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Renewable energies in the urban environment - building

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Renewables and buildings - the challenge

- The building sector is a key sector for an energy and climate policy endeavoring for more sustainability:
  - **Switzerland**:
    Almost 50% of Swiss primary energy consumption is used for buildings
    - 30% HVAC
    - 14% electricity
    - 6% embodied energy

    Share of buildings in CO_2 emissions: ca. 40%
  - **EU:**
    Share of buildings in energy consumption: ca. 40%
    in CO_2 - emissions: ca. 36%

Renewables and buildings - the targets

- Ambitious targets of Swiss energy and climate policy:
  - Federal energy policy 2050 (compared with 2010):

Reduction targets 2050: Federal energy strategy 2050 (NEP)	Final energy demand
Absolute reduction	-45%
Per m² conditioned floor area (2050: 937 Mio. m²)	-63%
Per person (2050: 8.94 Mio.)	-55%

From today's perspective, population growth until 2050 might also be higher

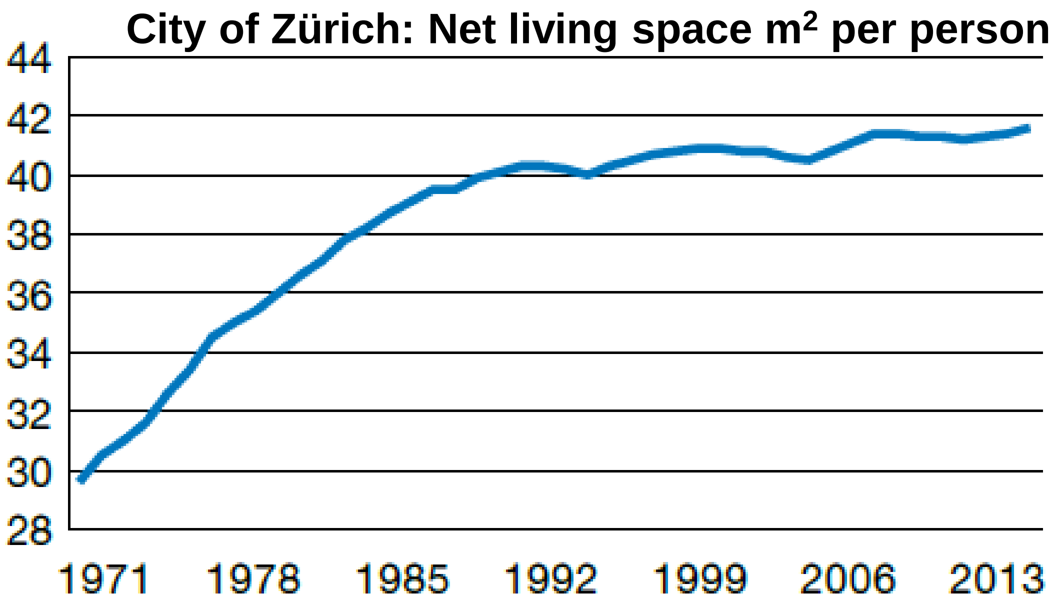
  - SIA energy efficiency path 2050 (compared with 2010):

Reduction targets 2050: SIA energy efficiency path	non-renewable primary energy		GHG-emissions	
Residential buildings	new	retrofit	new	retrofit
Absolute reduction	-76%	-69%	-96%	-91%
Per m² conditioned floor area (2050: 644 Mio. m²)	-78%	-72%	-96%	-92%
Per person (2050: 8.13 Mio.)	-78%	-72%	-96%	-92%

The target is: Very low energy & (almost) zero emission buildings

Can the targets be achieved? Counteracting drivers (1)

- Demography, wealth, inflation of needs →
  - Higher indoor temperatures in the winter time, lower in the summer time
  - Growing living space per person:



