The building as system level for management and storage – electricity and heat storage in apartment and office buildings

Ruggero Schleicher-Tappeser, sustainable strategies

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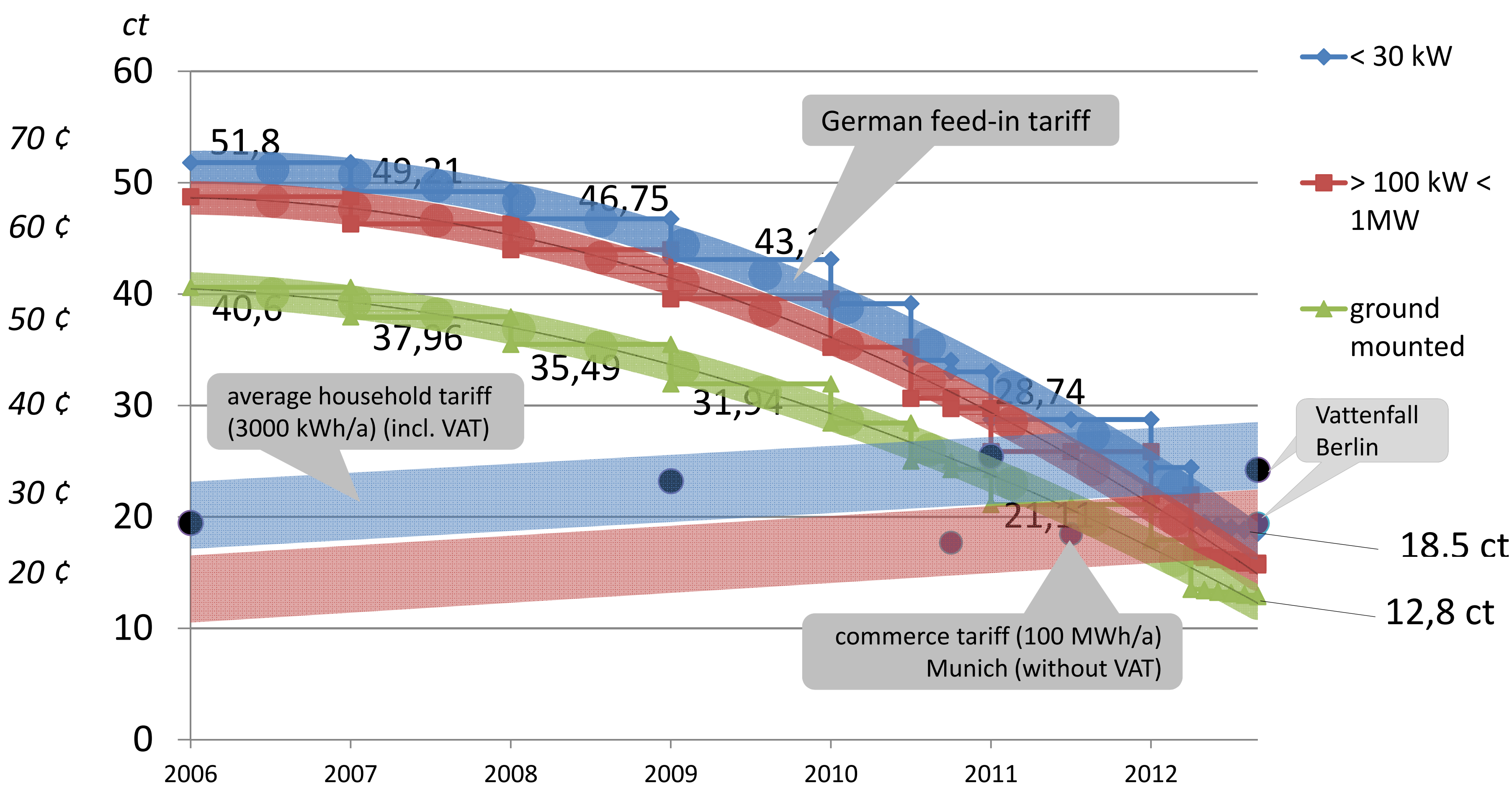
SELF-SUPPLY:
THE PRIVATE PERSPECTIVE

Rapidly decreasing feed-in tariff: Power from the roof cheaper than from the grid



Attractiveness for own power production: Germany - Scenario for the next four years

Experience 2006-2012:

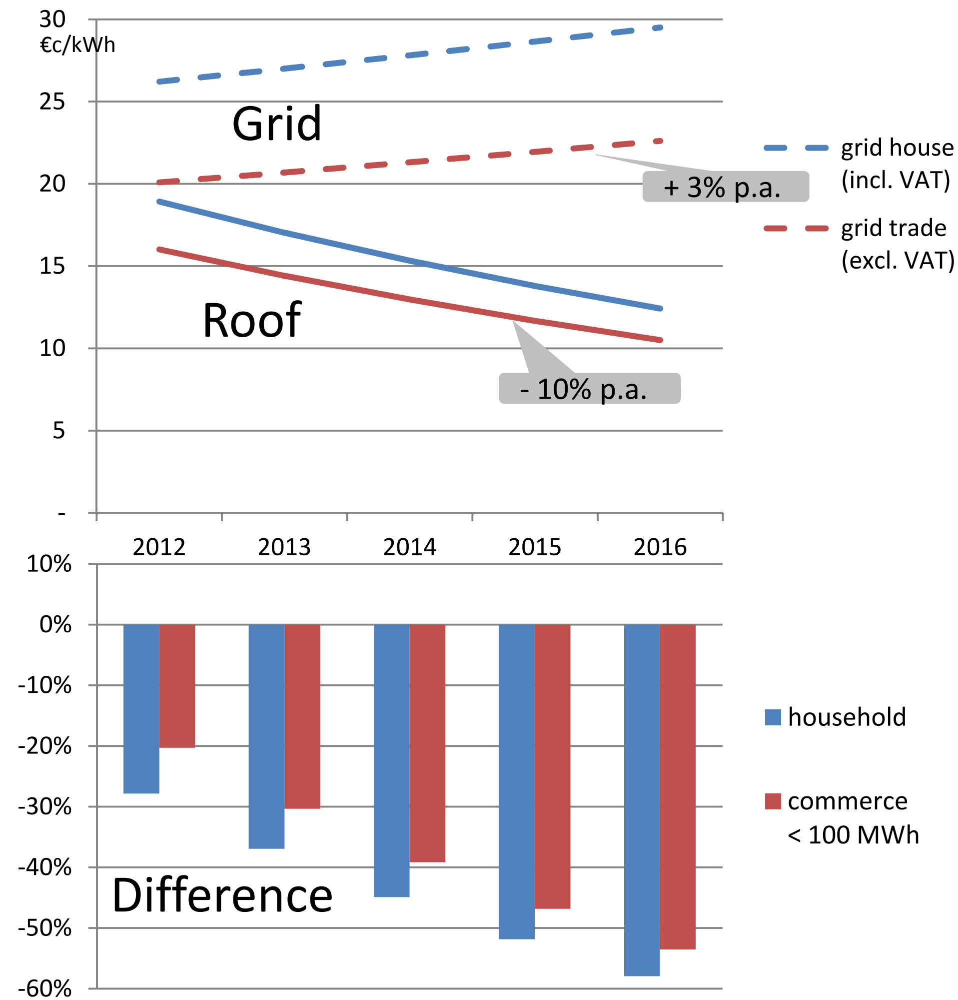
- System price minus 16% per year
- Grid power price plus 3% per year

Assumption 2012-2016:

