



## Finnish Solutions for Zero Energy Building

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## Definitions



### Net zero energy buildings

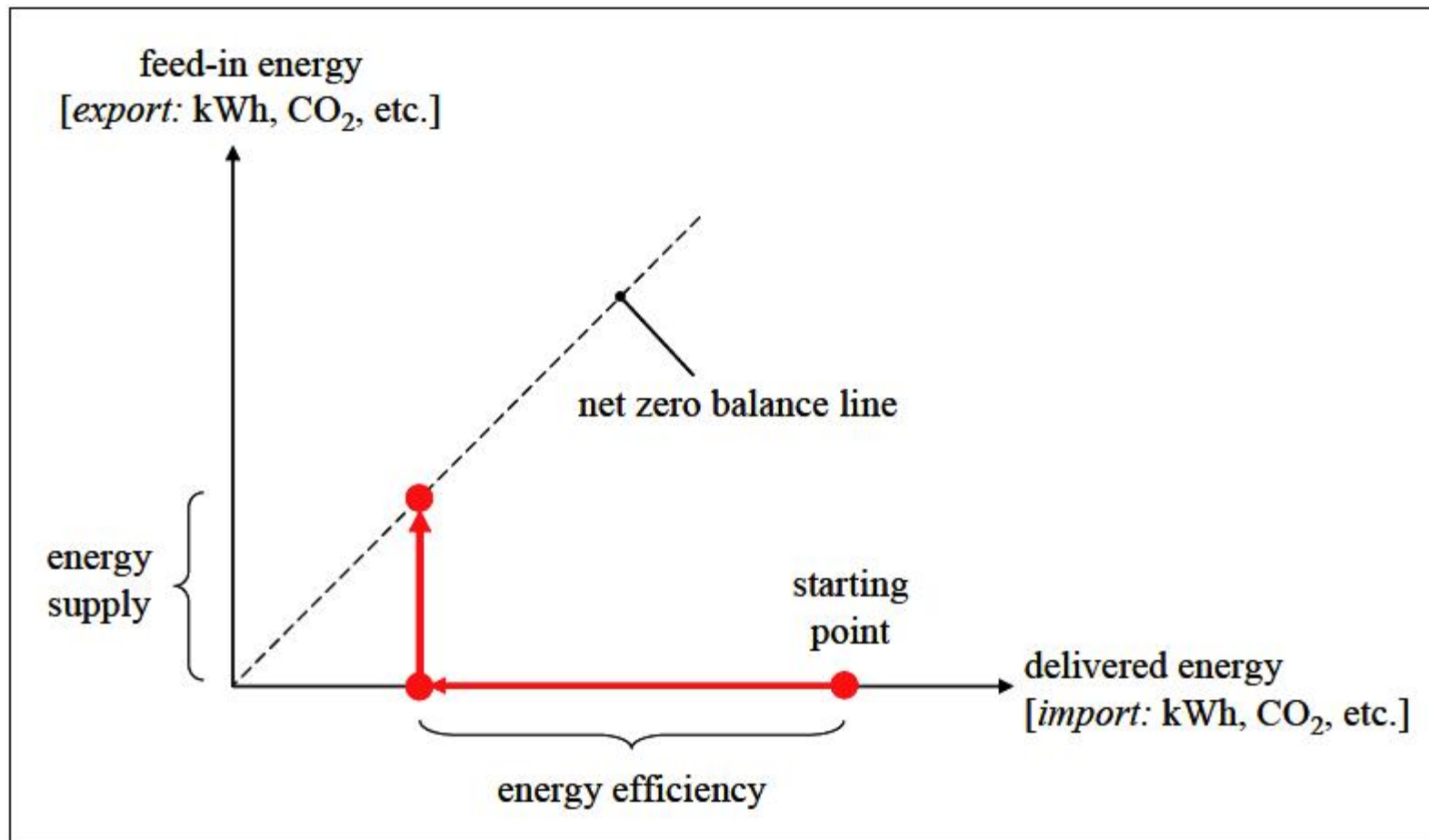
- The amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building
- Yearly balance
- Pilots in Finland: Kuopio, Järvenpää, Mäntyharju, Luukku/Aalto-Yliopisto