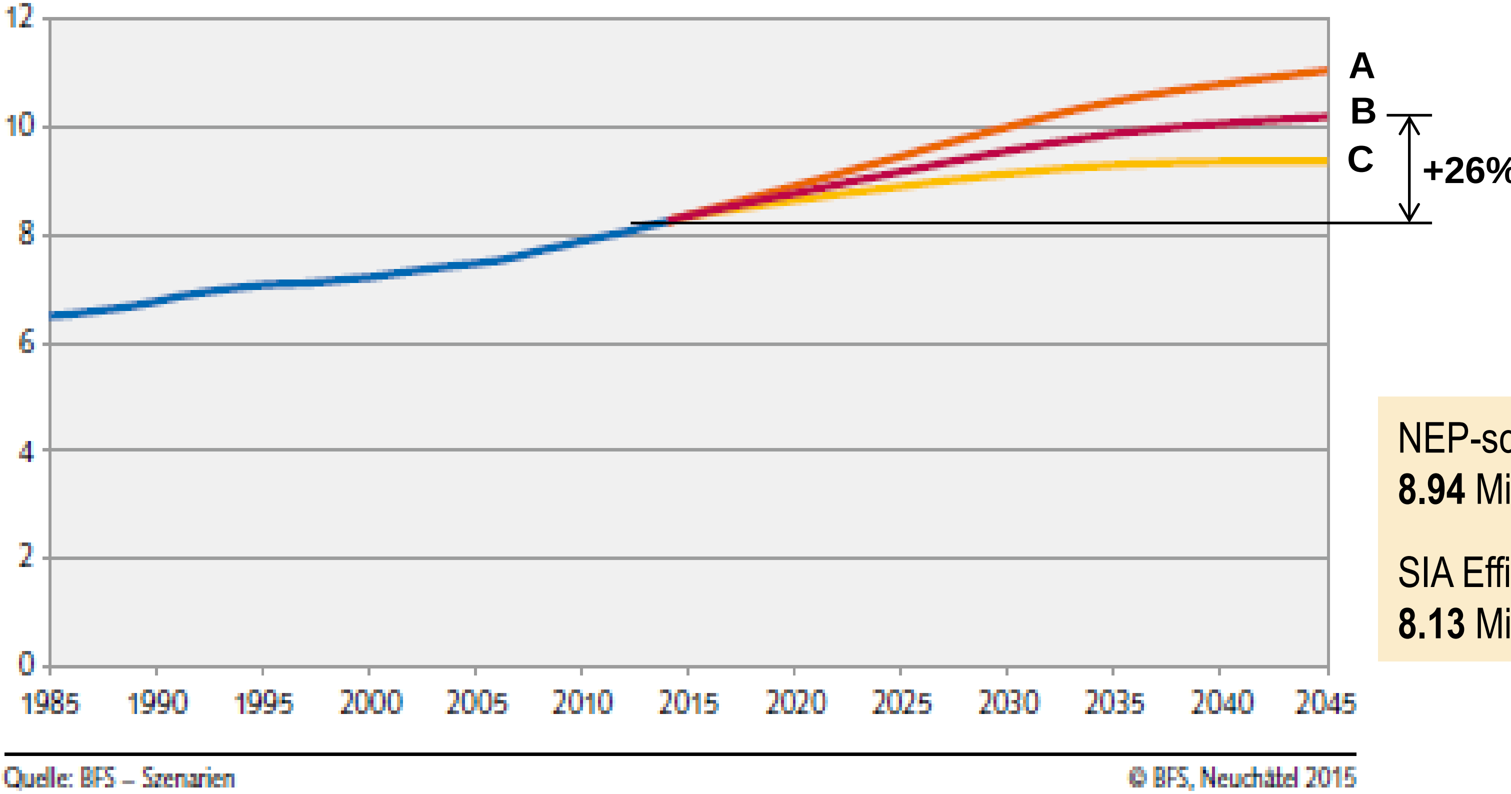
Energiebeauftragter Stadt Zürich 2014

Zürich growth stopped, lower average space/person in ZH than in Switzerland; Swiss average 2014: 45 m^2 per person

- Climate change →higher temperatures: Higher cooling needs

Can the targets be achieved? Counteracting drivers (2)

- Population growth: From 8.1 Mio. 2014 to 10.2 (-/+0.8) Mio. 2045 (Reference scenario: **B;** Swiss Federal Statistical Office, 2015)