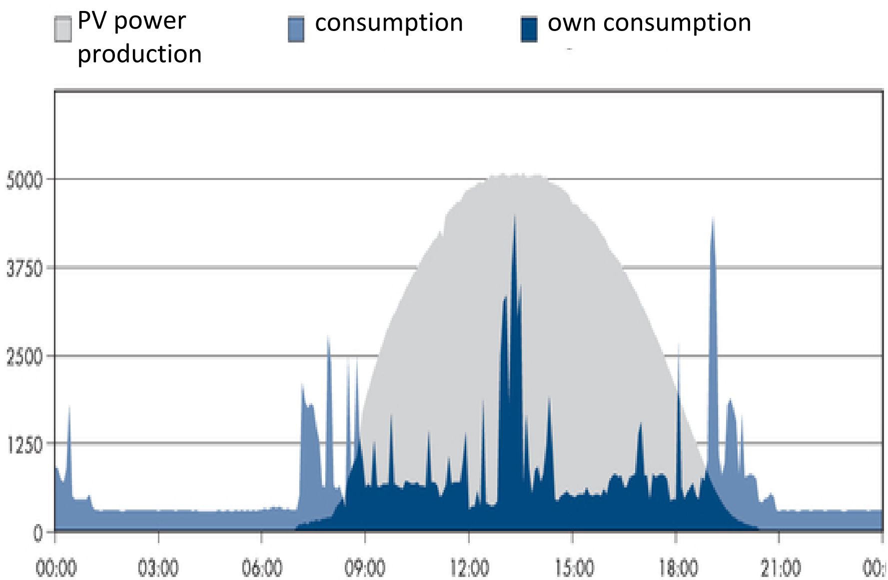
- System price minus 10% per year
- Grid power price plus 3% per year

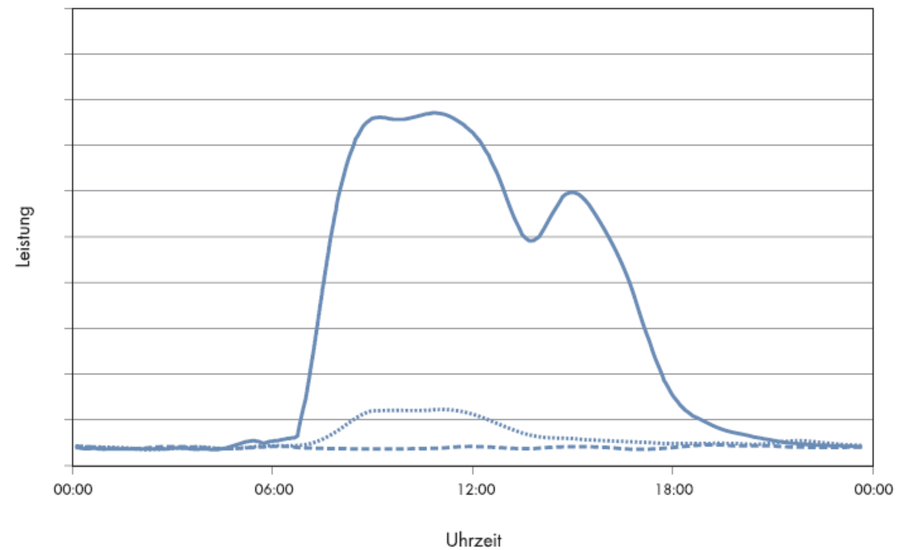
➢ In four years PV power from the roof may cost 50% less than power from the grid

➢ Boom for PV-based self-supply and control technologies



Power need when the sun does not shine: different potentials for own consumption





Private household

cloudless summer day, 4 persons,

PV installation 5 kWp

→ Efforts needed for > 30% of own consumption

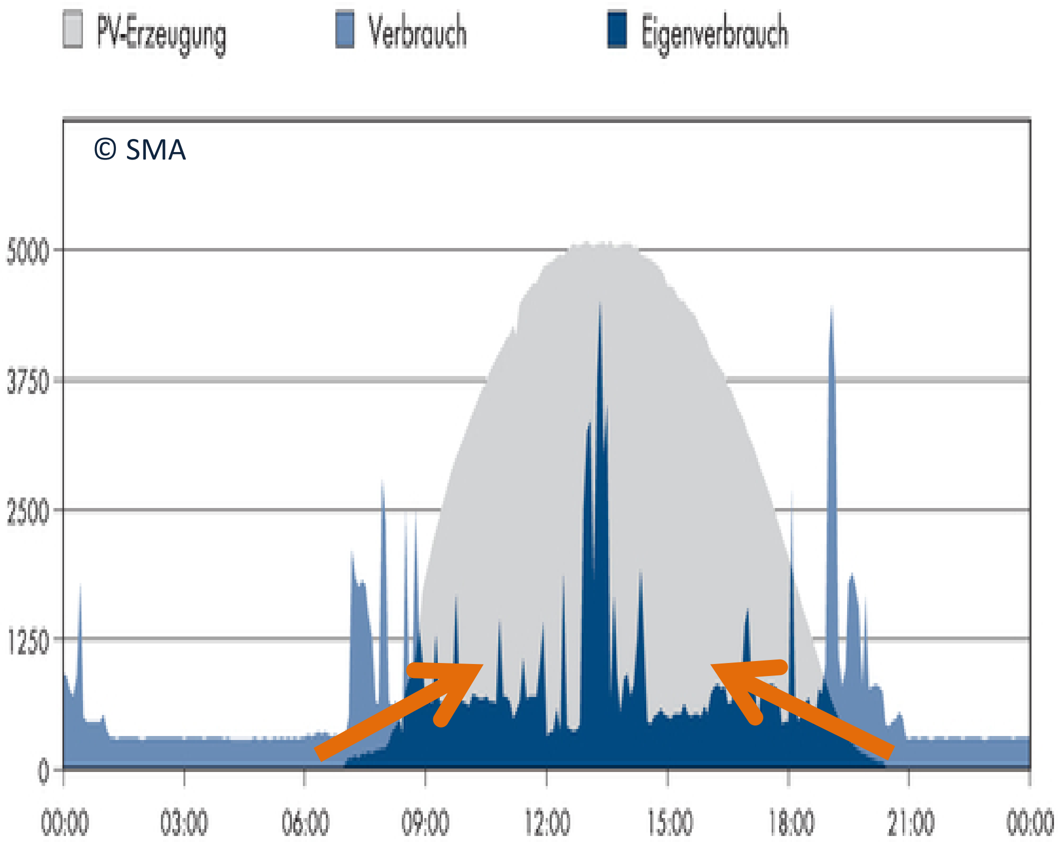
Commerce

working day 8-18h

BDEW Lastprofil G1

→ Good conditions for high share of own consumption

Shifting consumption into the sunshine hours: different options



1. Storing electricity
2. Shifting consumption
3. Coupling with heat and mobility markets

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SELF-SUPPLY: THE SYSTEM PERSPECTIVE

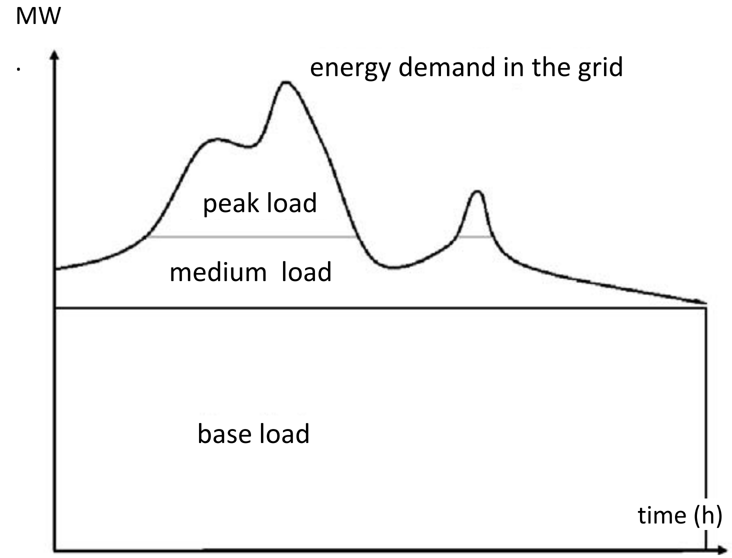
Fluctuation of wind and solar power requires flexibility instead of base load