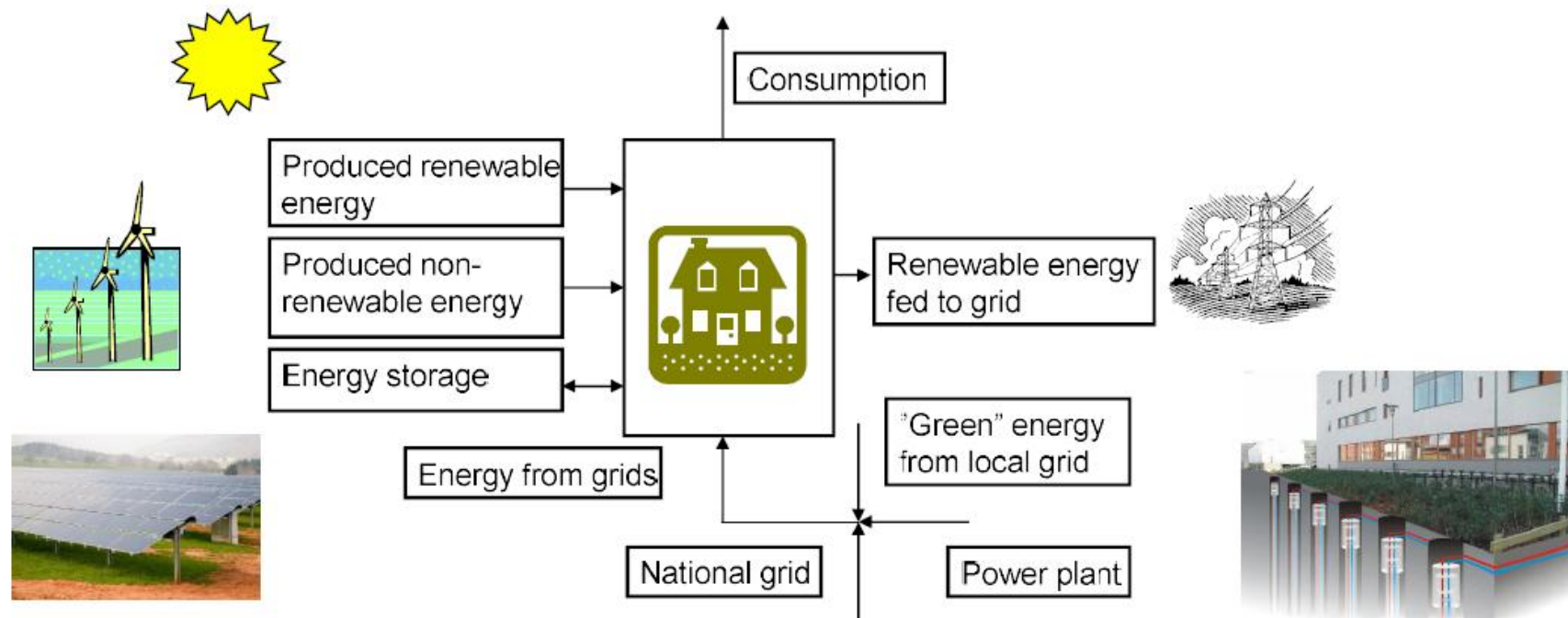
### EPBD: Nearly zero energy building

- NZEB's are buildings with very high energy performance and their energy requirements are covered by renewable energy sources to a significant extent
- Example in Finland: Pietarsaari 1994

## Energy efficiency is the key

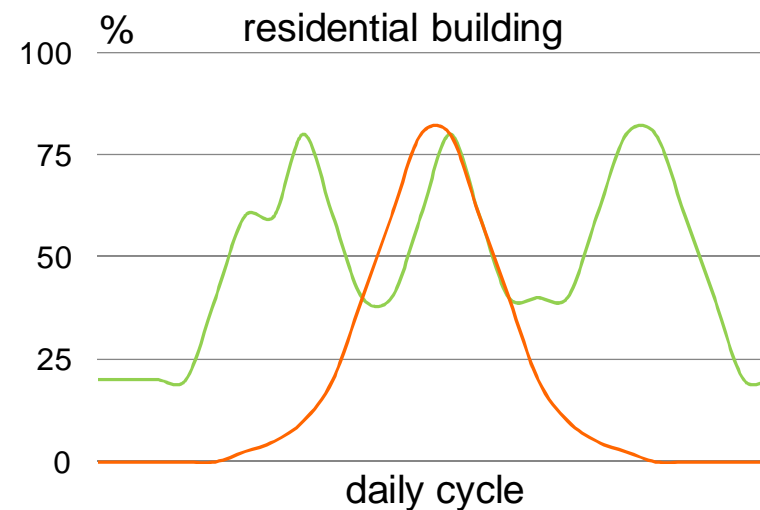
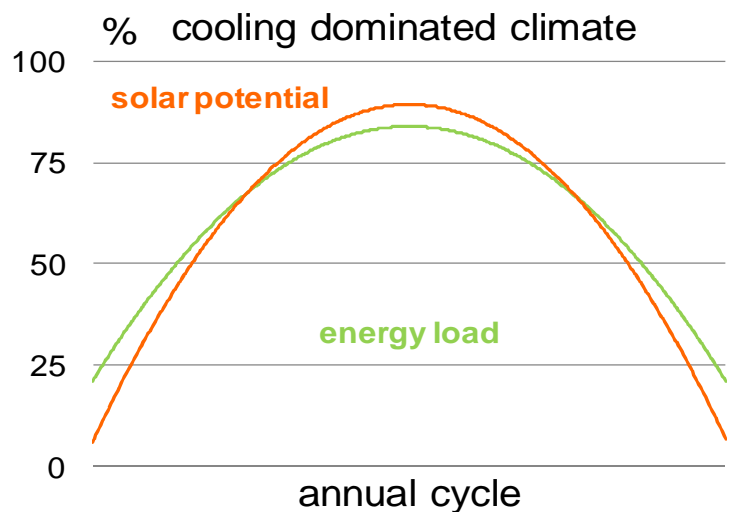
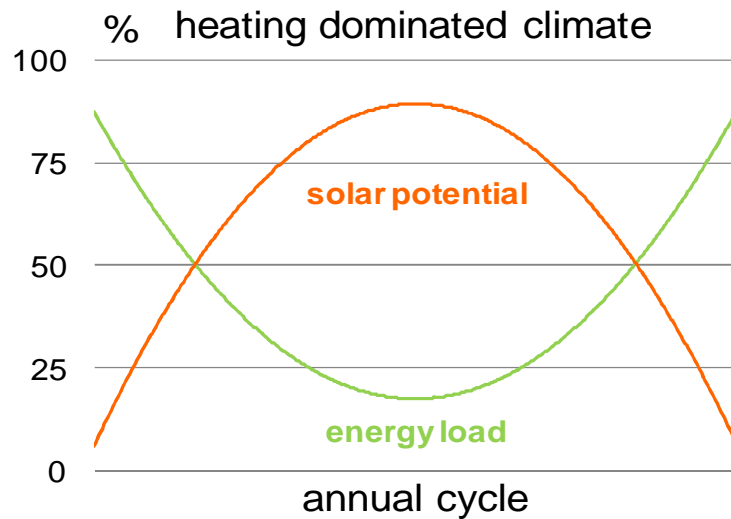


