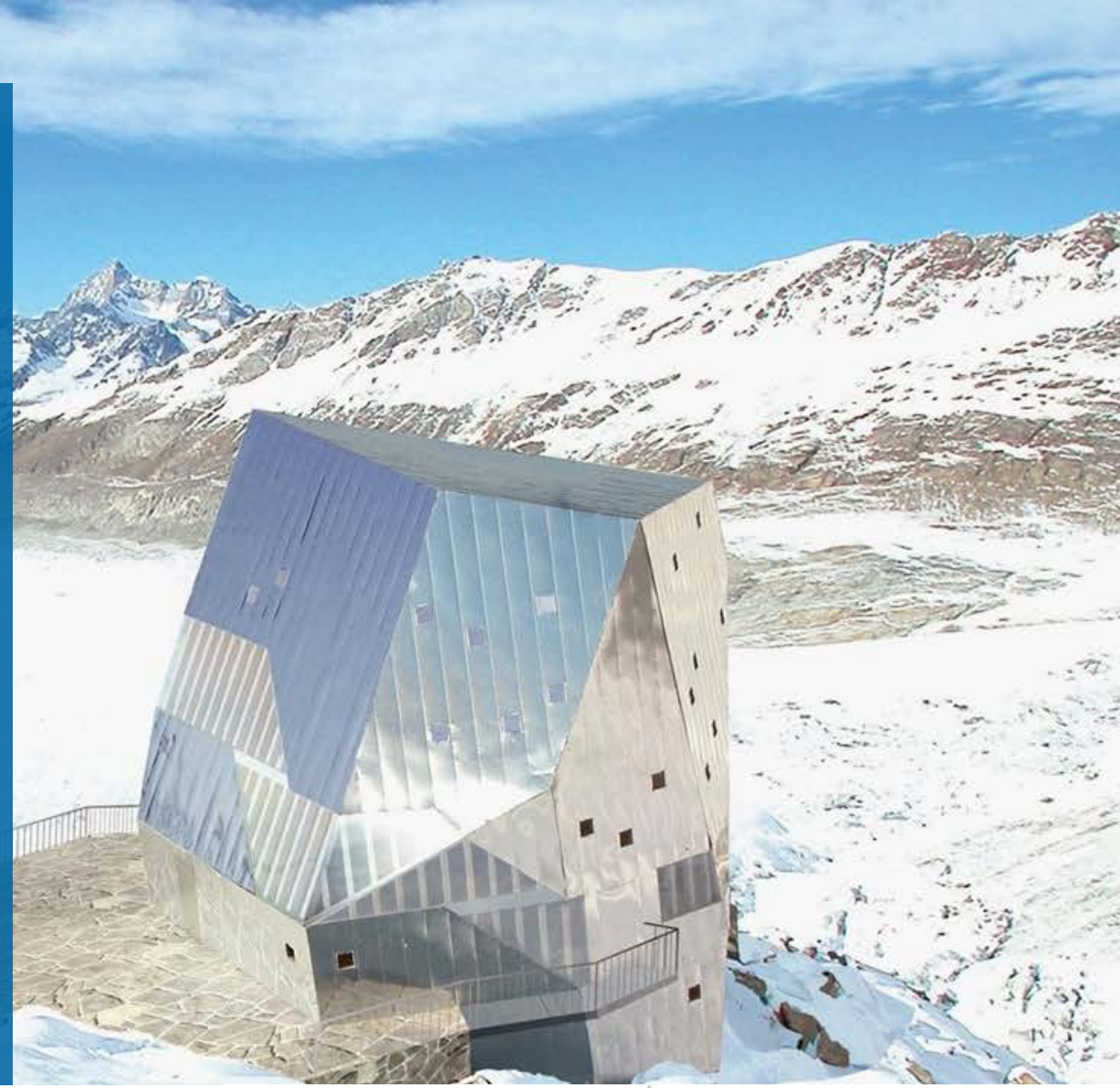
IEA Heat Pumping Technologies TCP
Annex 49

Overview of IEA HPT Annex 49

«Design and Integration of Heat pumps for nearly Zero Energy Buildings»



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Joint Workshop HPT Annex 49 & 50 and EBC Annex 67
12th IEA HP Conference, Rotterdam, May 15, 2017

HSR HOCHSCHULE FÜR TECHNIK RAPPERSWIL
FHO Fachhochschule Ostschweiz

IET INSTITUT FÜR ENERGIETECHNIK

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Federal Office of Energy SFOE

12th IEA HEAT PUMP CONFERENCE 2017 | ROTTERDAM

IEA HPT

iea Energy Technology Network
International Energy Agency

Outline

- **State of heat pumps in nearly Zero Energy buildings**
  - Examples Switzerland
  - State Europe
- **Overview IEA HPT Annex 49**
  - Participants and interested countries
  - Project outline
  - Contributions of participants
- **Conclusions**