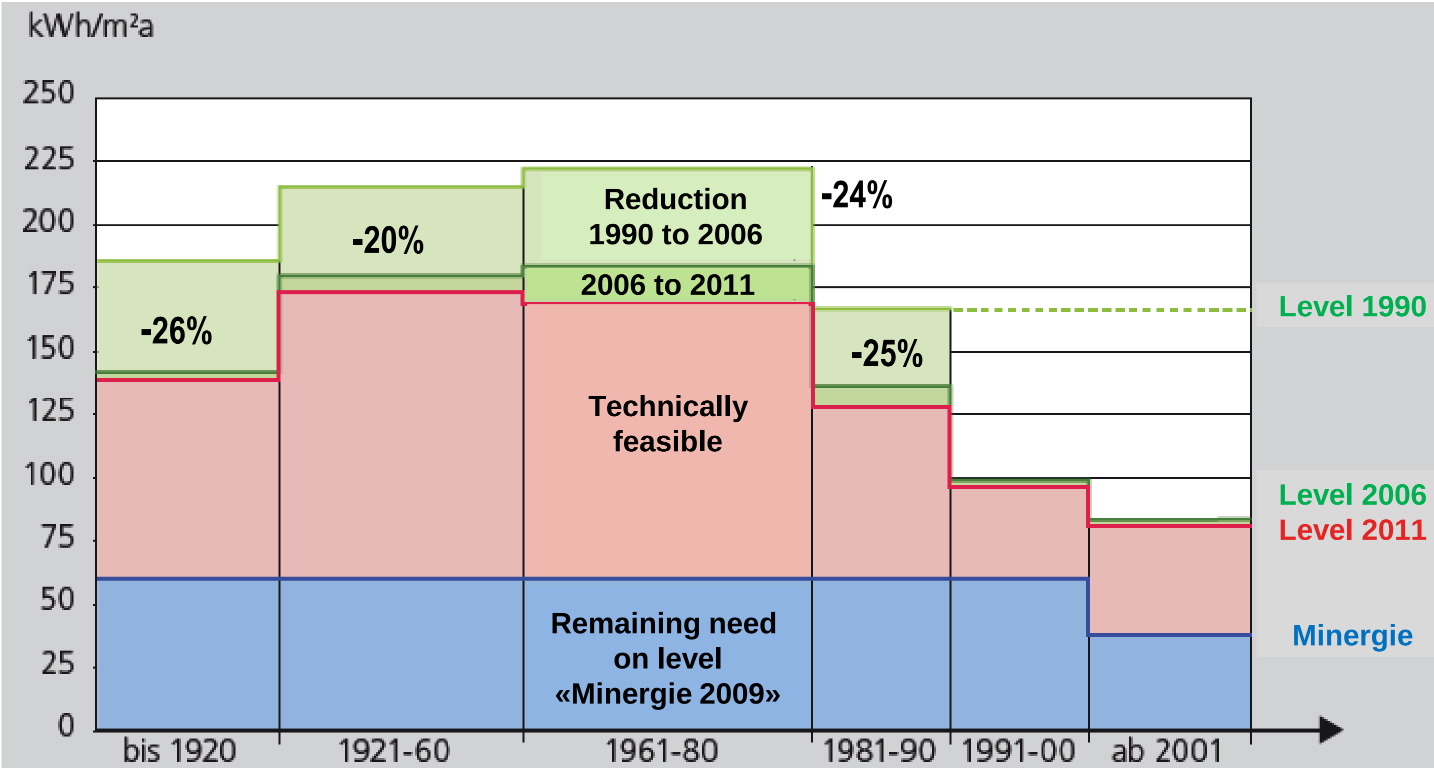


NEP-scenario :
8.94 Mio. 2050

SIA Efficiency path:
8.13 Mio. 2050

Insufficient demand reduction in the building stock

- Reduction of energy demand not fast enough:
  - Slow reduction of energy need of the dominating building stock
  - Insufficient improvement of energy performance in renovation projects



Conditioned floor area per period (total of 87 Mio. m²)

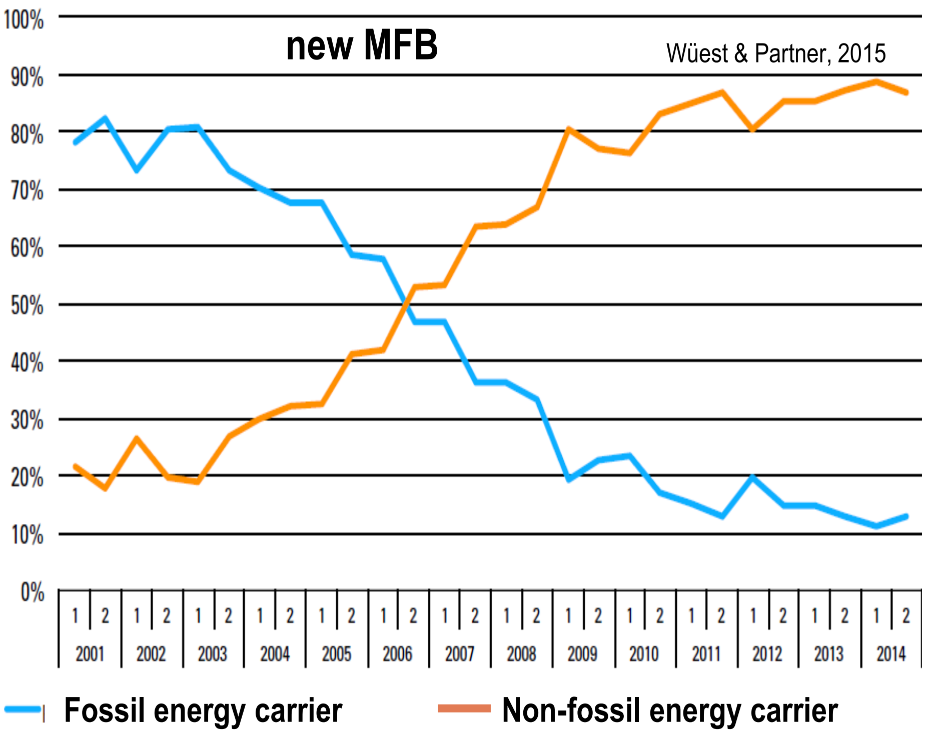
Renovation of building stock in 20 year period from 1990-2011:

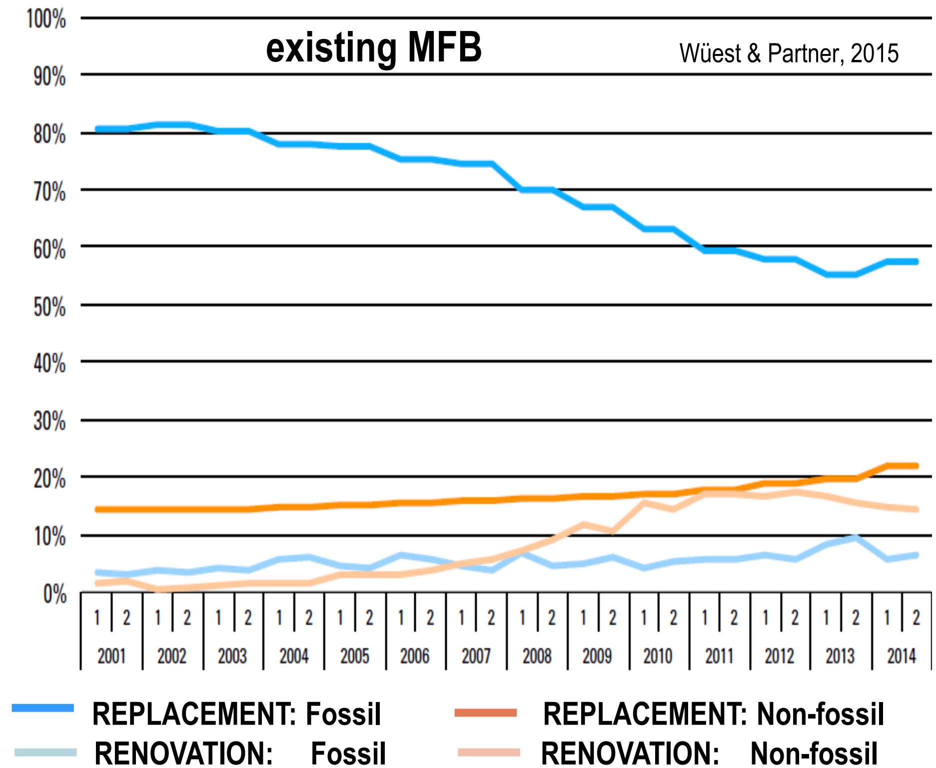
Reduction of 20% - 26%

Standard for new buildings was not ambitious enough

Insufficient change to renewables in existing buildings

Market share in 2014 [%] Wüest & Partner, 2015	New SFB [%]	New MFB [%]	Replacement SFB [%]	Renovation SFB [%]	Replacement MFB [%]	Renovation MFB [%]
Fossil energy carrier	6.0	**12.1**	44.4	2.8	**57.4**	**6.1**
Non-fossil energy carrier	94.0	**87.9**	38.3	14.7	**21.9**	**14.7**





Policy priorities in the building sector: Role of the renewables (1)

- Main focus of energy policy is so far on reducing energy needs with efficiency measures on building envelope
  - MuKEn (2008), but MuKEn (2014) puts more weight on renewables: Until 2020, new buildings provide themselves with the heat energy still needed and existing buildings have to generate hot water mainly with renewables; until 2025 electric heating should be phased out
  - EPBD of EU («"nearly zero-energy building" means a building that has a very high energy performance…. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby»*)*

Policy priorities in the building sector: Role of the renewables (2)

- Furthermore, increasing relevance of GHG reduction in climate and energy policy
- Limitations to reach 'nearly-zero energy' in building renovation:
  - Highly decreasing marginal benefits of energy efficiency measures
  - Rising marginal costs with increasing energy efficiency
- Technology development and economic drivers facilitating deployment of renewable energies