## Net zero energy principle



## Energy use and supply mismatch

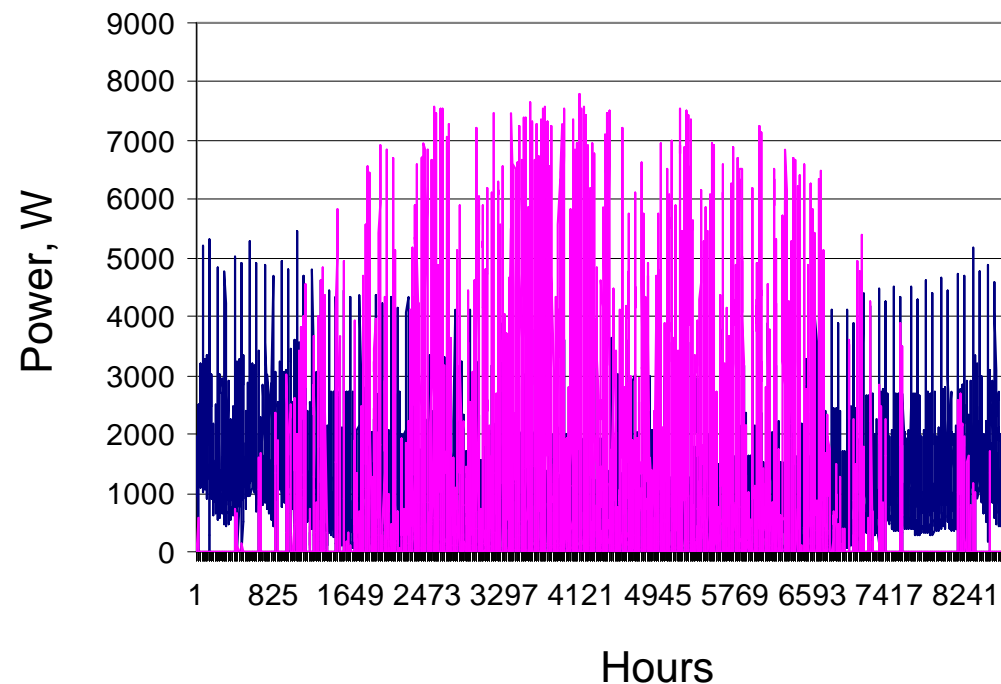
- Optimization of yearly demand and supply
- Energy efficiency reduces mismatch
- Other means
  - Energy storages
  - Orientation (PV): Supply responds demand more efficiently