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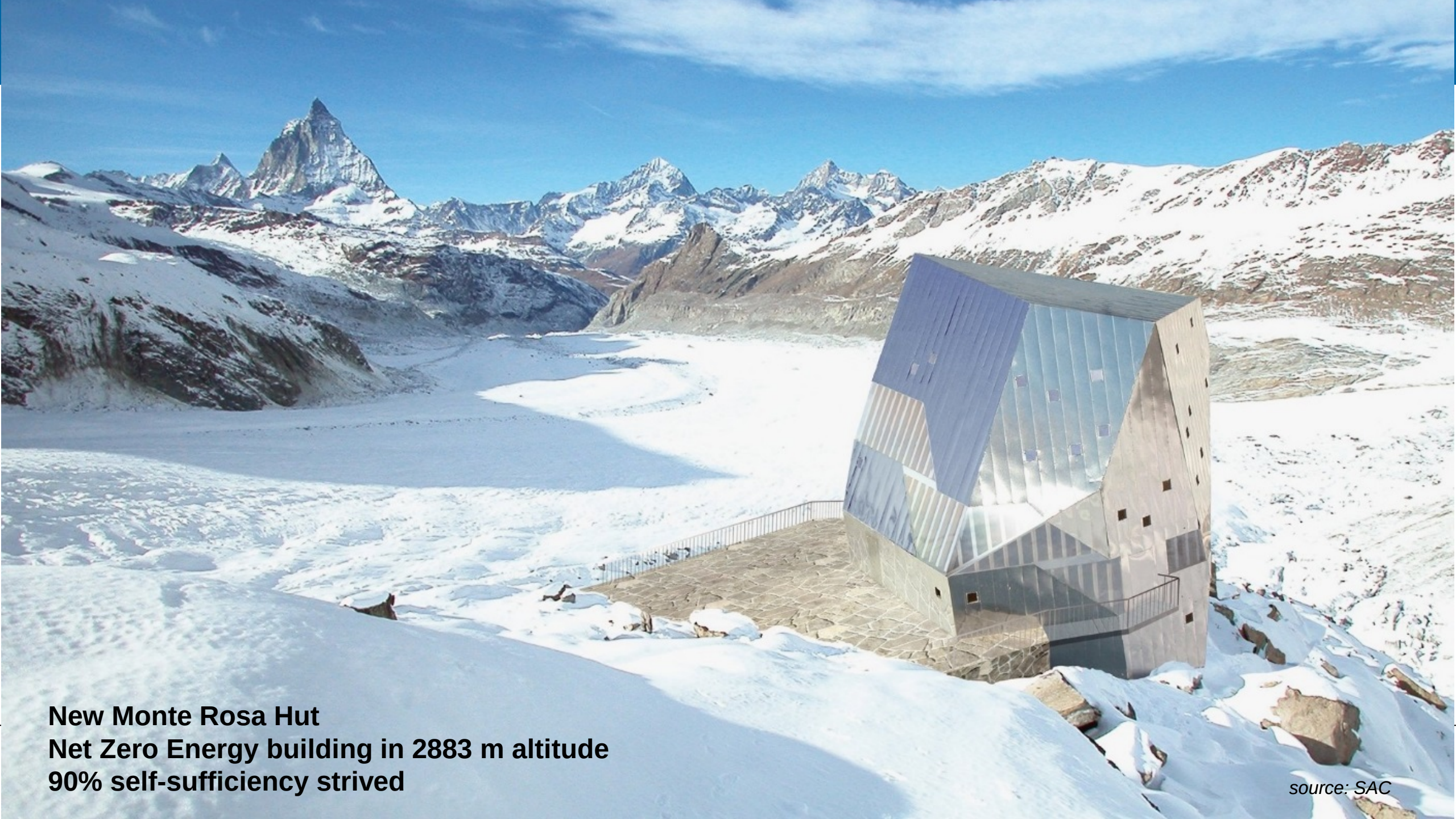


New Monte Rosa Hut
Net Zero Energy building in 2883 m altitude
90% self-sufficiency strived

source: SAC

Retrofitted Office building to Plus Energy
Positive balance measured

source: Viriden, Flumroc

Plus Energy building with façade integrated BIPV
Mixed commercial use, office use and residential use

source: www.black-and-white.ch

Low-Ex Zero Emission neighbourhood
with office and residential buildings
Seasonal ground storage with PV/T charging

source: Zug Estate AG

Low-Ex Zero Emission neighbourhood
with office and residential buildings
Seasonal ground storage with PV/T charging

source: Zug Estate AG

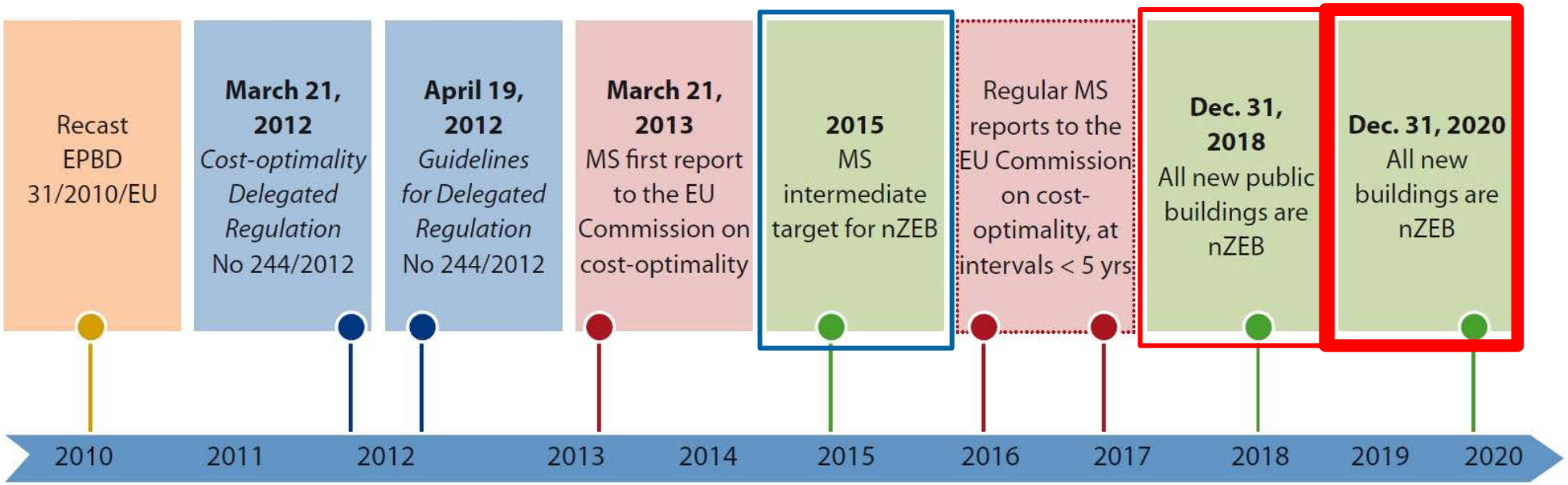
First 100% self-sufficient multi-family house worldwide
No grid connection, sun as only energy source

source: www.umweltarena.ch

State of the art nZEB - Definition and time schedule nZEB EU

DEFINITION “Nearly Zero Energy Building”