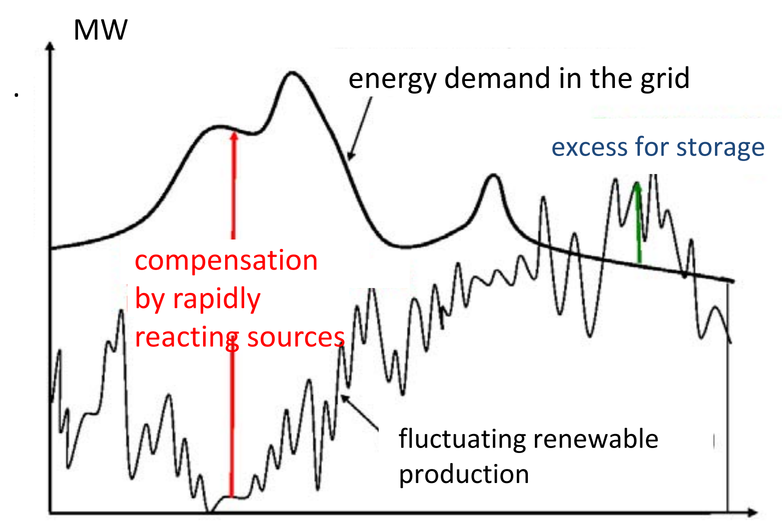
The old base load concept:

- cheap base load electricity from large plants
- expensive peak load from more variable sources

The new paradigm:

- Variable production from renewables with zero marginal cost
- Compensation with rapidly reacting sources (hydro, gas turbines)
- Storage becomes important
- Load management becomes important (smart grid)
- No need for baseload plants

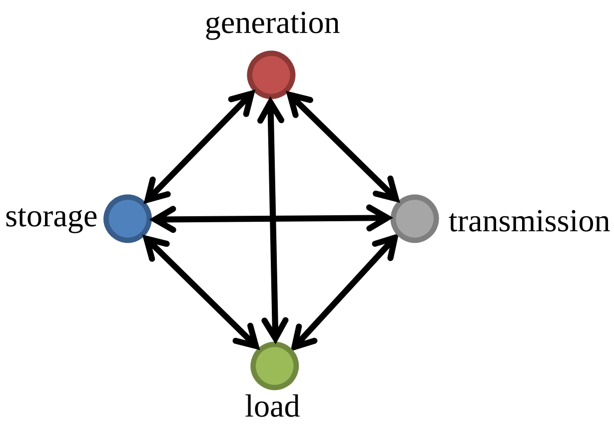




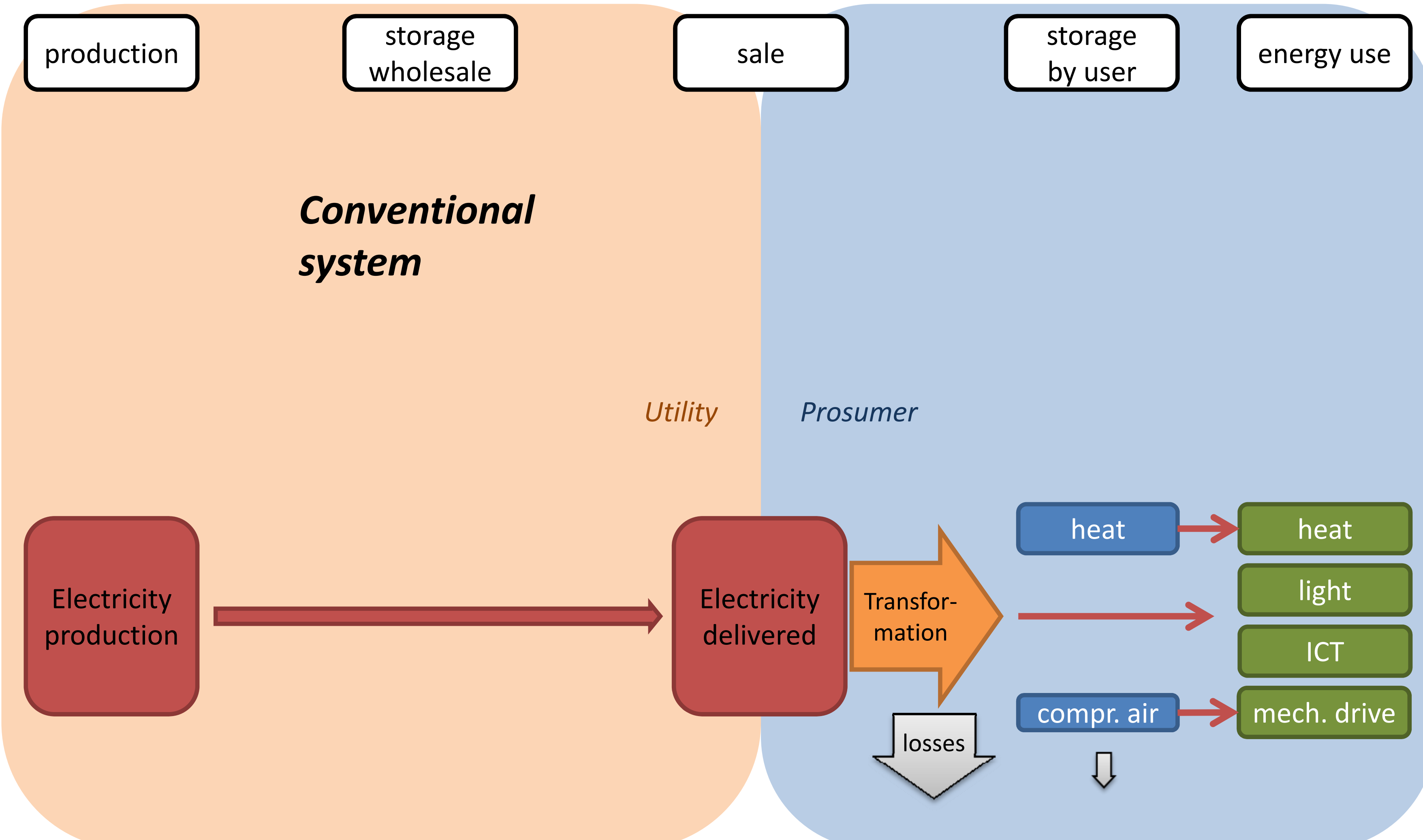
The system gets much more complex: more flexibility – four options

Generation, load, storage and exchange must be balanced at each point in time – all four can be managed:

1. Flexible backup generation
   - traditional approach, limited when needing fossil fuel
   - old technologies not flexible enough
   - new technologies: gas turbines, **distributed CHP, fuel cells**
   - today: natural gas, tomorrow: renewable fuel – SNG
2. Increased transmission
   - compensates local fluctuations over distance
   - requires additional transmission capacities
   - cannot compensate daily and seasonal cycles
3. Storage of electricity
   - intuitively the easy solution, but costly
   - different technologies for different time horizons, scales
4. Adapting demand
   - up to large extents cheaper than other solutions
   - nearly untapped: regulatory barriers, new opportunities with ICT



Creating flexibility with storage: Where is it most efficient?