➡ Increasing relevance of RES as GHG reduction measures

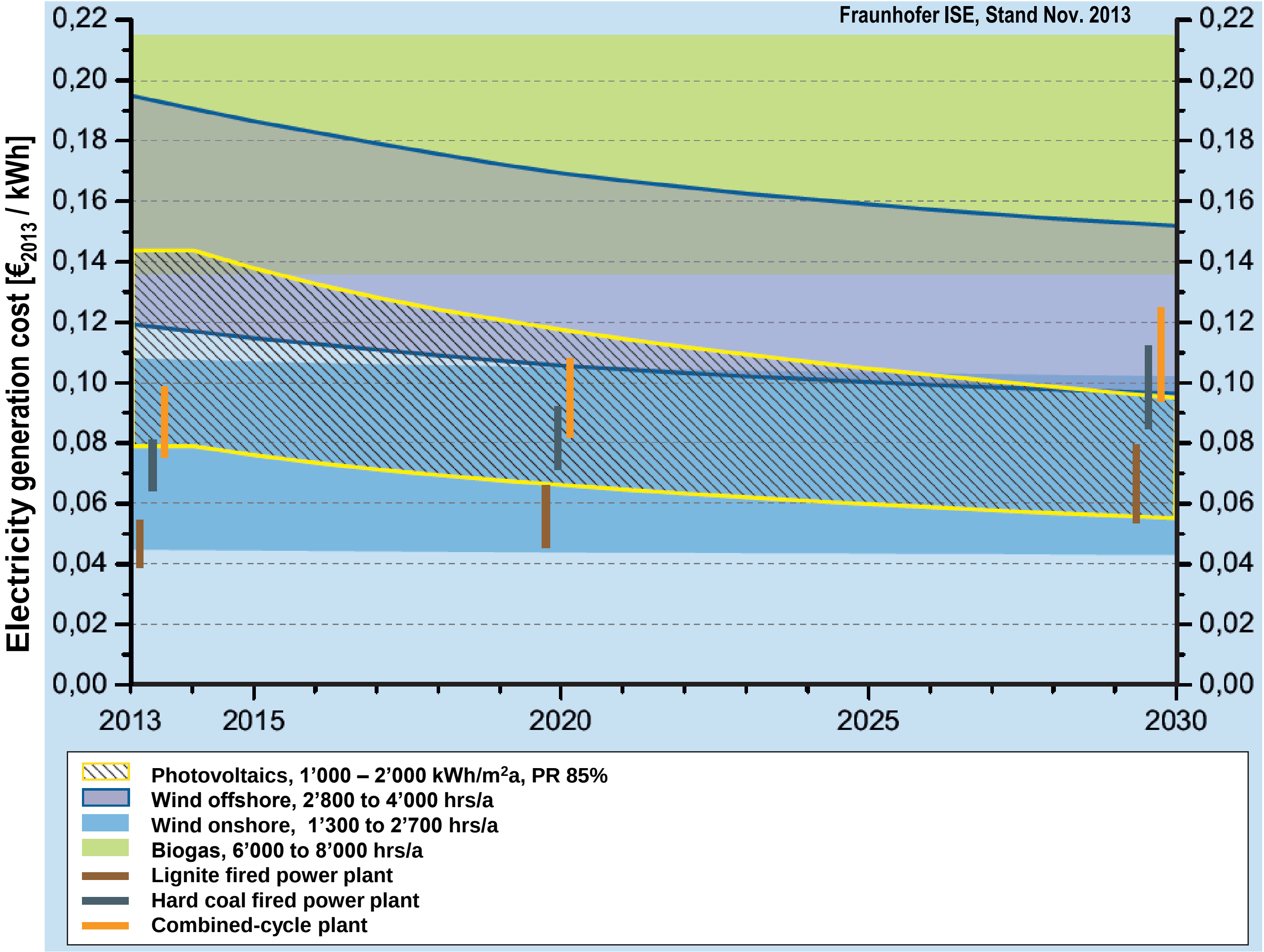
➡ Rethinking of the role of renewables in the building sector: widening and shift of focus to RES and reduction of GHG?