- Means a building that has a ***very high energy performance***
- ***Nearly zero or very low energy amount*** should be covered to a ***very significant extent*** by energy from renewable sources, including renewable energy ***produced on-site or nearby***
- **Currently no uniform definition of nZEB**



source: BPIE

State of the art nZEB - Definition nZEB in EU member states

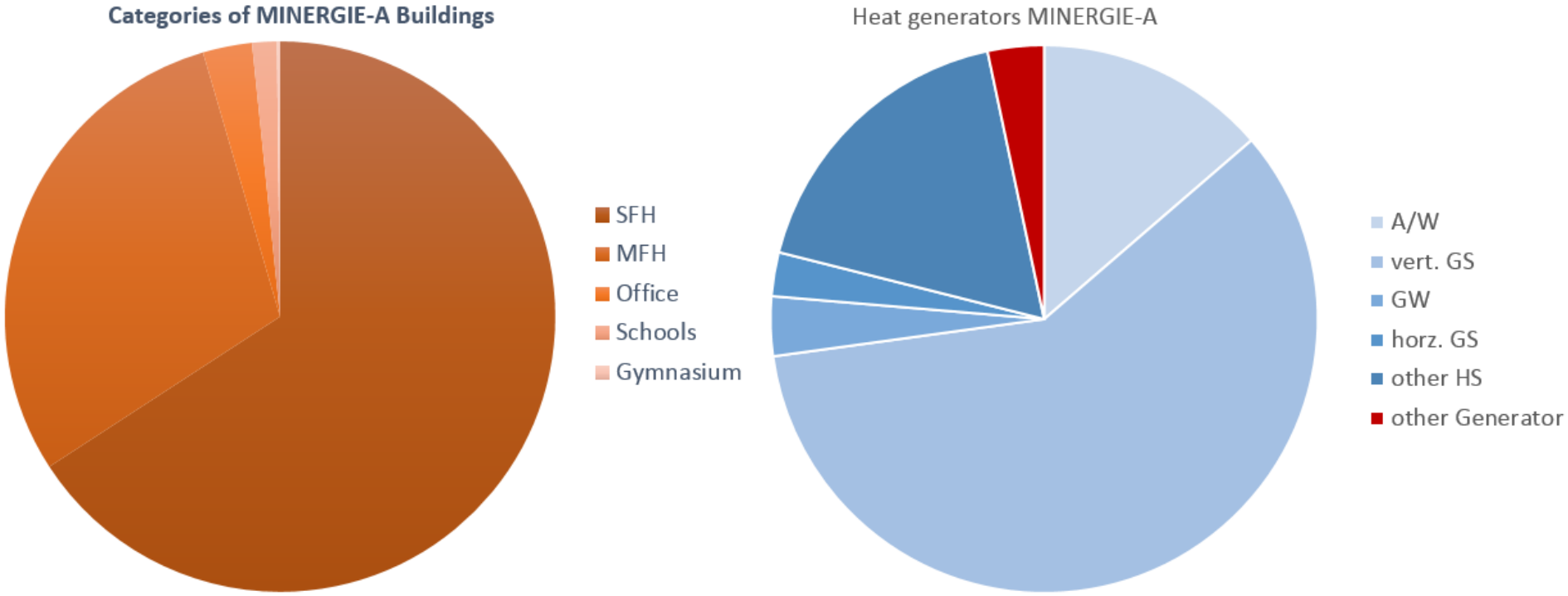
- **State of nZEB definition in the EU (April 2015)**
  - Progress has been made regarding availability of definitions of nZEB in EU Member States (MS) since 2012
  - 15 EU MS have a Definition of nZEB (inkl. Brussels region)
  - Definition in 3 EU MS in approval
  - Definition in 11 EU MS under development (inkl. Norway)
  - Existing definitions vary regarding criteria and limits
  - Some EU MS set more ambitious targets than nZEB
    - NL: Net-Zero-Energy Buildings
    - UK: Net-Zero-Emissions residential Buildings (zero carbon)
    - DK and FR: Plus energy buildings
    - DE: Climate neutral buildings