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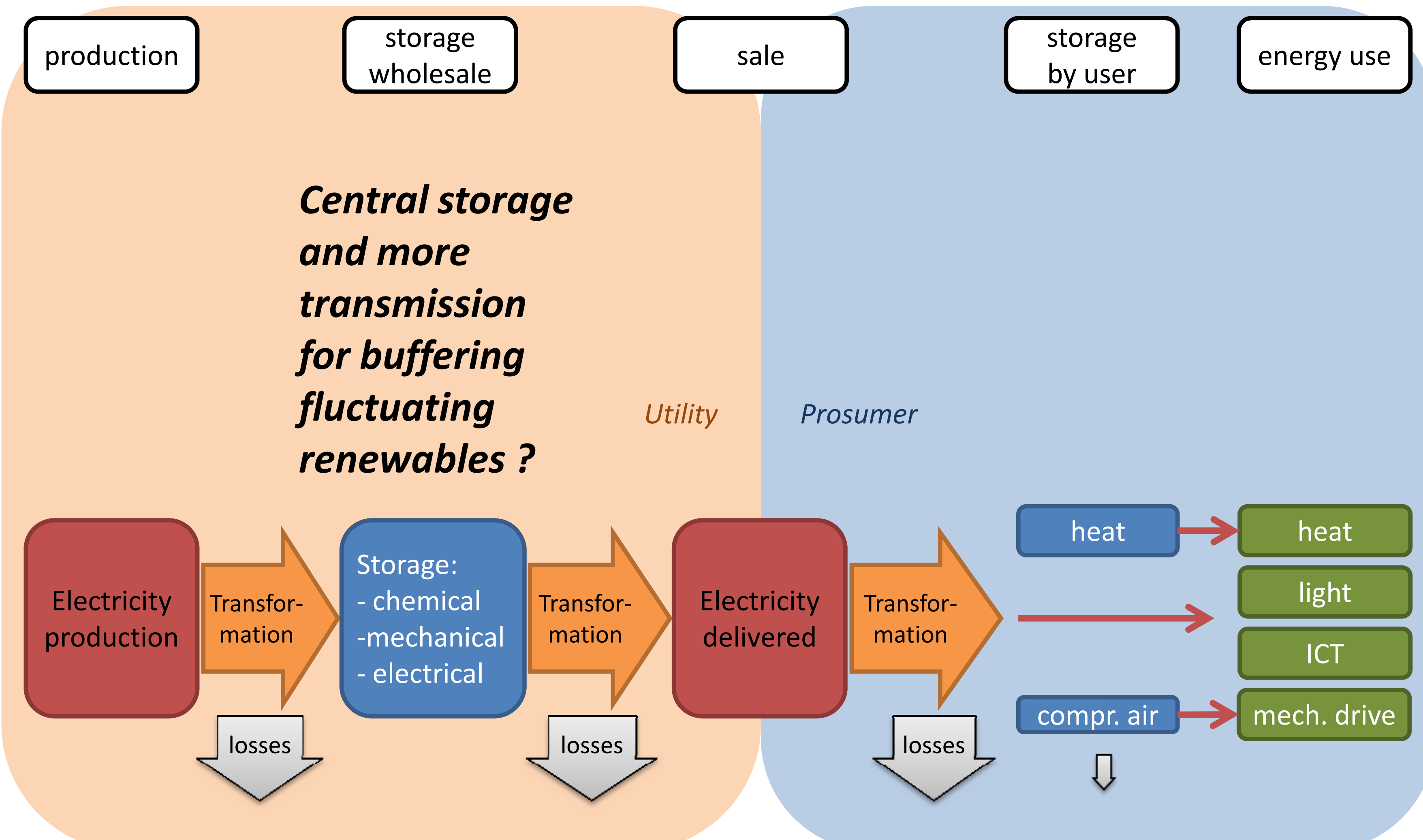
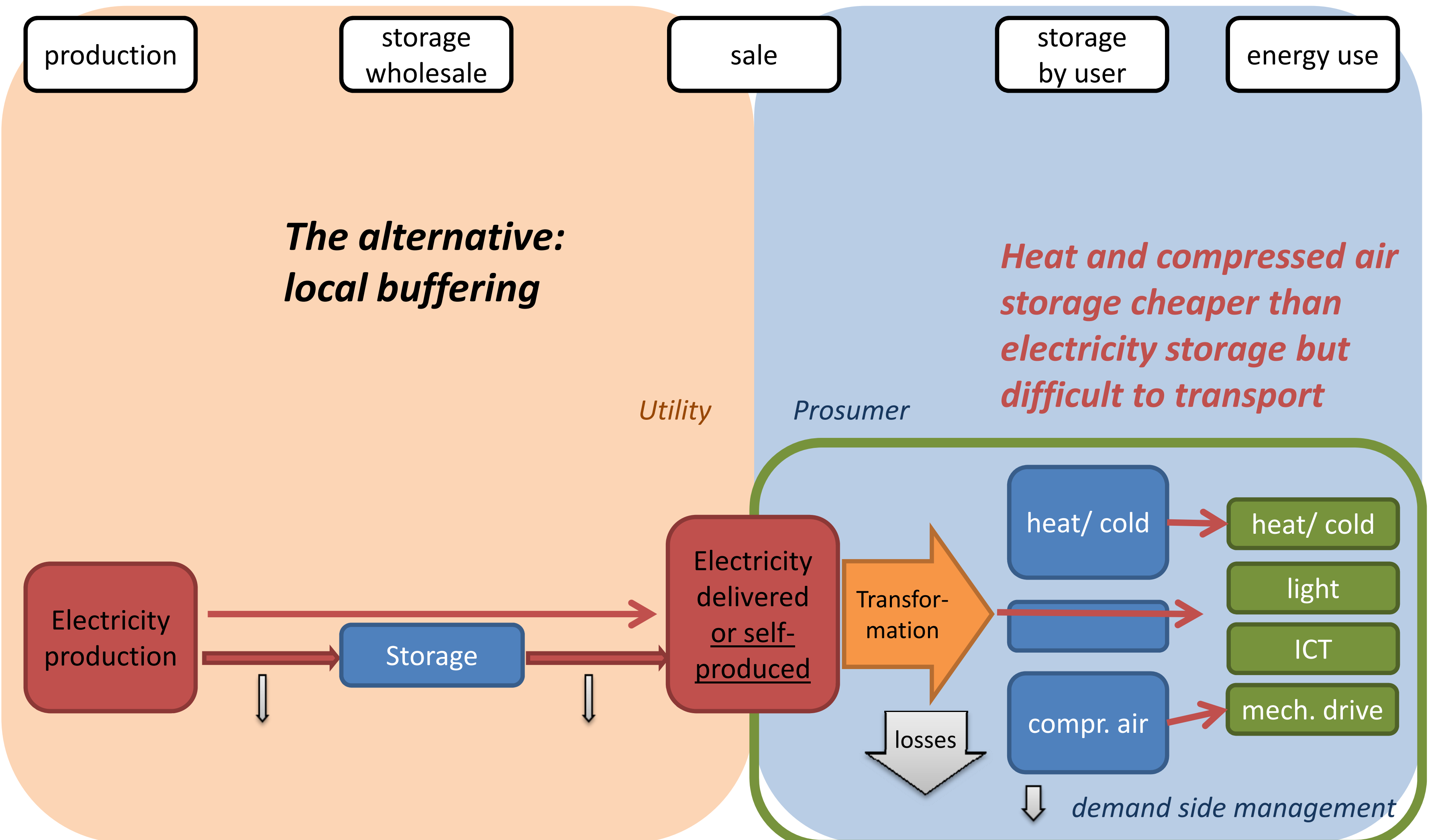