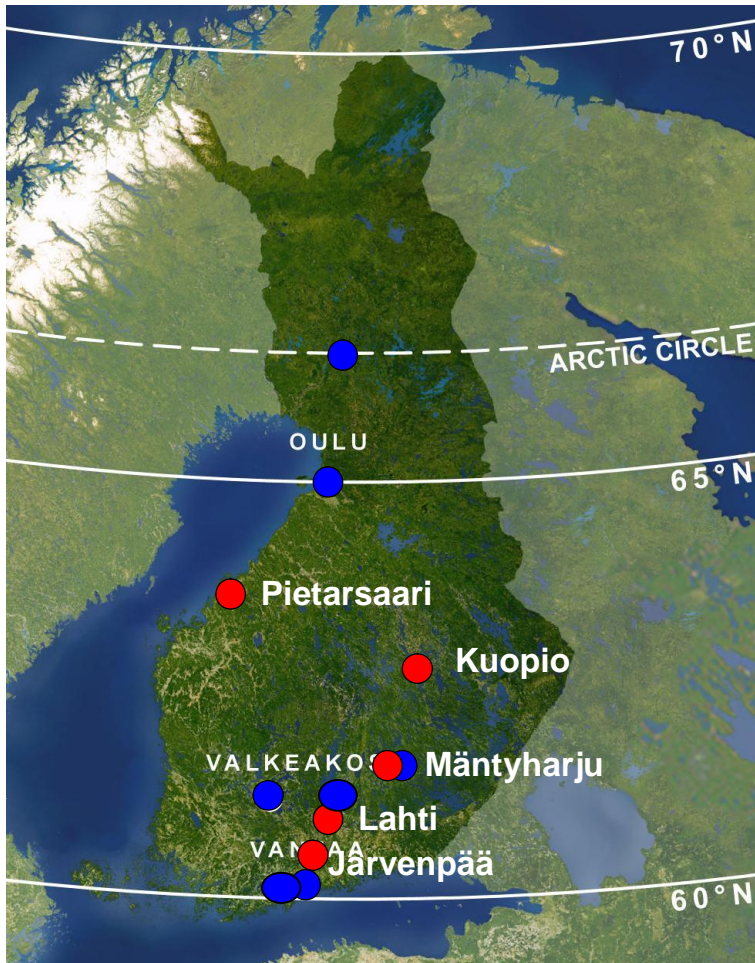
## Zero energy design challenges

- Mismatch between local energy use and production
- Dark and cold winter vs. bright and sunny summer
- Energy storages in off-grid solutions
- Grid integration (electricity, district heat and district cooling)
- System dependencies: heating, cooling, thermal mass, internal loads, solar load
- Whole building solution
- Cost effectiveness

Hourly performance of a zero energy house. Total demand 8400 kWh/m<sup>2</sup>. 10 kW PV



## Examples of net zero and nearly zero energy buildings in Finland



- Net zero energy buildings:
  - Järvenpää: Apartment house 2124 m<sup>2</sup>
  - Kuopio: Apartment house 2124 m<sup>2</sup>
  - Mäntyharju: Single-family house 154 m<sup>2</sup>
  - Hyvinkää: Single family house 160 m<sup>2</sup> (2013)
- Nearly zero energy buildings:
  - Pietarsaari: Single-family house 165 m<sup>2</sup>
  - Lahti: Elderly service centre 16 500 m<sup>2</sup>

- Net zero and nearly zero energy buildings
- Passive buildings

## Very low energy buildings

**Passive house Lupaus, Valkeakoski:**  
Total energy demand < 60 kWh/m<sup>2</sup>



[www.paroc.com](http://www.paroc.com)



**Paroc Passive house, Vantaa:**  
Total energy demand < 60 kWh/m<sup>2</sup>

## Very low energy buildings

**MERA Passive apartment house, Heinola:**  
Heating demand < 25 kWh/m<sup>2</sup>



[www.merainfo.fi](http://www.merainfo.fi)

**TA Passive apartment house, Oulu:**  
Heating demand < 30 kWh/m<sup>2</sup>



[www.ta.fi](http://www.ta.fi)

## Net zero energy building, Kuopio



[www.nollaenergia.fi](http://www.nollaenergia.fi)

### Energy demand

Space heating	12 kWh/m <sup>2</sup>
Water heating	13 kWh/m <sup>2</sup>
Electricity, facility	6 kWh/m <sup>2</sup>
<u>Total</u>	<u>31 kWh/m<sup>2</sup></u>

### Renewable energy

PV	7 kWh/m <sup>2</sup>
Solar thermal	16 kWh/m <sup>2</sup>
Ground heat	12 kWh/m <sup>2</sup>
<u>total</u>	<u>35 kWh/m<sup>2</sup></u>

### Excluded

Residents electricity	16 kWh/m <sup>2</sup>
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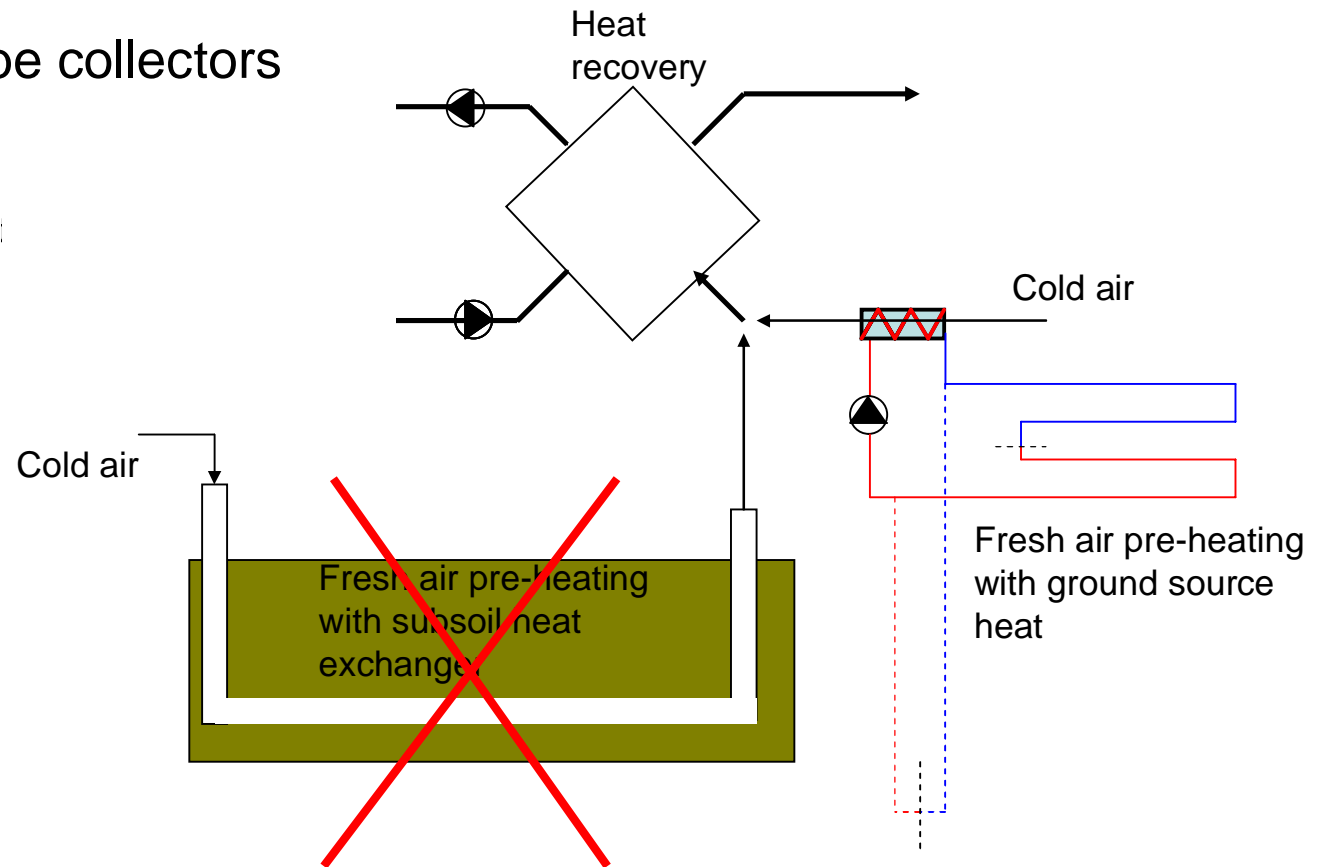
## ZEB solutions