Quelle: BPIE, 2015

State of the art nZEB – Building system technology in Swiss nZEB

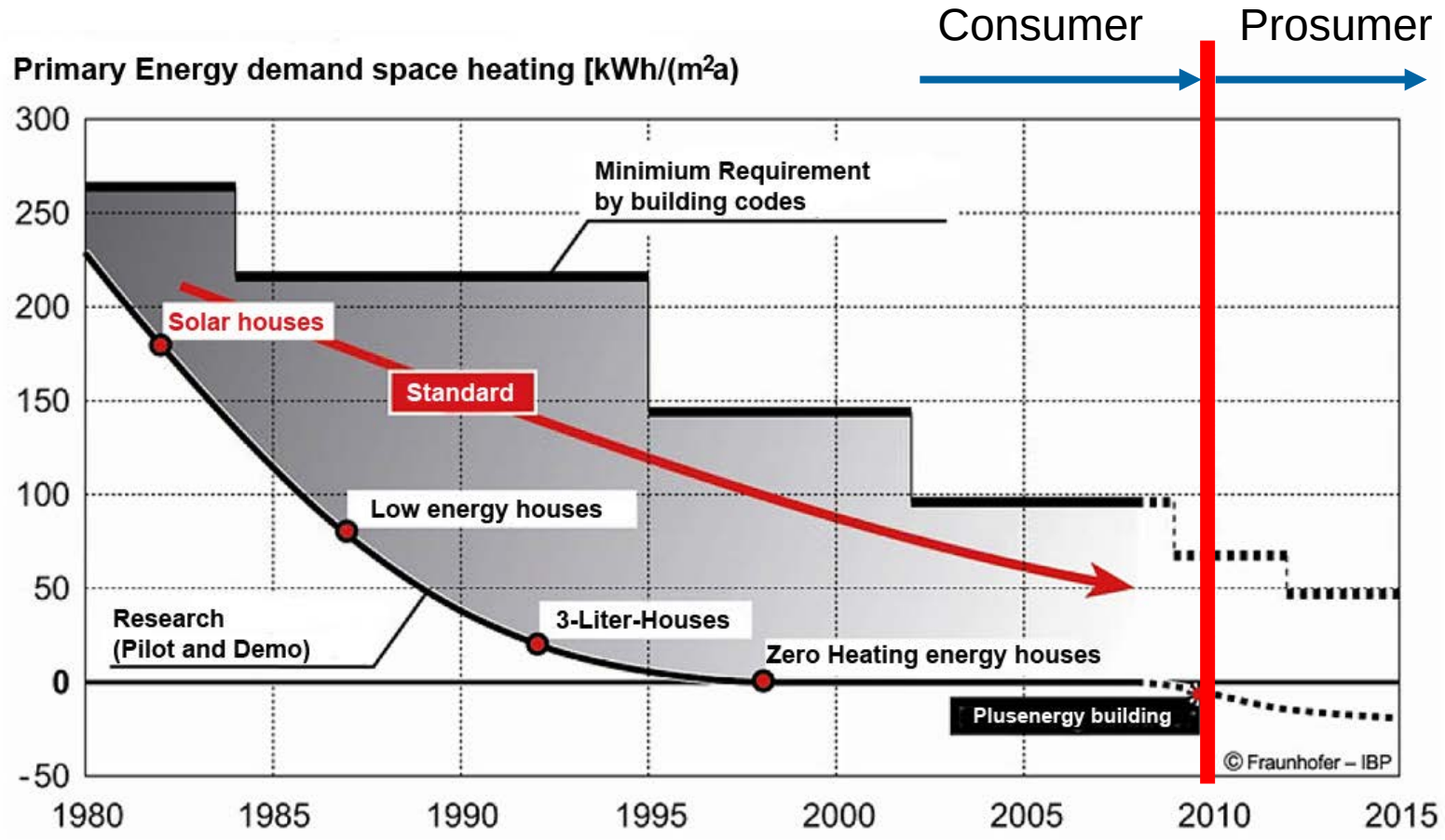
MINERGIE-A®

- **Buildings and building technology in Swiss MINERGIE-A® Buildings**
  - Most realized buildings are single-family houses
  - Dominating concepts are all-electric buildings (Heat pump & solar PV for nZEB balance)
  - In SFH nZE balance relatively easy to reach, since building roof/surface is large enough



State of the art nZEB – Development to nZEB

Development to nZEB



- With nZEB the building is turning from a consumer to a prosumer and storage
- Integration of buildings into energy grids gets more important
- Heat pumps help to access thermal storage capacity of buildings for load management and grid support

Source: Fraunhofer IBP, 2015

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Participating and interested countries and institutions

- **Participating and *interested* countries and institutions**


AT: Energy efficient building working group of University of Innsbruck


BE: Aero Thermo Mechanics, Free University of Brussels


CH: Institute of Energy Technology of the University of Applied Sciences Rapperswil


DE: Energy campus TH Nürnberg, TEB GmbH, IGS of Technical University of Braunschweig



ES/FI: Aalto University,Tallinn University of Technology


JP: University Nagoya, HPTCJ


NO: SINTEF Energy Research, NTNU, COWI, Enova SF


SE: RISE, Swedish manufacturers

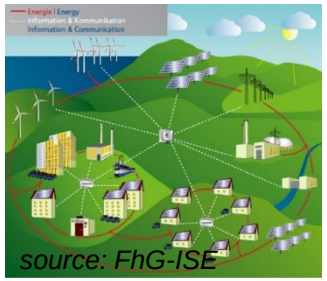

UK: Glen Dimplex


US: Oak Ridge National Laboratory, CEEE of University of Maryland, NIST

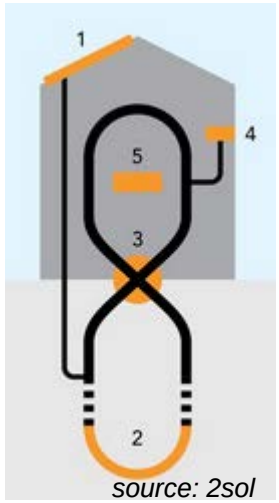
Project structure IEA HPT Annex 49

- **Task 1: Update on definitions and heat pump applications**
  - Definition of nZEB in participating countries
  - Conclusions for system configurations and design
- **Task 2: System integration**
  - Evaluation of integration options (storage, ground, building envelope)
  - Integration of nZEB into connected energy systems and grids
- **Task 3: Prototype development and field monitoring**
  - Development of integrated heat pump prototypes
  - Field monitoring of new and existing nZEB with heat pump
- **Task 4: Design and control of heat pumps for nZEB**
  - Design criteria regarding performance, cost and demand response
  - Controls for improved self-consumption and grid-supportive operation

source: BPIE



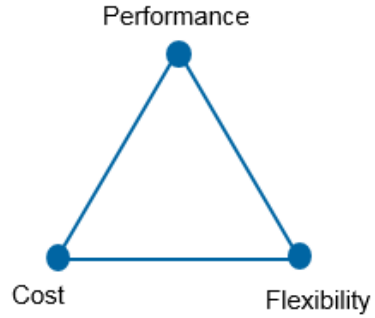
source: FhG-ISE

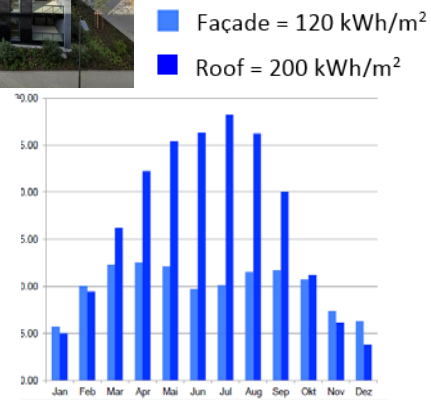


source: 2sol

source: ORNL

source: IGS





source: Viridén

Contribution to Task 2

- **Contributions to Task 2: Integration of heat pumps**

AT: Simulation of two passive MFH with heat pump and solar PV and solar thermal collectors

BE: Evaluation of water as heat source for large nZEB

CH: Integration of heat pumps and solar technologies

DE: Simulation of storage integration for group of terraced nZEB dwellings

ES/FI: Integration of heat pumps and ground

JP: Heat pumps in office buildings

SE: Comparison of system configurations acc. to Swedisch definitions

UK: Investigation of building technology for nZEB with building company

US: Simulation of Net Zero Energy Residential Testing Facility

Contribution to Task 3

- **Contributions to Task 3: Prototype developments and field monitoring**

AT: Field monitoring of two passive MFH with heat pump and solar PV and solar thermal collectors

BE: Field monitoring of Belgian nZEB

CH: Field monitoring of plus energy office with ground heat pump and façade integrated PV

DE: Monitoring of 3 nZEB (single family, multi-family, educational building)

