Presentation in the REHVA seminar
HVAC for Net Zero Energy Buildings
at ISH Frankfurt March 17, 2011

REHVA Task Force "Nearly Zero Energy Buildings" nZEB

Energy boundaries and scientific definition of nZEB based on the results of REHVA Task Force

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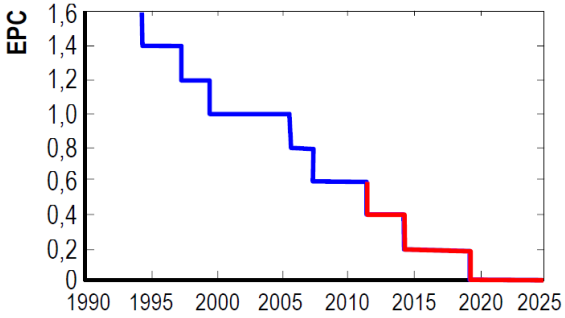
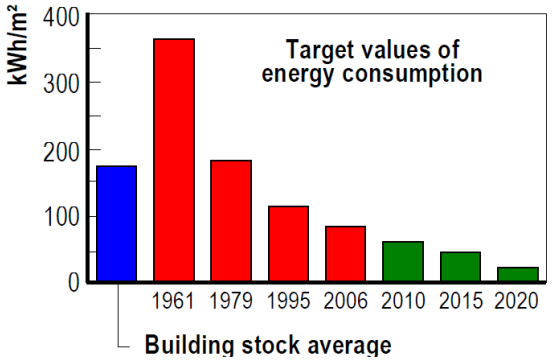
Towards nZEB:

- **Roadmap of some countries towards nearly zero energy buildings to improve energy performance of new buildings**
- **Many countries have prepared long term roadmaps with detailed targets**
- **Helps industry to prepare/commit to the targets**

The Netherlands



Denmark



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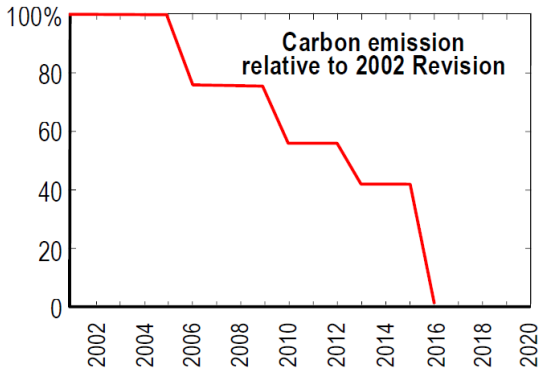
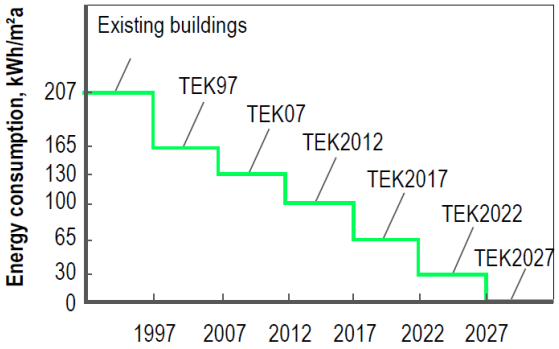
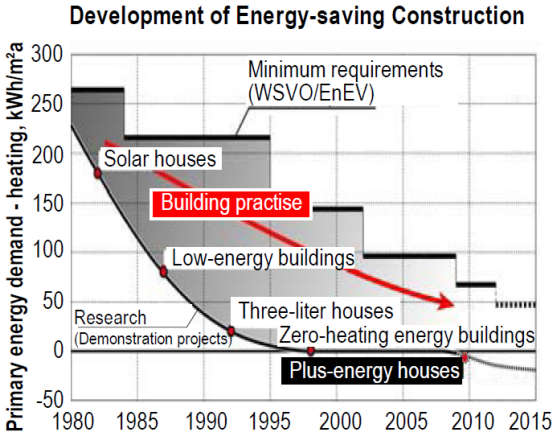