The drivers: Technology and market development decreases costs of renewables

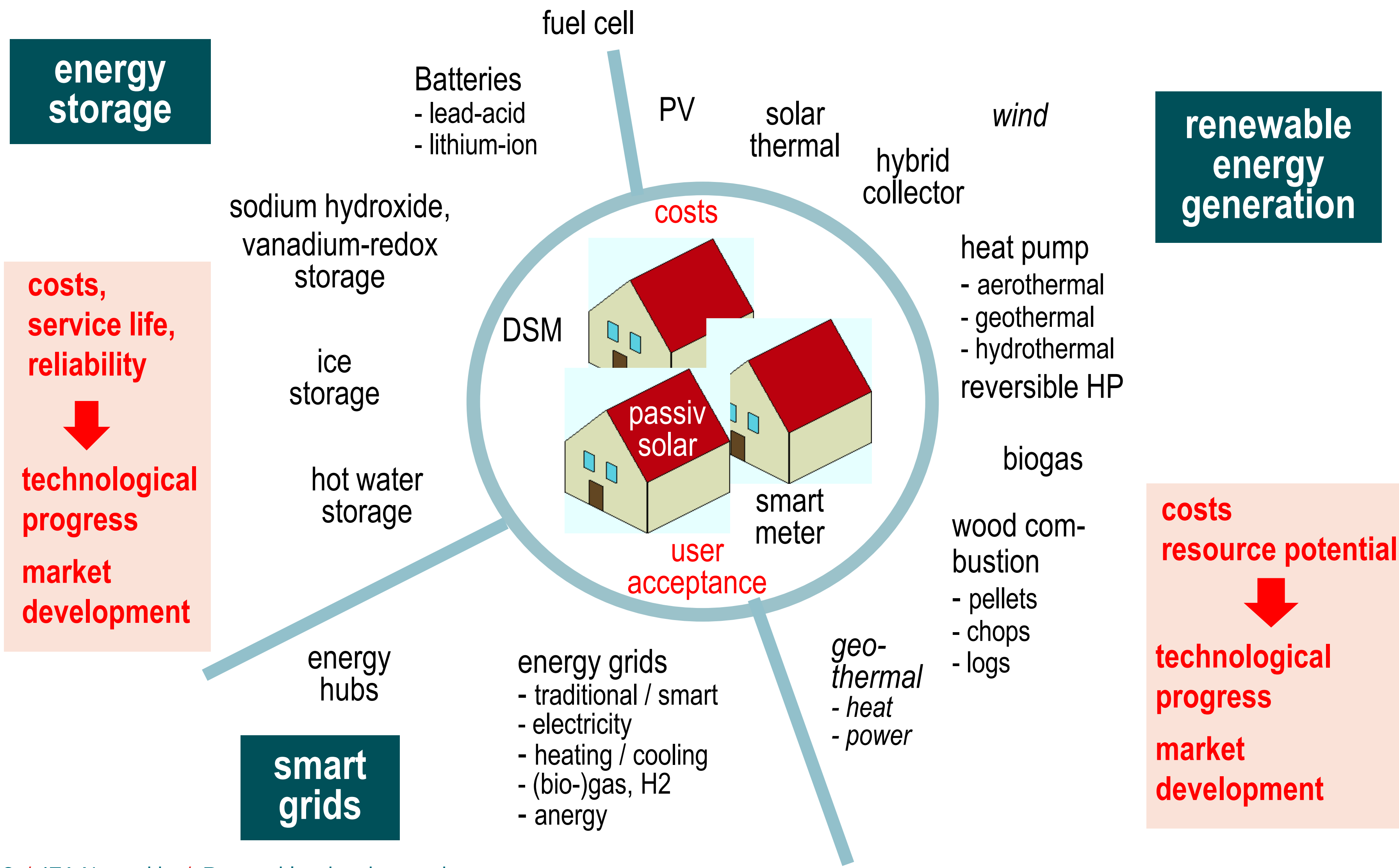
Further cost degression of renewables expected

Wind and PV are competitive or will become competitive

Considerable potential at least for PV in Switzerland



Renewable energy in the building sector - overview



PV in the building sector

- Progress of PV technologies and technology choice
  - Efficiency of the modules and particularly of the integration/balance of systems of PV
  - Price decrease of module/inverter, system integration, combined with module-efficiency
  - Thin film and silicon mono-cristalline PV
- Progress in PV deployment on the building envelope: PV combined with elements of the building envelope (active interfaces)
  - Advanced technology and process developments for multifunctional envelope elements → Tap unexploited deployment potentials to be developed for the market
  - Development of multifunctionality for customized modules, easy integration on-site
  - Reduction of aesthetic obstacles by new surface technologies which should yield little negative trade-offs regarding resulting unit generation costs

➡ Expected: Higher potential for PV deployment, decreasing generation costs, but necessity to integrate stochastic generation of PV-electricity into the on-site as well as into the overall supply-/demand-system

Solar thermal in the building sector

- Domestic hot water supply is the major remaining energy need for heat after improving energy efficiency of buildings
- Renewable domestic hot water supply by solar thermal collectors is in competition with:
  - Heat pumps (only partly renewable if not renewable electricity),
  - other, e.g. biomass
- Large potential for seasonal and medium-term heat storage
- Besides seasonal storage: Limited technological and economic development potential
- Higher solar rate of return than PV but competition with regard to
  - available area for collectors
  - resulting unit-costs for heat generation
  - practical application (integration in hydraulic system is more complex than PV in the electric system)