Creating flexibility at the bottom of the system →lower costs, higher efficiency



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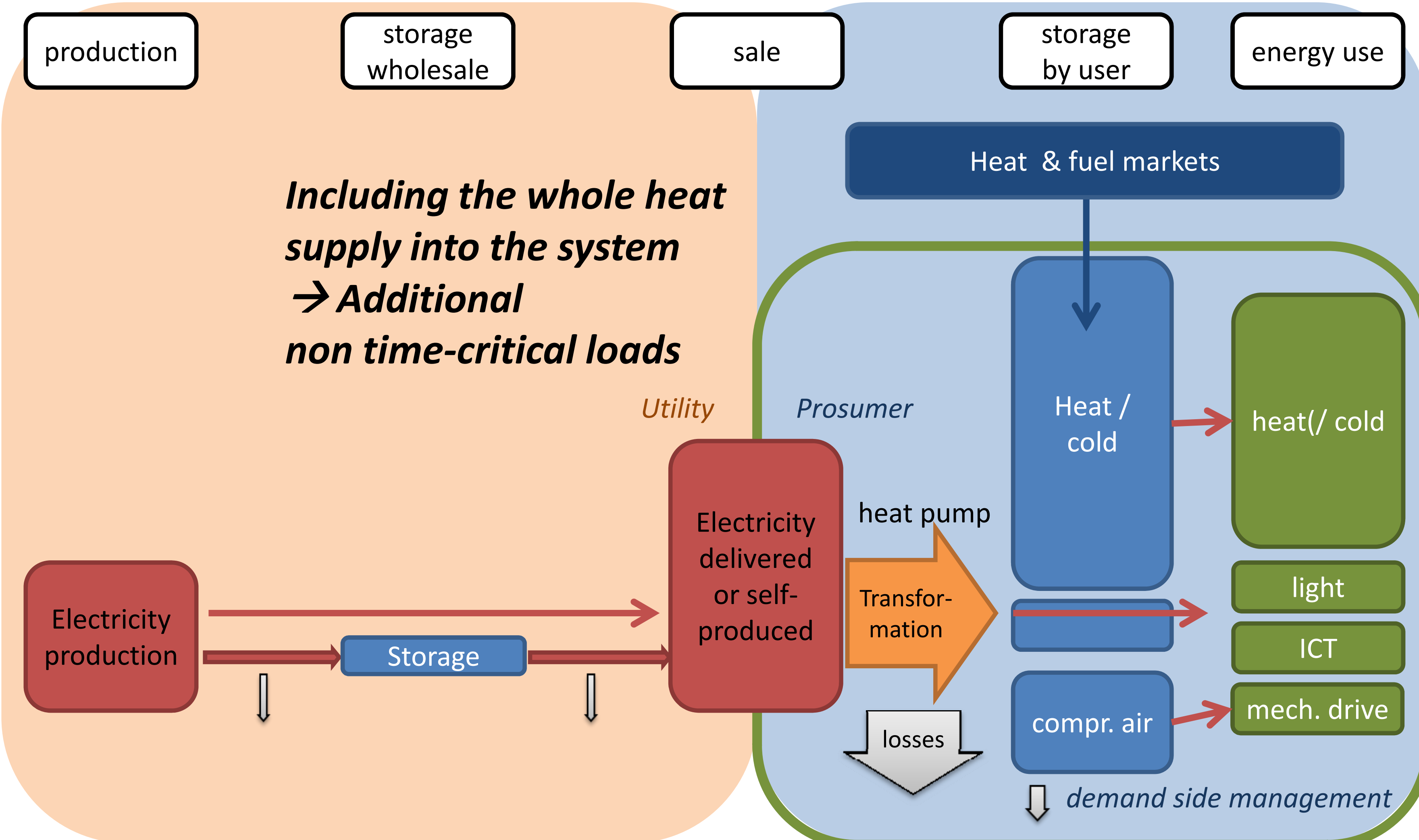

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Efficient storage by combining power and heat supply

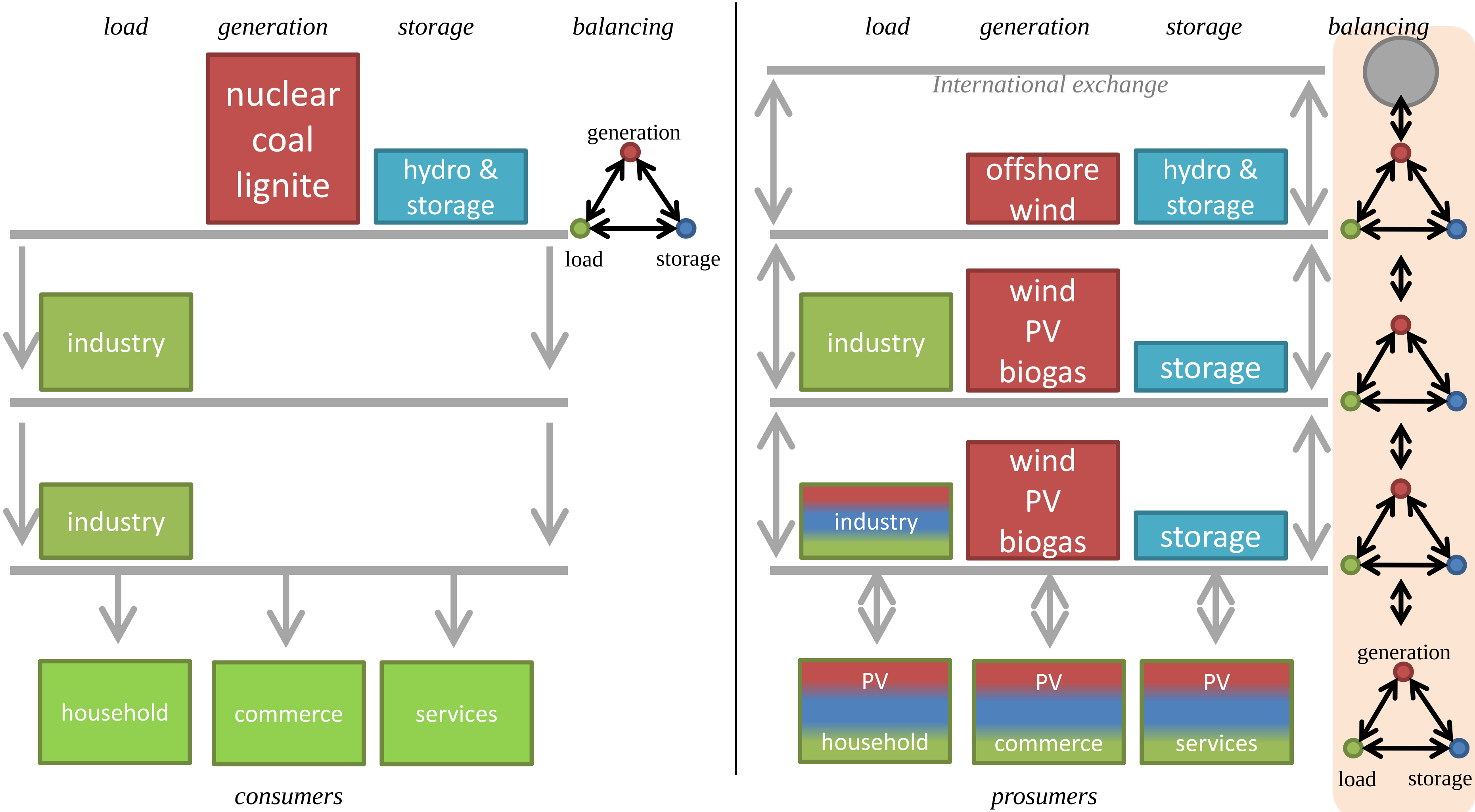
- Storage of heat/cold and also compressed air is cheaper than electricity storage
- Transport of heat/cold and mechanical energy is more difficult

➢ Buildings with central heat/cold supply or district heating/ cooling systems are a <u>key level for storage</u>

➢ The owner/ manager of complex processes consuming heat and electricity is a <u>key actor for balancing fluctuating electricity</u>

Top-down supply system
(central control)

Multi-level exchange system
(subsidiarity, shared responsibility)



SELF-SUPPLY:
THE CHARM OF LARGE BUILDINGS

Large share of large multi-user buildings

Residential buildings:

- In Berlin 90% of the flats are in buildings with more than 3 flats; in Germany 53%, corresponding to 40% of the living space

Non-residential buildings:

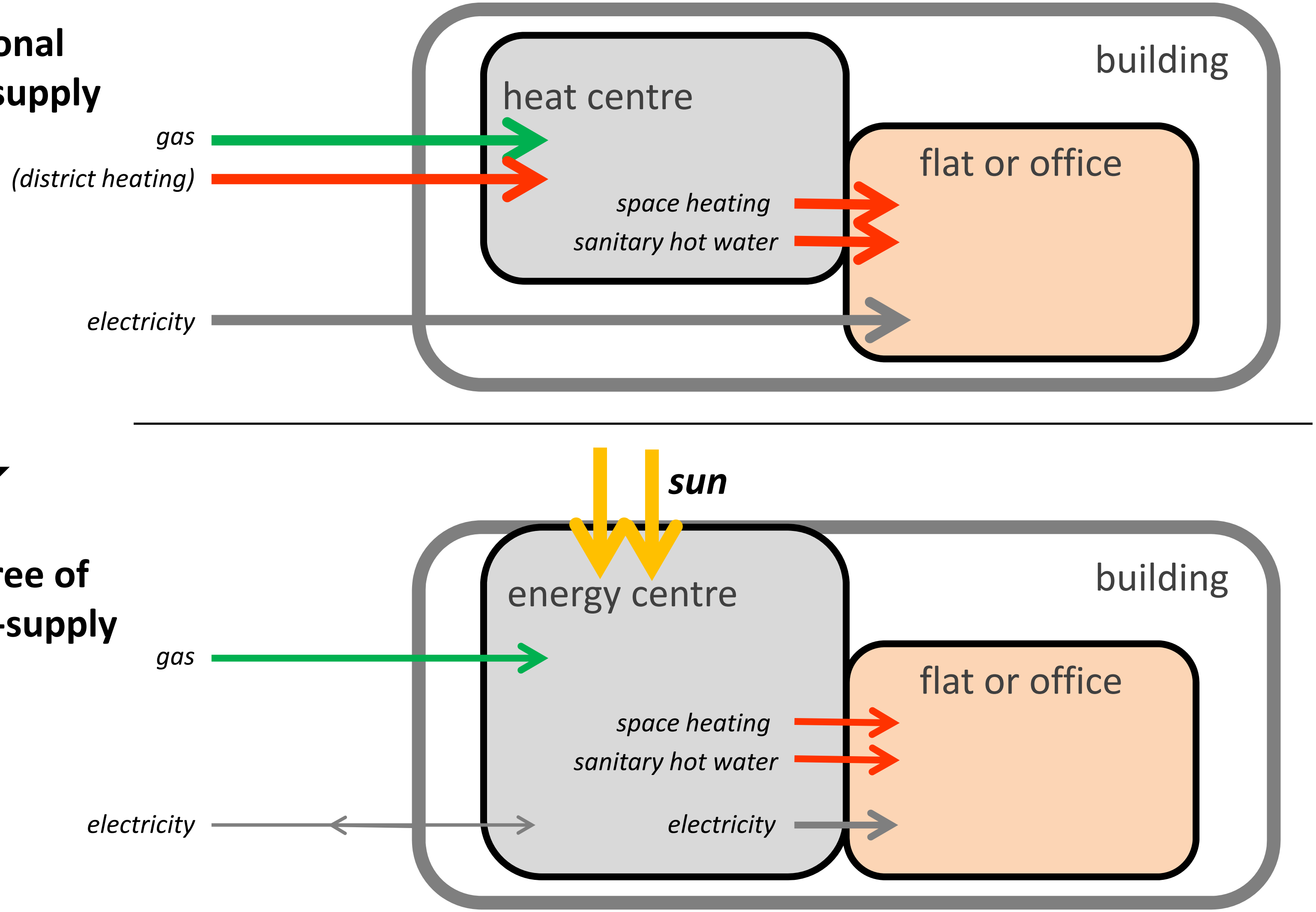
- No data available but concentration in large buildings much higher
- In large cities also many office and trade buildings with many users

→ Not only *industrial electricity use*, but also the overwhelming majority of *non-industrial electricity use* occurs in <u>buildings with several users</u>

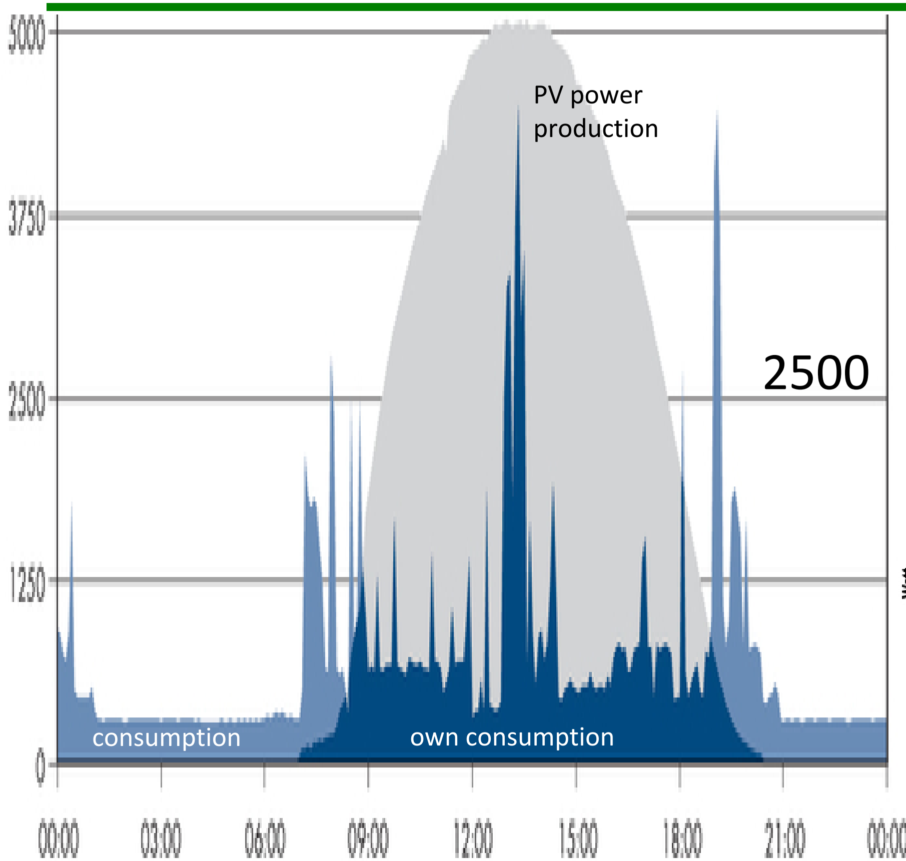
Buildings have own heat supply – combine it with own power supply

Conventional external supply

High degree of solar self-supply



Multiple users:
peaks level out over large numbers

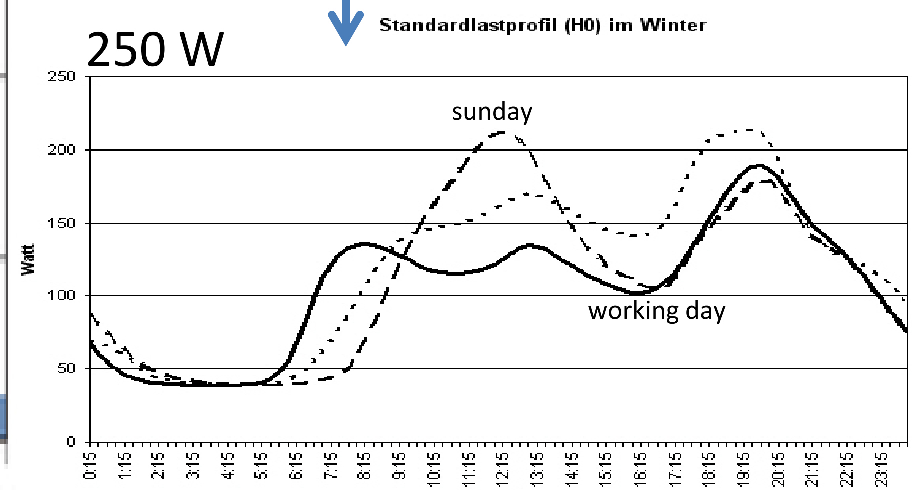


Single private household, 4 persons
cloudless summer day, PV installation 5 kWp

> 30% of own consumption difficult

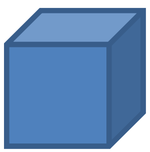
Average private household, winter
peaks levelled out