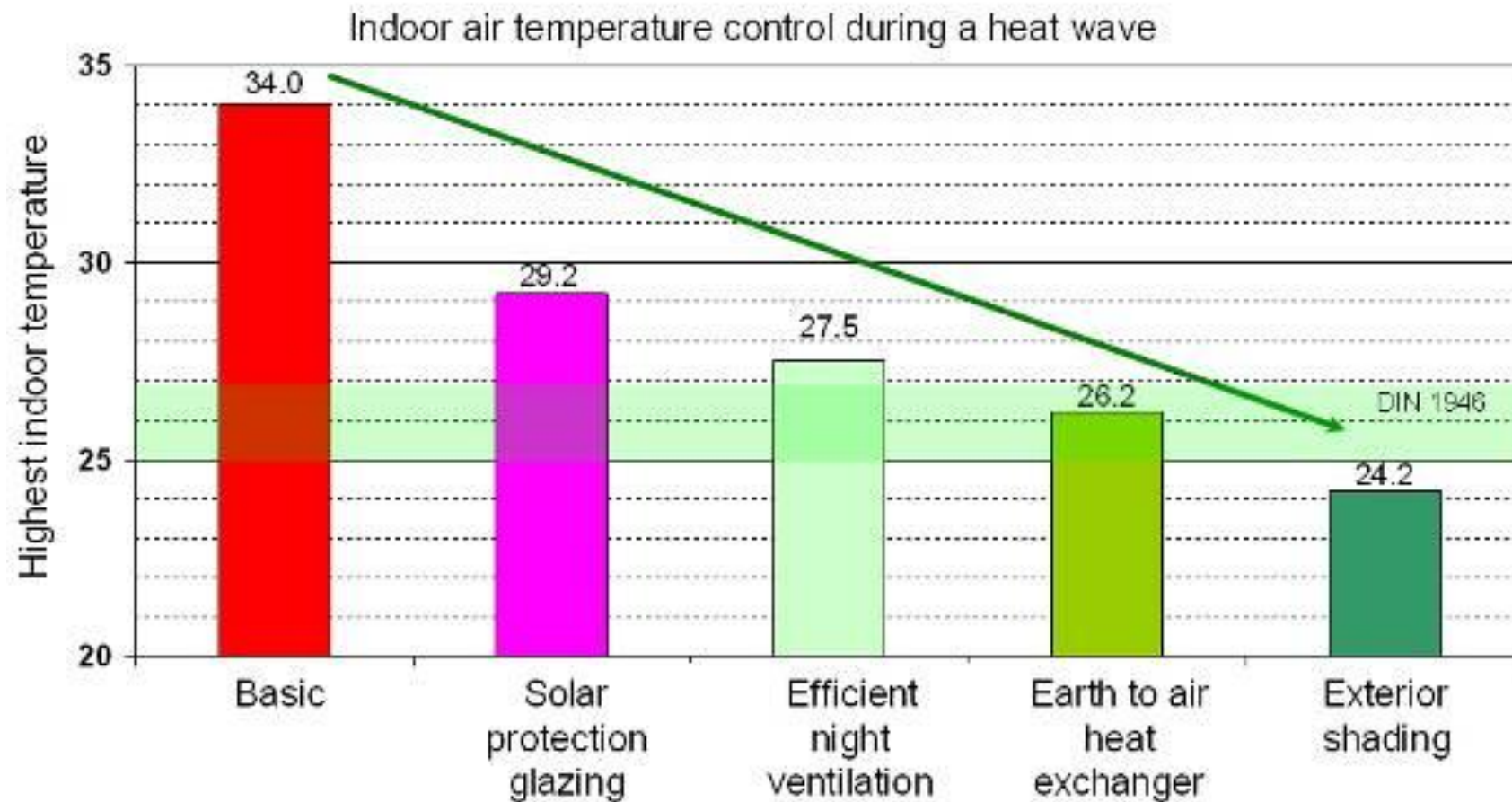
- Low demand
- Air tightness  $n_{50} < 0,4$  1/h
- High insulation level
- All equipment energy classified: A++
- Low water consumption: 30 m<sup>3</sup>/person/year
  - Water saving fixtures, low pipe pressure, metering (user pays)
- Low electricity demand of all HVAC equipment
- Building integrated renewables
- Back-up heat: district heat
- Back-up electricity: grid
- **On site supervision and management**