Heat pump (HP) in the building sector

- Progress in HP technology and technology choice
  - Expected: Further increase of efficiency of HP which extends the range of economic viable applications of HP
  - Especially for large HP: Efficient provision of high supply temperature, possible by cascading or by use of unconventional cooling agents (CO_2, NH_3) extends application range (e.g in energy systems)
  - Multifunctional use for heating and cooling extends deployment range for HP, particularly for office buildings (especially considering rising average temperatures)
  - Limits and obstacles: Availability/potential of heat source and access to heat source:
    - Airsource HP: Limited efficiency , especially when heat demand is high; noise risks
    - Groundsource HP: Often limited space for boreholes; long term capacity/recovery of the ground-source in densely built areas can be insufficient → reload groundsource
    - Groundwater HP: Often restrictions for groundwater use (minimal capacity of groundwater well, groundwater protection areas, limited temperature decrease of ground water)

➡ Large and often economically attractive deployment potential
  - Deployment potential can be extended by integrating in energy networks
  - But: HP increase electricity demand

Biomass: Wood and biogas combustion

- Several small and medium scale applications:
  - Wood combustion: Pellets, chops, logs
    - Existing potential is limited, economic viability often questionable
    - Problem: High air pollution potential → particle filters, clean combustion
    - Further progress towards easy operation, clean combustion and exhaust gas cleaning
    - Deployment in large systems with exhaust gas treatment or in less densly populated areas
  - Biogas use: For heat, CHP (microgeneration, fuel cell) or feed into a gas grid
    - Limited existing potential, economically mostly not viability or questionable
    - Biomass use in fuel cells: Fuel cells still need development
- Swiss strategy regarding biomass feedstock use is not finally clarified
  - Current priorities of use in the NEP energy scenario : Use for transport and CHP
  - Current situation:
    - Most common use in small and medium size combustion units, trend towards pellets use
    - Technologies other than combustion: Further technological development needed

Renewables in buildings: Need for storage technologies

- Fluctuating energy supply of wind and solar → balancing of renewable energy supply and overall energy supply with demand is indispensible:
  - Supply side balancing/storage options for buildings *and for non-building options*:
    - Decentralized heat and power storage capacities (short and long term: batteries, etc.)
    - Heat storage in heat distribution grids (short term)
    - Centralised storage capacities (e.g. pump storage power plant, centralized heat accumulators)
    - Supply turn off (short term: Wind and PV)
  - Demand side balancing/storage options:
    - Demand shift (short term) by the end users
    - Decentralized heat and power storage capacities (short & long term: Batteries, heat storage)
  - Technological prerequisites for wide spread balancing of renewable supply by decentralized demand-control (DSM demand side management) in buildings
    - An adequate (smart) control infrastructure from local to zentral: Smart meter → smart local operation and optimization → smart grid and vice versa.

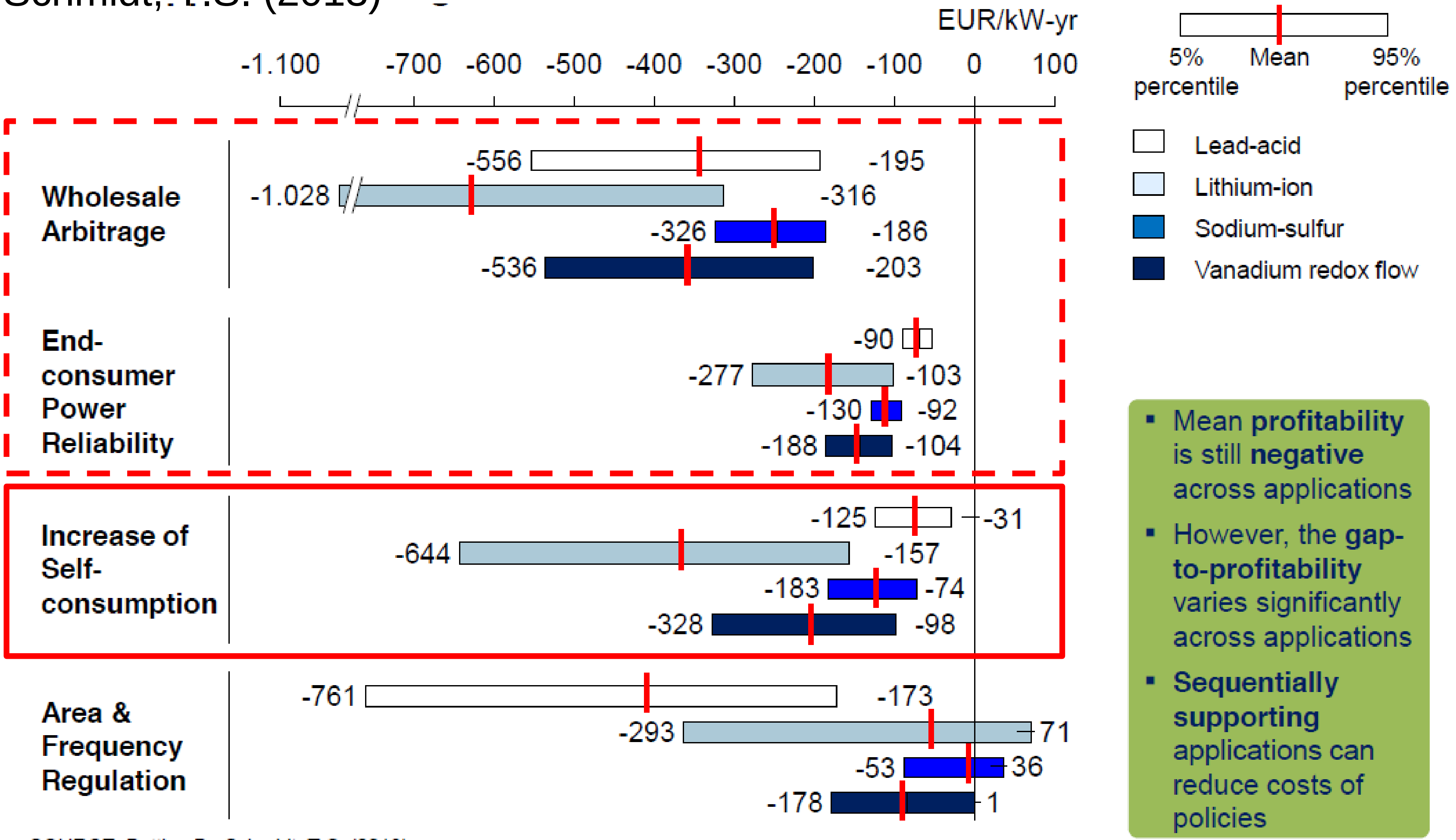
Utilization of storage capacities in the building sector