Peaks 20 x smaller

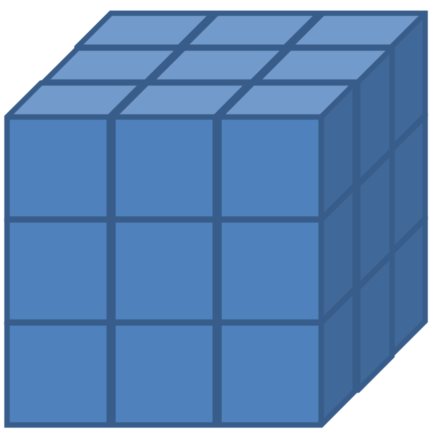


→ Need for storage is much smaller

Storage of sensible heat is more efficient in large units



Surface	6 m^2
Volume	1 m^3
Ratio	6

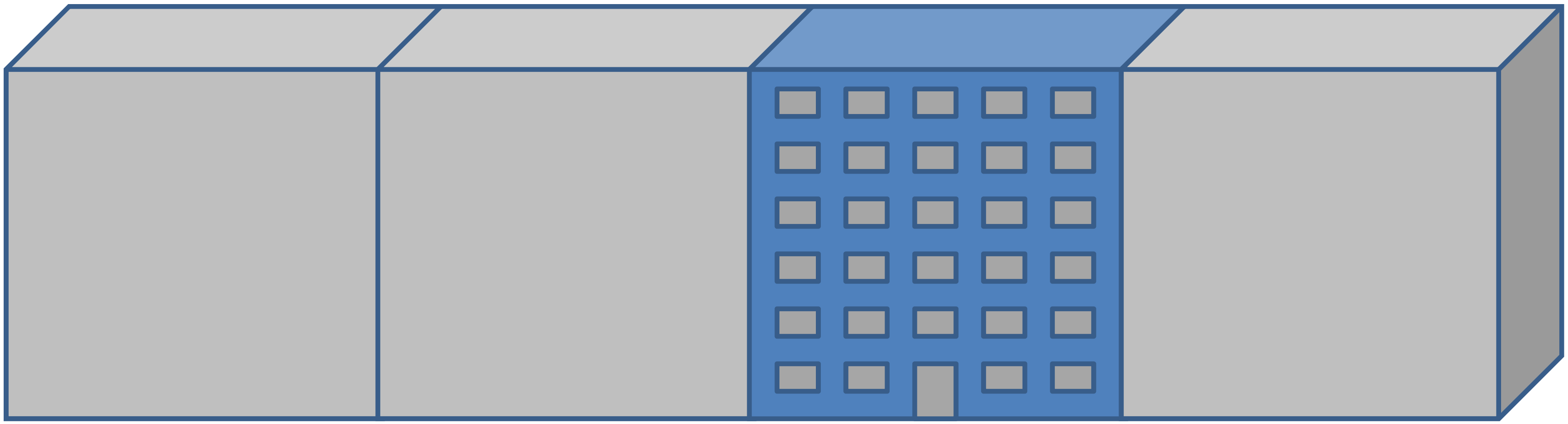


Surface	27 m^2
Volume	54 m^3
Ratio	2

Surface / volume ratio decreases with size

- Less heat/ cold losses with larger storage volumes
- Solar thermal pilot plants: seasonal storage with water tanks > 1000m^3, for > 100 flats
- But in larger buildings the sunlight-exposed surface is also smaller

Model calculation: 6-storey house can cover electricity demand with PV



- Dimension: 18m large, 10m deep, 6 storeys à 3m
- **PV-covering: roof flat 68%, two opposite facades 50% each**
- **Assumption: no shadow by trees, other buildings etc.**
- PV standard modules, radiation values in Berlin
- Facades contribute nearly 60%
- Orientation is not optimal → 70% additional costs
- Average German power consumption in households (30 kWh/a /m^2)

The alternative: small district heating systems

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The main advantage

- heat storage: larger units → cheaper storage
- better levelling out of peaks

Disadvantages

- more complex owner/user structure, takes longer to build
- different buildings: compromises may reduce efficiency
- distribution: heat losses and capital costs increase with distances

Examples

- Denmark: success of cooperative small district heating systems

Modular generation → no need for large units
Sensible heat storage → size matters → larger units
More scalable storage technologies
would reduce need for large systems

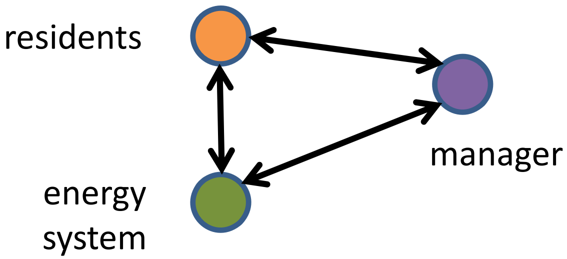
OBSTACLES AND SOLUTIONS

The challenge: high degree of self-supply in existing multi-user buildings

The challenge: Who develops appropriate integrated models ?

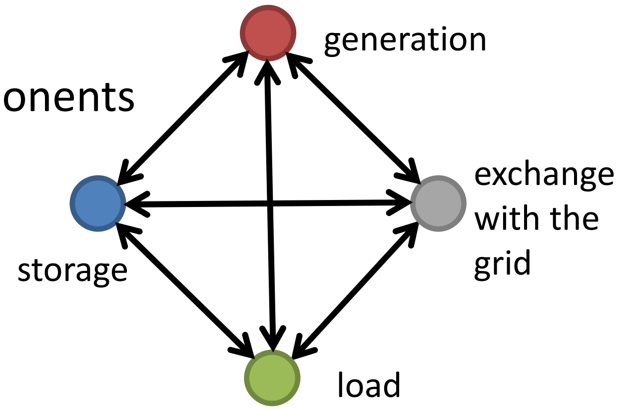
Behaviour / Control:

- emphasis on people
- learning processes



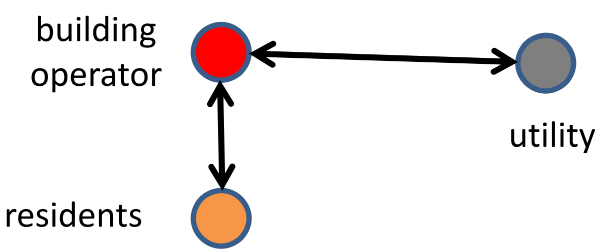
Technology:

- complex system
- innovative components
- dynamic cost development



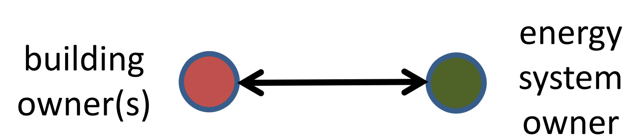
Business model / contracts:

- building operator as energy supplier
- internal flexible tariffs

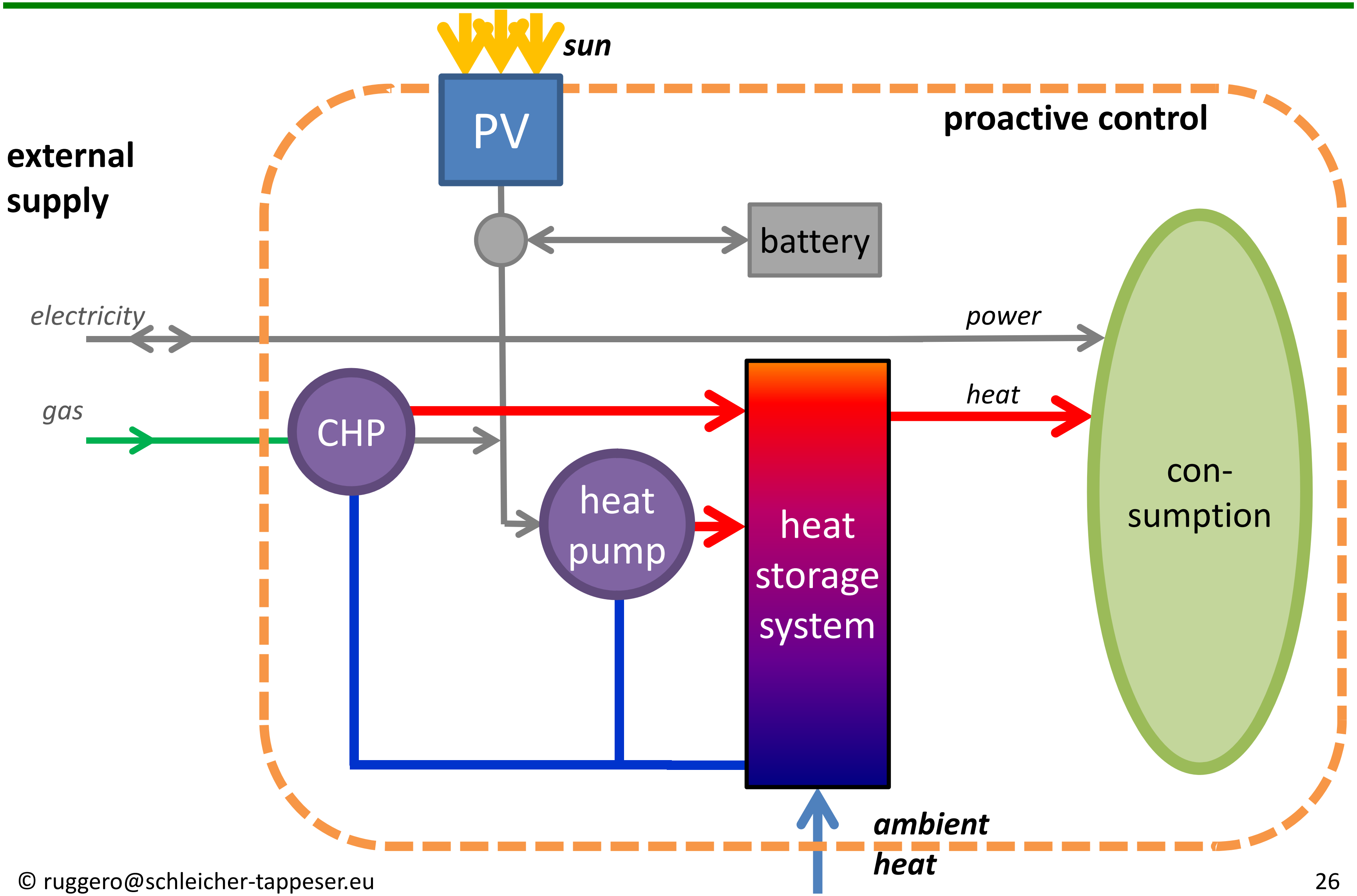


Business model / financing:

- ownership / balance sheet
- contracting / leasing



Technology: Integrated flexible supply of power and heat, mostly renewable



The key role of storage

Electricity storage

- The time when electricity generation in large units was much cheaper is over, distributed renewable electricity generation is getting competitive
- Short-term storage in modular batteries is getting affordable too: distributed storage can help to buffer between distributed generation and consumption
- For the foreseeable future competitive long-term electricity storage needs large structures (pump storage, power-to-gas)

Heat / cold storage

- Heat cannot be transported as easily as electricity, but heat storage is cheaper than electricity storage at all levels
- Until now, long-term heat storage needs medium-size structures (for over 100 residential units), this **may be changed by less size dependent new (sorption or chemical) technologies**

The progress of heat storage technology is a key element for the possible degree of self-supply in buildings

Social innovation challenge: involvement of the users / residents

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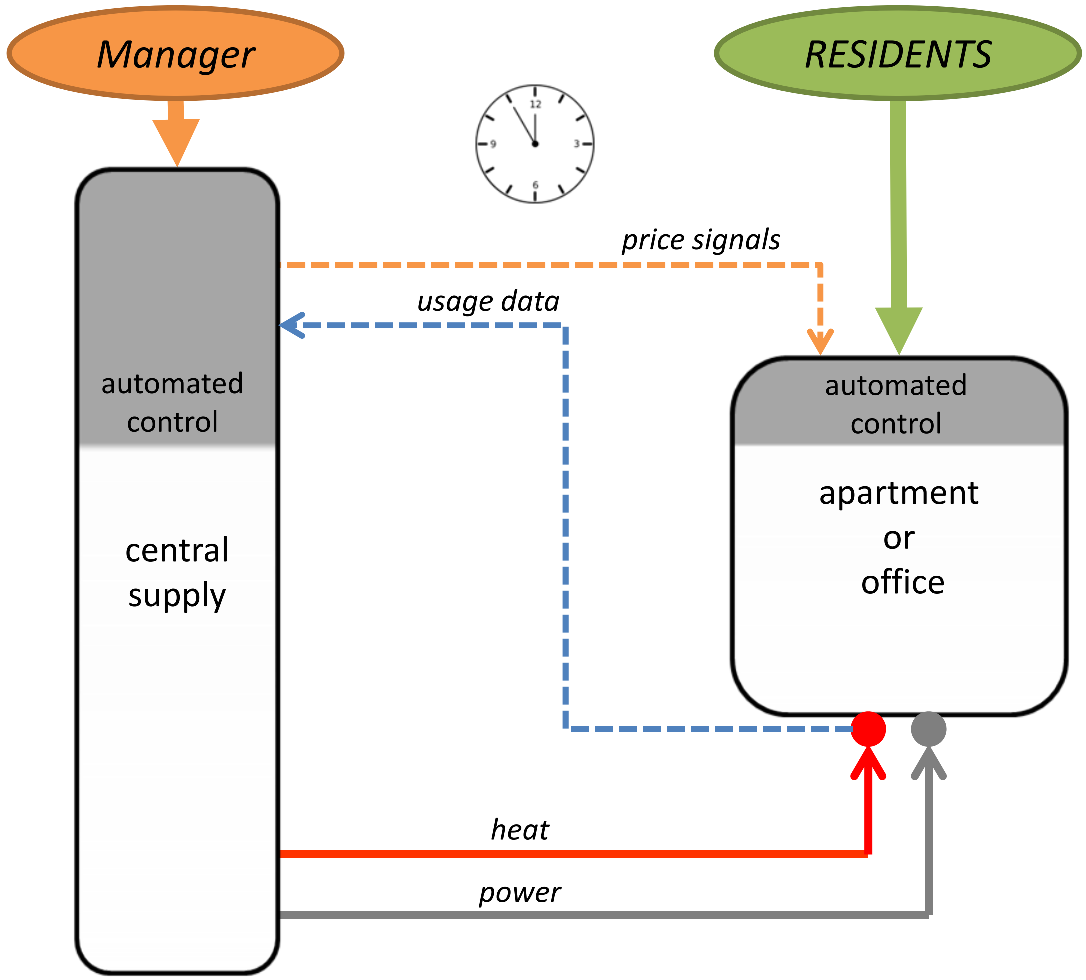
- Convince users to accept power supply by the building operator
  - Free choice of supplier is guaranteed by law
  - Advantages must be evident
- Convince users to support optimal functioning of the building system by appropriate consumption behaviour
  - Information, motivation, communication
  - Time-variable tariffs which incentivise appropriate consumption habits
  - Provide appropriate control systems and easy-to-use interfaces allowing for automated response to price signals
  - Motivate/ incentivise purchase of appliances which facilitate automated control
- Respecting and enabling autonomous choices of users is key to encourage supportive behaviour
- Support learning processes by adequate feed-back. Cooperation and communication between users may be essential to this end

Control of the system: key role of the residents



Social innovation challenge: the building operator as power supplier

- Building owners/ operators are <u>not used to</u> be power suppliers but they have experience in supplying heat and hot water
- Supplying electricity has specific <u>legal and contractual requirements</u>
- Challenges in <u>developing an own tariff structure</u>:
  - Using market mechanisms for a continuous multi-dimensional optimisation of the energy system of the building in function of user's needs
  - Understanding the tariffs as a communication instrument between the users and the technical system
  - Adaptation to the specific characteristics of the energy system
  - Attractiveness and comprehensibility for the users
  - Regular adaptation as residents learn to use the system and the tariffs
  - Legal requirements
- Building owners/ operators need to <u>understand the risks, the capital requirements and the know-how requirements</u> of this new role
- **Outsourcing of certain functions may be a solution**

Social innovation challenge: financing upfront investments

- Substituting external fuel and electricity supply with in-house harvesting of renewable power requires considerable up-front investments instead of continuous operational costs
- Options for raising sufficient capital
  - using own capital of the building owner(s)
  - raising external capital
- Specific challenges when raising external capital
  - proving the functionality and ensuring the reliability of the system
  - long life-times and long payback-times of immobile goods linked to a specific building
- Possible solutions
  - Pilot projects for standard system configurations
  - contracting models which link system responsibility and provision of capital

In 30 years most European buildings will be those of today

Constructing new optimal buildings is nice…

…but does not meet the challenge

CONCLUSIONS

- Integrated self-supply concepts for large buildings will become interesting soon
- The possible degree of self-supply will depend on energy consumption, available surfaces for PV and on medium-term storage costs
- Social innovations and social learning are essential for the success of such concepts
- Since technical solutions are not sufficient, pilot projects of building operators are needed
- The big challenge is to provide standard solutions for existing buildings

THANK YOU FOR YOUR ATTENTION

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www.sustainablestrategies.eu

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