## Renewable energy systems

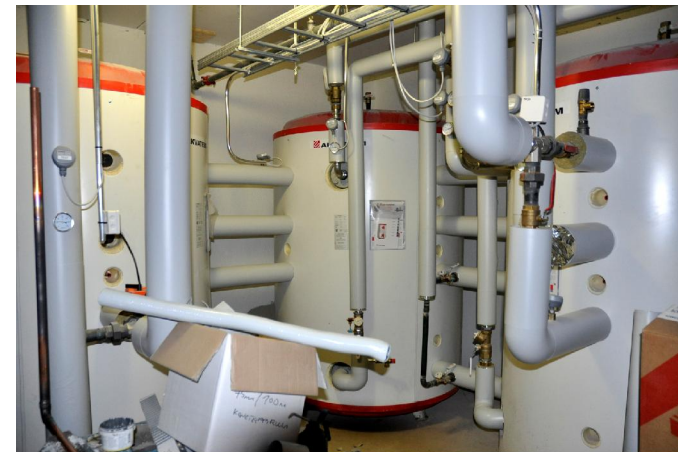
- PV panels: 14 kW
- Solar collectors: vacuum tube collectors



## Solar control - cooling may be the main problem!

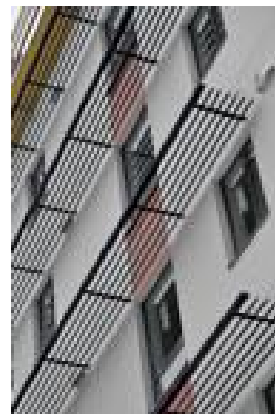


## NZEB Järvenpää 2011



PV panels 14 kW ~ 108 m<sup>2</sup>

Solar thermal 126 m<sup>2</sup>



## Net zero energy house, Mäntyharju



- Systems integration, building system
- Ground source heat pump heating
  - Low-temperature floor heating
- Solar collectors for hot water heating (50 %)
- Water saving fixtures (25 % savings)
- Lighting: LED (30 – 50 % savings)
- Shading / blinds
- Ventilation pre-heating/cooling
- Energy classified household appliances
- Energy demand 7000 kWh = 45 kWh/m<sup>2</sup>
- Solar collectors 5 m<sup>2</sup>
- PV panels 8 kW<sub>p</sub>

## IEA5-Solar House



- Ground source heat pump
- Solar thermal
- PV
- Quality
- Professional use
- High insulation level

	Pietarsaari 1993	Tavallinen 2011
<b>Component</b>	<b>U-value [W/m<sup>2</sup>K]</b>	
Wall	0,12	0,17
Roof	0,09	0,09
Floor	0,1	0,16
Door	0,4	1,0
Window	0,7	1,0

## Nearly zero energy house

- Pietarsaari 1993: Purchased energy  $< 50 \text{ kWh/m}^2$
- Technical development: Purchased energy  $< 40 \text{ kWh/m}^2$
- PV:
  - Present system  $2 \text{ kW}_p$
  - Possible renewal  $\sim 8 \text{ kW}_p \Rightarrow \text{NZEB}$



## Elderly home, Lahti



- Nearly zero energy building
- Energy demand 60 kWh/m<sup>2</sup> primary energy
- 16500 m<sup>2</sup>
- Priority in user needs
- Procurement
- Bidding process
- Ground heat/cool
- District heating (renewable!)
- PV
- Atrium

## Nearly zero housing area



- Mainly detached, semi-detached and row houses
- Total floor area 27000 m<sup>2</sup>
- Energy systems for varying energy efficiency levels
  - Building code 2010
  - Building code 2012
  - EPBD 202
- Heat pump heating
- Electricity supply
  - Wind power
  - PV