NO: Monitoring of different residential and non-residential buildings

SE: Prototype development and testing in twin houses

UK: Investigation of building technology for nZEB with building company

US: Monitoring of integrated heat pump prototypes in different applications

Contribution to Task 4

- **Contributions to Task 4: Design and control for heat pumps for nZEB**


CH: Design for heat pumps, ground and integrated solar components


DE: Heat pump control for smart grid, design recommendations for storage integration



ES/FI: Design guidelines for heat pumps in nZEB


NO: Design tool for heat pumps of Zero Emission houses, Design/control for smart heat pumps


SE: Design and operation of capacity controlled heat pumps


UK: Investigation of building technology for nZEB with building company


US: Design evaluation based on testing in NZERTF

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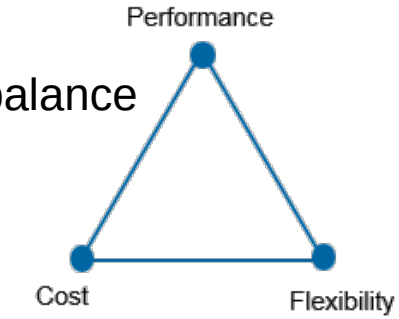
Conclusion

- **Introduction of nZEB**
  - Tight time schedule for the introduction of nZEB in the EU
  - Different definitions in the EU member countries
  - North-America and Japan also declared nZEB as future building requirement

source: BPIE

- **All electric buildings are an archetype solution for nZEB**
  - Buildings with heat pump and solar PV are a standard system to reach nZEB

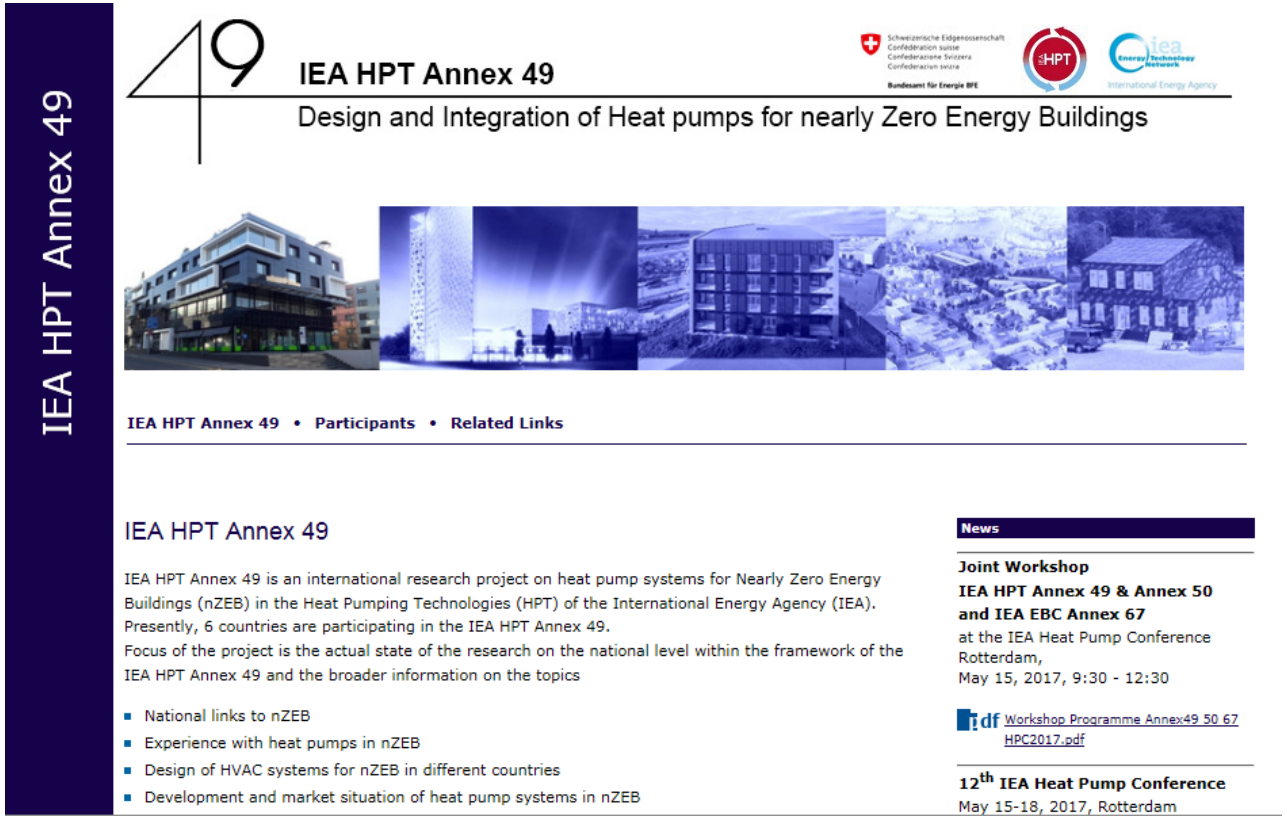
- **Heat pumps for the application in nZEB**
  - Heat pumps are high performance generators in nZEB operating conditions
  - High performance of heat pumps reduces necessary energy production on-site to keep the balance
  - Heat pumps can cover different buildings services with one generator
  - Heat pumps are among the main electricity consumers and enable load management for optimised self consumption of on-site electricity



Information on IEA HPT Annex 49

- **Website IEA HPT Annex 49**
  - Information and links to nZEB
  - Outline of project
  - Information to the participants and national project contributions
  - Download of publications
  - Workshop publications
  - Links to related projects and organisations

