaks (DSM)
2. **Per person credits** of the surplus of future renewable energy sources (RES)
3. Energy balance target value depending on **building density**

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.