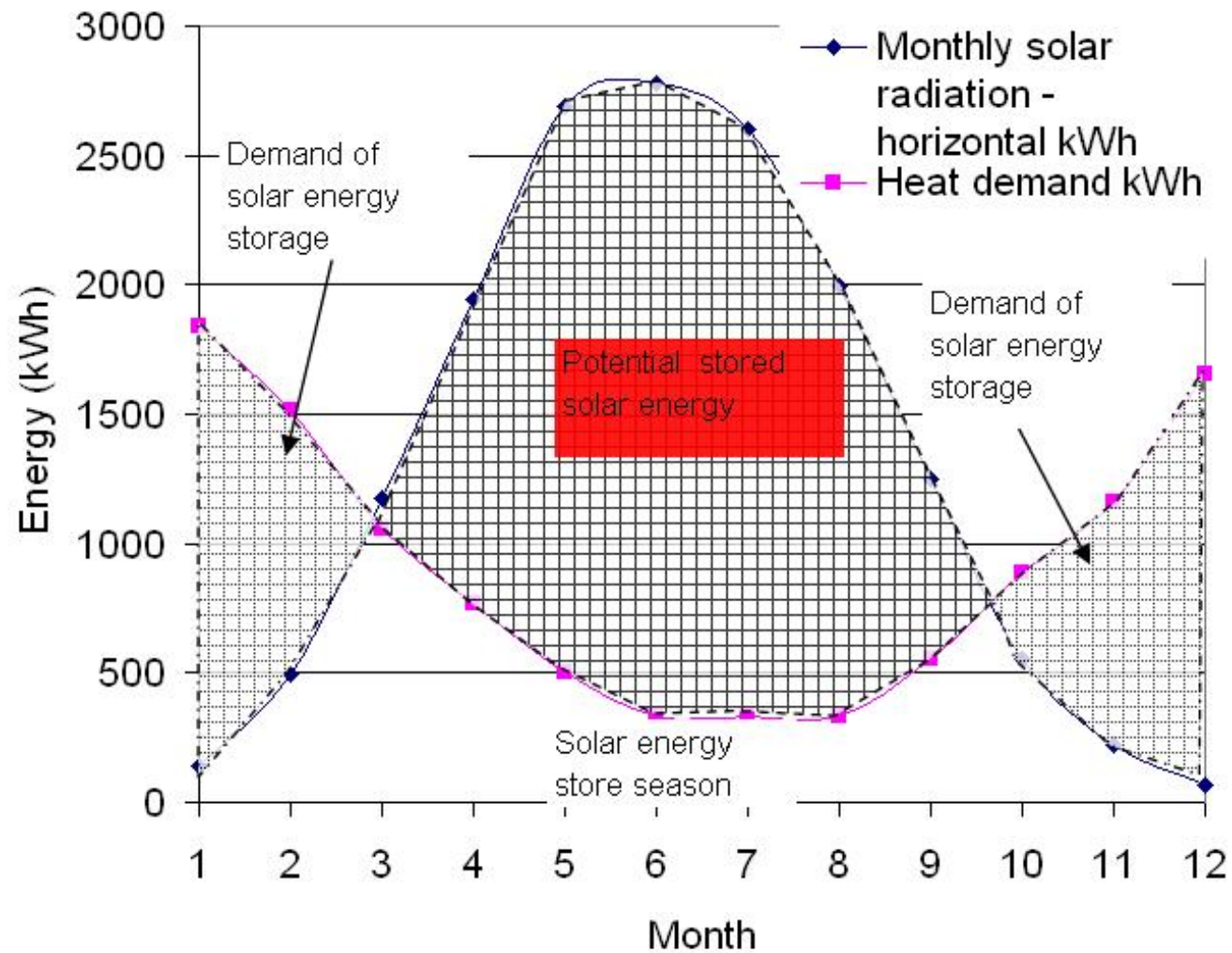
## Nearly zero approach

Solar electricity 50 %

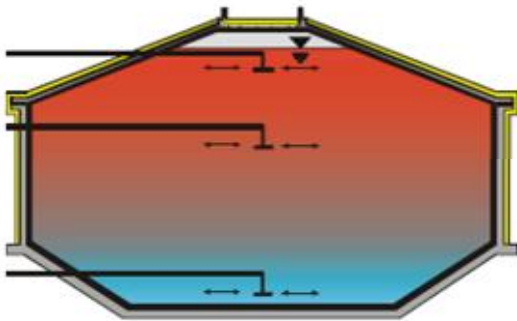
Wind power 50 %

Level	Electricity for heating GWh	Other electricity GWh	Total GWh	PV electricity kW <sub>p</sub>	PV m <sup>2</sup> /k-m <sup>2</sup>	Wind Power kW	Investment on renewables and buildings	
							Renewables €/m <sup>2</sup>	Buildings €/m <sup>2</sup>
2012	0,8	0,8	1,6	940	0,04	320	150...	0
2020	0,3	0,8	1,1	647	0,03	220	100...	100

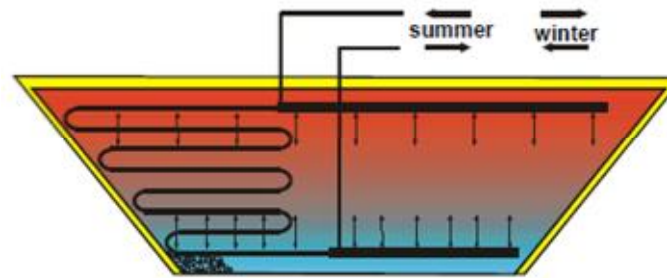
## How to utilize solar thermal potential?