- **http://www.annex49.net**



Thank you for your attention

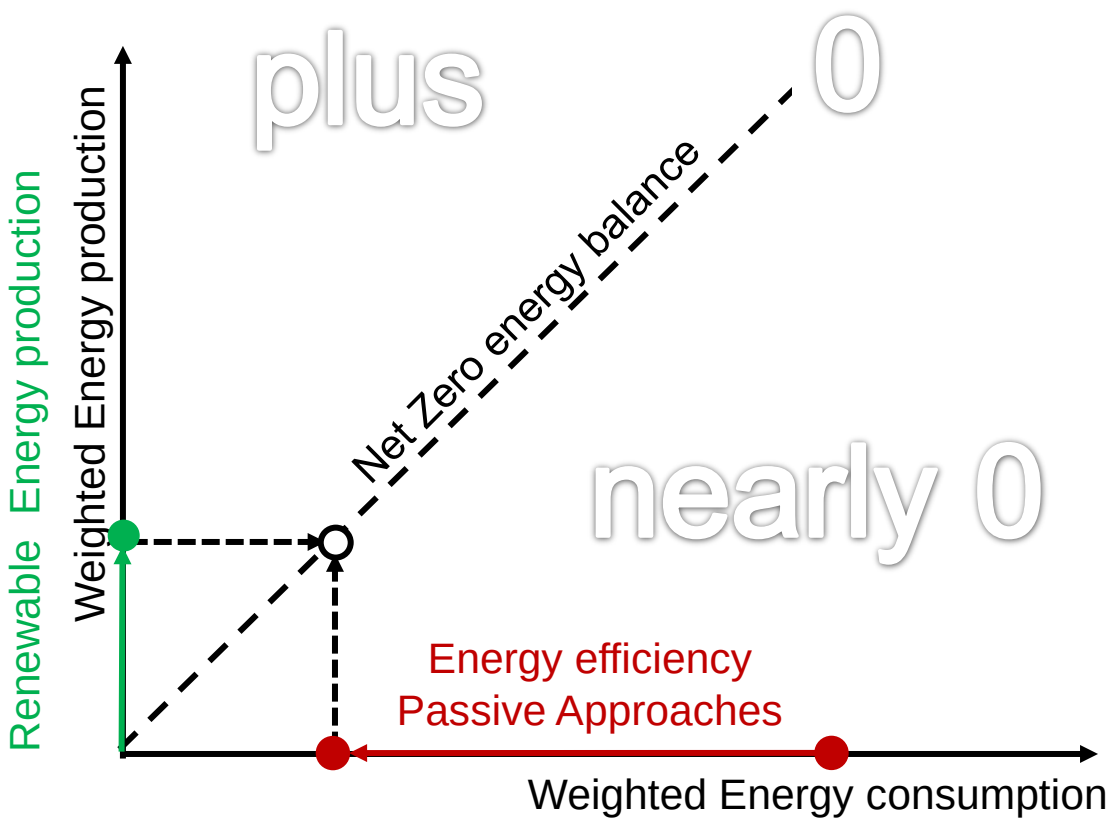
Discussion

- **What is the experience with national nZEB concepts?**
- **How will the introduction of nZEB affect heat pump application?**
- **How can heat pumps unlock retrofitting potentials?**
- **Which strategies for retrofitting to nZEB level exist on the national level?**
- **What are the biggest challenges for heat pump application in multi-family buildings?**
- **How are nZEB best integrated in the energy system?**
- **What is the state of smart heat pumps for self-consumption and grid-supportive operation?**

Discussion

Zero = Zero? Definitions of nZEB

- **Principle of nZEB (nearly-Zero Energy Building)**



Based on Sartori et al. (2012)

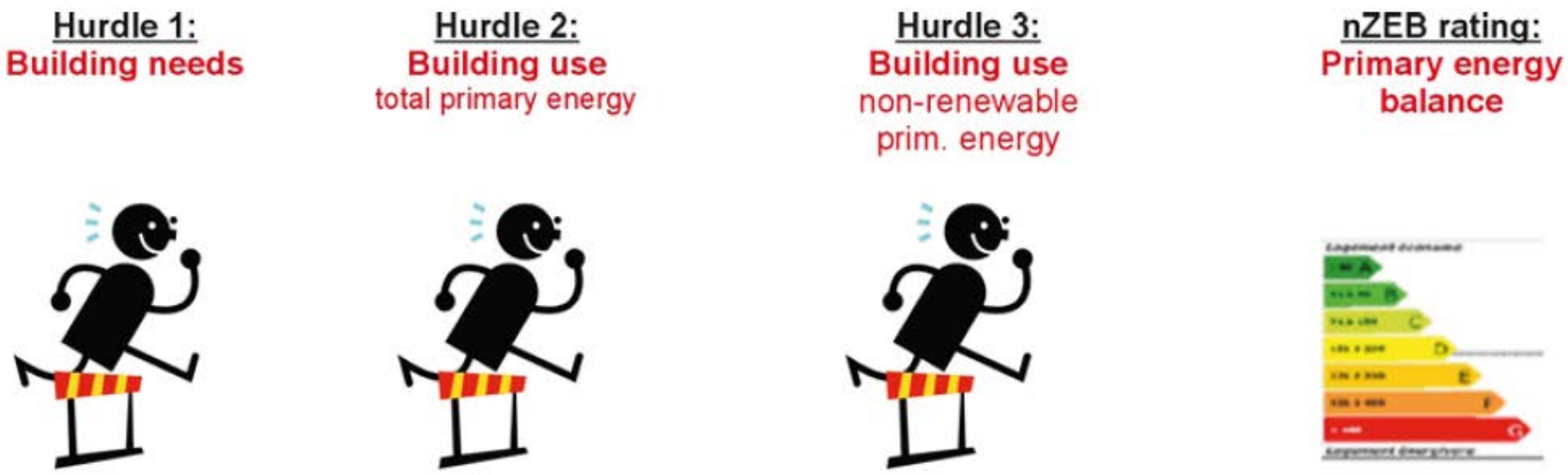
Items for a consistent definition and currently most common choices

- System boundary:
  Physical Boundary (**Buildings,** Group, Neighbourhood)
  Balance Boundary (**Building technology**, **Plug loads**, Embodied Energy)
- Weighting system:
  Metric (**Primary energy**, CO_2, cost)
  Symmetric Weighting (**symmetric**, asymmetric)
  Time dependent weighting (time dependent, **time independent**)
- Net-Zero Balance:
  Balance period (hour, month, **year**, life cycle)
  Balance time step (hour, **month, year**, life cycle)
  Type of Balance (**Design** (**Demand)**, Measurement (Consumption))
  Requirement Energy efficiency (**Envelope, Illumination, Plug loads**)
  Requirement Energy production (**minimum renewables**, none)
- Temporal Energy profile:
  load match (Supply cover factor, load cover factor)
  Grid interaction
- Measurement concept and verification:
  Compliance with Balance (**Design values**, consumption values)