- On-site short/medium term and seasonal heat storage in buildings
- Electric storage capacities to increase self consumption of on-site generated electricity and possibly arbitrage on the wholesale and regulation markets
- Widespread deployment of decentralized electric storage capacities will not be needed before 2035 (Kema 2013*)
- Nevertheless: Need for R&D for
  - decentralized electric storage capacities to further develop storage technologies and to achieve distinct cost reductions,
  - seasonal heat storage: Progress in technology development and cost reductions is needed

* Kema Consulting: Energiespeicher in der Schweiz; SFOE, 12th December 2013

Profitability of electric storage technologies

- Gap to profitability of 4 electric storage technologies according to Battke, B., Schmidt, T.S. (2013)



- Mean **profitability** is still **negative** across applications
- However, the **gap-to-profitability** varies significantly across applications
- **Sequentially supporting** applications can reduce costs of policies

SOURCE: Battke, B., Schmidt, T.S. (2013)

Energy grids and renewables in buildings

- Relevance of energy grids:
  - Ambitious targets of Swiss energy policy require use of locally available renewable energy sources (and waste heat)
  - On-site potential of renewable energy sources is often limited → better exploitation of theoretical potentials requires decentralized energy sytems
  - Stochastic fluctuations of on-site renewable energy generation challenges grid integration and creates need for optimal use and control of renewable generation
  - To give incentives for optimal allocation and feed-in of on-site generated renewable energy – especially if combined with local storage capacities and/or DSM – requires smart grid information
  - Climate change and increasing thermal comfort requirements will increase cooling needs. In energy grids anergy from cooling can be used for reloading of the heat source of ground source heat pumps

Decentralized energy systems and renewables in buildings

- Decetralized energy systems consist of one/several local energy hubs of energy consumers and mainly on-site renewable energy producers, interconnected by:
  - A multi-energy-grid (heating/cooling supply, electricity, gas),
  - (smart) metering and control systems for the hubs and grids as well as for the local on-site producers of (renewable) energy and for the consumers of energy (DSM),

  deploying:
  - Local and mainly on-site renewable energy generation units,
  - local/on-site electric and thermal storage capacities.
- Decentralized energy systems improve the conditions for renewable energy use in buildings, especially if combined with smart grid, smart metering and deployment of storage capacities

Concluding remarks: Renewables in buildings

- Energy transition in the building sector requires zero non-renewable energy and zero emission buildings, i.e. reduction of energy needs combined with covering remaining needs by renewable energy
- Costs matter: Highly decreasing marginal benefits and increasing marginal costs of energy performance measures favour RES deploy-ment for zero non-renewable energy or zero emission buildings
- If GHG-reduction has high priority: Renewable energy deployment delivers higher contributions than single energy efficiency measures
- Facilitating and increasing deployment of renewables by smart grid, storage and DSM solutions: Explore/consider
  - trade-offs between low tech and high tech solutions
  - practical barriers to build up new grid systems in built districts
  - lock-in effects by grid structures with high initial costs and low flexibility

Thank you for your attention!