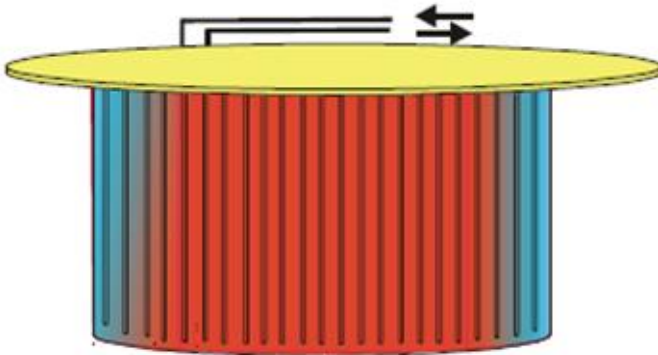
## Heat storage



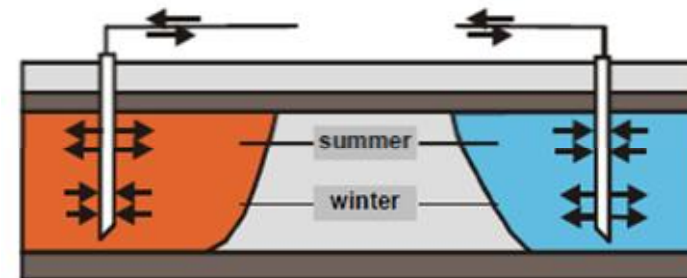
Water



Water - gravel

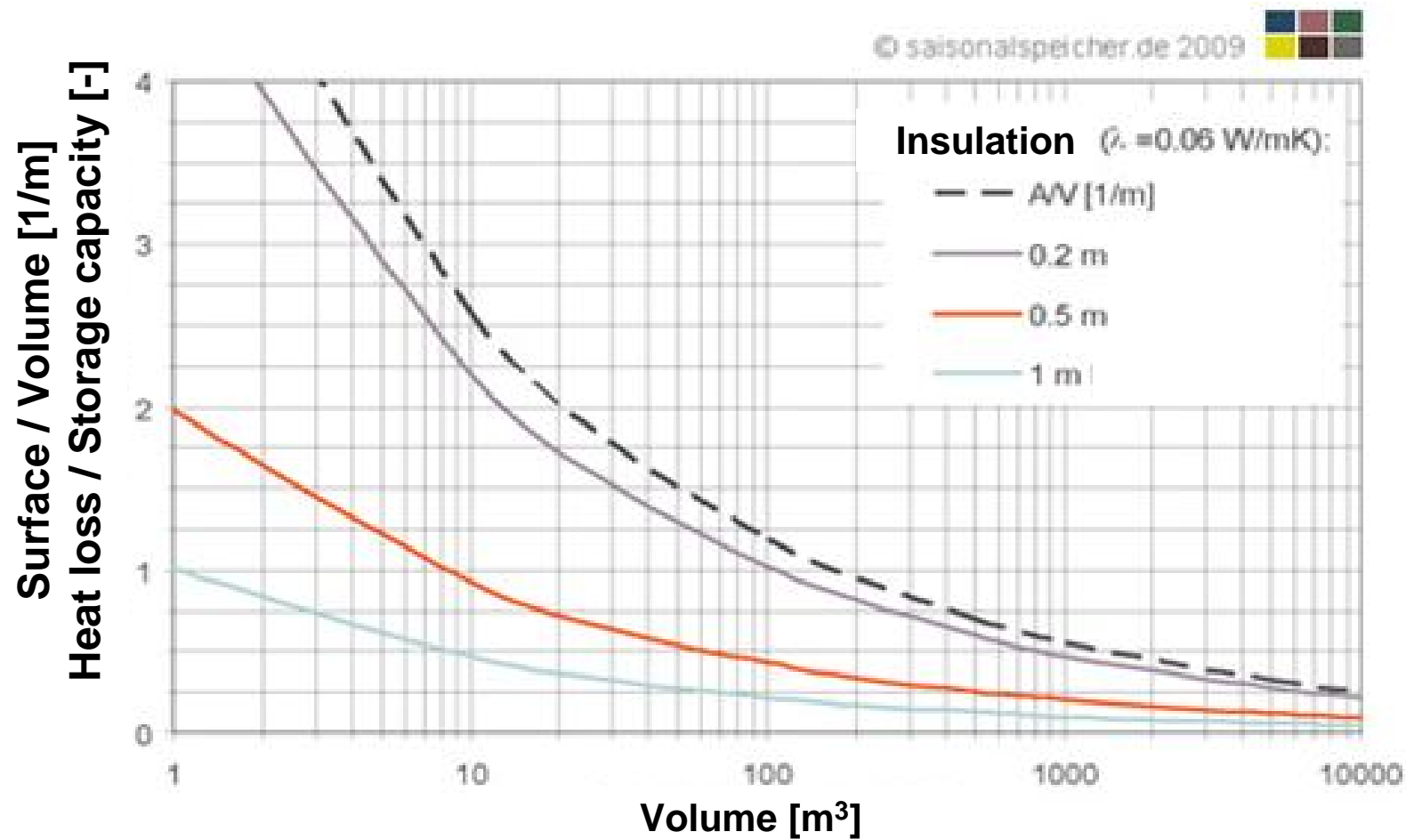


Heat wells



Ground water

## Storage design





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