CEN Rating procedure for nZEB

- **CEN standard for nearly Zero Energy Buildings (nZEB rating)**
  - “on-site” energy production is related to the building or the estate
    => uniform and stron relation to the building
  - “nearby energy source” refers to a close technical or contractual link
    to the building, which e.g. requires special technologies (e.g. district heating, investment wind power)

- **CEN nZEB rating procedure (informative)**



Quelle: Zirngibl (2014)

Annex 40 Task 2 - Simulation study of system concepts

- **Investigated concepts and boundary conditions:**

Photovoltaic

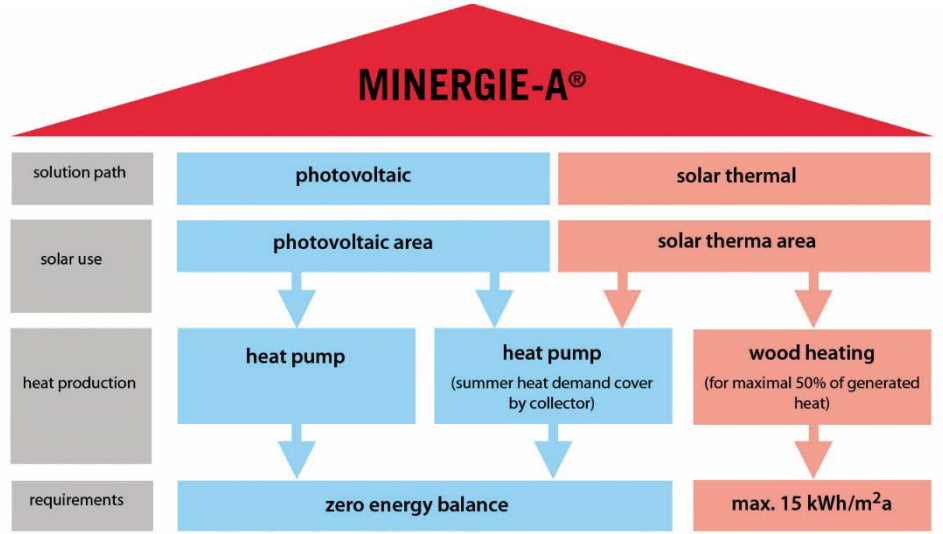
Air-water or brine-water heat pump

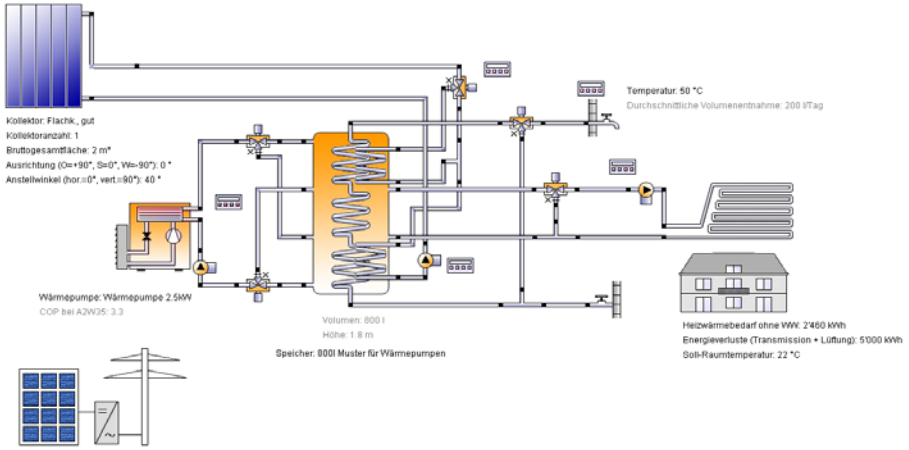
Solar thermal

District heating

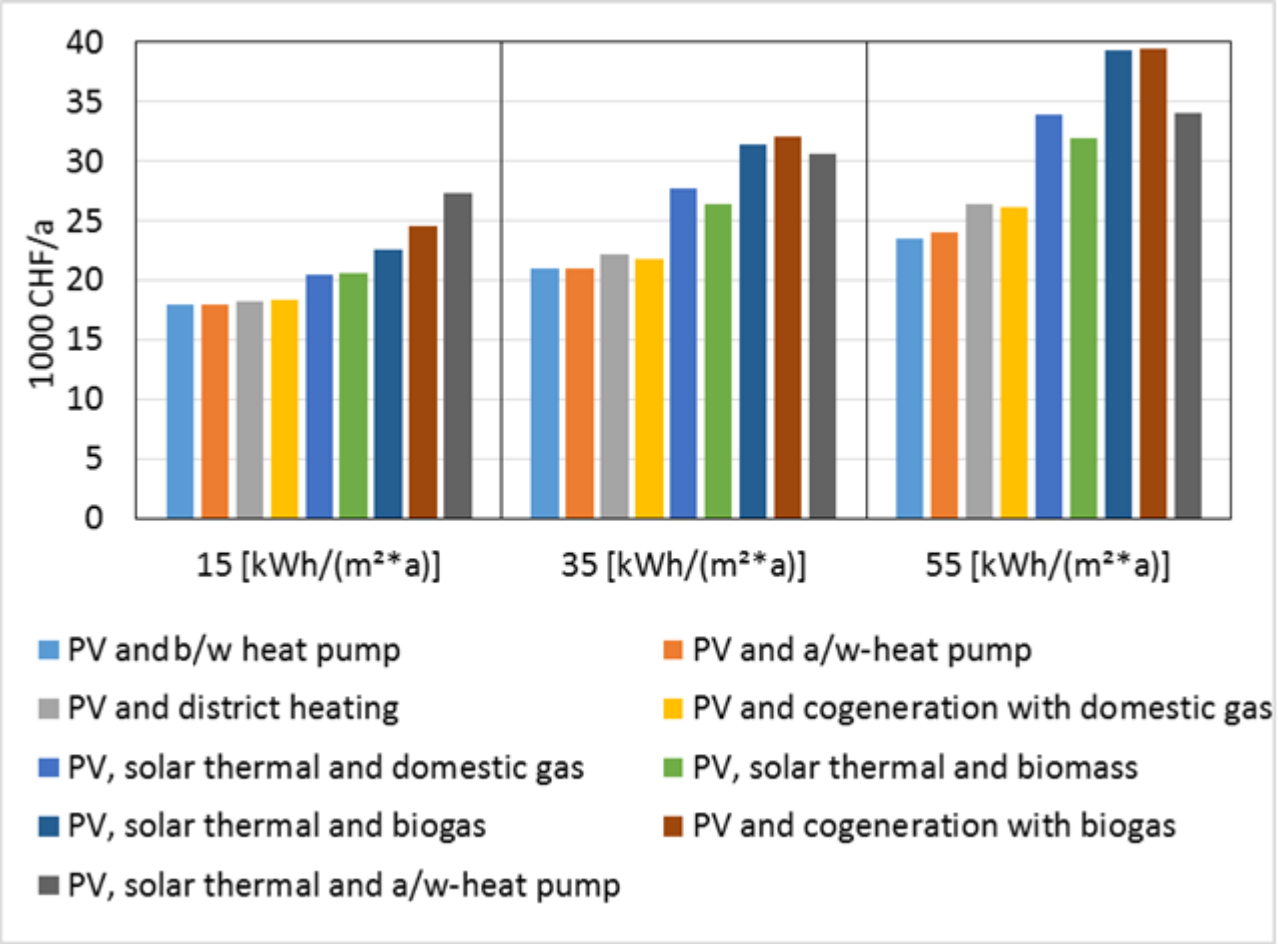
Cogeneration with fuel oil, biogas and natural gas

Space Heating/DHW with oil, biomass, biogas or domestic gas





Annex 40 Task 2 – cost balance of system comparison in residential buildings



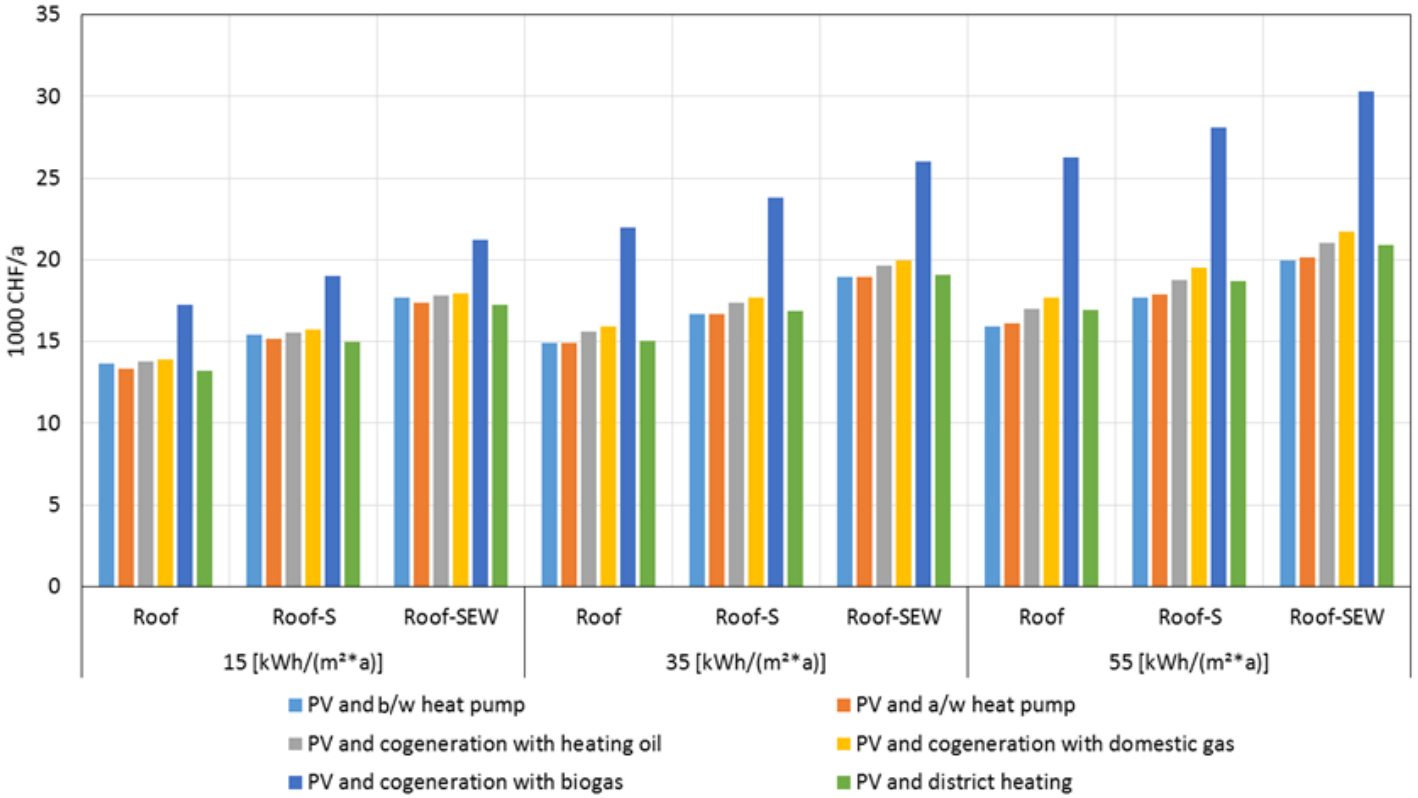
Single family house

- nZEB reached up to 55 kWh/m²/a
- HP energy- and cost-efficient solution
- A/W-HP cheaper as B/W-HP for lower Energy demand
- Solarthermal system tend to increase the cost
- Systems with biomass more costly, especially biogas

Multi-family house

- nZEB is reached, but for higher spec. demand facade for solar PV has to be used
- Heat pump, district heat and CHP have lowest cost
- B/W-HP is cheaper than A/W-HP with increasing energy demand
- Biogas systems have the highest cost

Annex 40 Task 2 – cost balance system comparison office buildings



Office buildings

- Up to 3 storeys nZEB can be reached in offcies with use of PV on the roof
- Limit for nZEB at 3-4 storeys for solar PV only on the roof
- B/W heat pump and CHP with biogas have the best performance regarding the energy balance
- At low heat demand lower investment cost of district heating compensate the higher operation cost
- For higher heat demand, the lower operation cost and the smaller PV areas increase the competitiveness of heat pumps
- CHP has advantages by the lower required PV area and the weighting factor of electricity of 2
- CHP and PV have a good load match