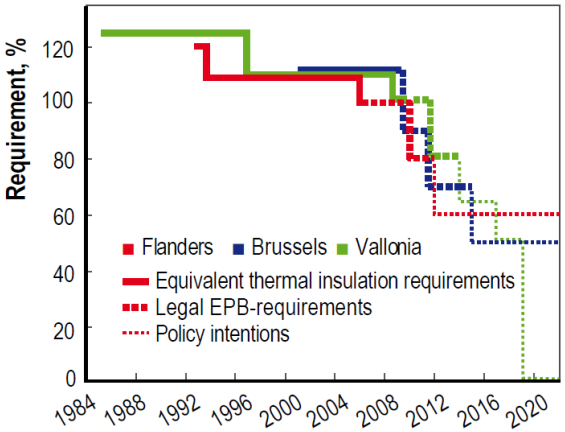
Norway



Germany



Belgium



Why nZEB definition is needed?

- EPBD recast requires nearly zero energy buildings, but does not give minimum or maximum harmonized requirements
- It will be up to the Member States to define what nZEB for them exactly constitute
- In the definition local conditions can be obviously taken into account, but the uniform methodology can be used in all Member States

REHVA nZEB Task Force:

- Proposes a technical definition for nearly zero energy buildings
- Provides energy calculation framework and system boundaries associated with the definition to specify which energy flows in which way are taken into account in the energy performance assessment
- The intention of the Task Force is to help the experts in the Member States in defining the nearly zero energy buildings in a uniform way

EPBD recast – major changes

Article 9 **Nearly zero energy buildings**

- By 31 Dec 2020, all new buildings are **nearly zero energy** buildings
- After 31 Dec 2018, public authorities that occupy and own a new building shall ensure that the building is a nearly zero energy building

Articles 4 & 5 Setting of energy performance requirements

- Setting of minimum energy performance requirements based on calculation of **cost-optimal** levels with the methodology referred to in Article 3.
- The calculation of cost-optimal levels shall be performed in accordance with the methodology developed by the Commission (so called comparative methodology Annex III)
- Primary energy target values have to be set in kWh/m^2
- The Commission shall establish by 30 June 2011 a comparative methodology framework

http://eur-lex.europa.eu/JOHtml.do?uri=OJ%3AL%3A2010%3A153%3ASM%3AEN%3AHTML

The laws and regulations shall be adopted and published in Member States by 9 July 2012.

EPBD recast – Nearly zero energy buildings

- In the directive '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.

- Since the Commission does not give minimum or maximum harmonized requirements, it will be up to the Member States to define what for them exactly constitutes a "very high energy performance"

Net zero energy buildings in practice

What nZEB means in practice?

- Energy demand/delivered energy use is reduced as much as reasonable achievable (insulation, heat recovery, heat pumps etc.)
- On site renewable energy production, most commonly solar PV and thermal, district heat from renewables and renewable fuels also accounted
- Annual balance of delivered and exported primary energy = 0
- Typically a grid connected building exporting energy in summer, using delivered energy in winter

Luukku house: Finnish net plus energy building in Solar Decathlon 2010 competition in Madrid

To define nZEB it was needed

In order to propose a general definition, it was needed to clarify:

- which energy flows shall be included – ALL
- the use of primary energy factors for primary energy indicator
- system boundary definition with inclusion of active solar and wind
- the technical meaning of “nearby” in EPBD recast so that it may mean existing district heating or cooling network or any other technical system serving a group of buildings

- Energy performance definition of EPBD recast was followed so that appliances (households and outlets) were included, i.e. all energy used in buildings would be accounted.
- For the system boundary definition, a general form modified from the one of EN 15603:2008 is proposed.

REHVA Task Force "Nearly Zero Energy Buildings" nZEB proposed definitions

net zero energy building (nZEB)
energy use of 0 kWh/(m^2 a) primary energy

nZEB has exact performance level of 0 kWh/(m^2 a) primary energy use

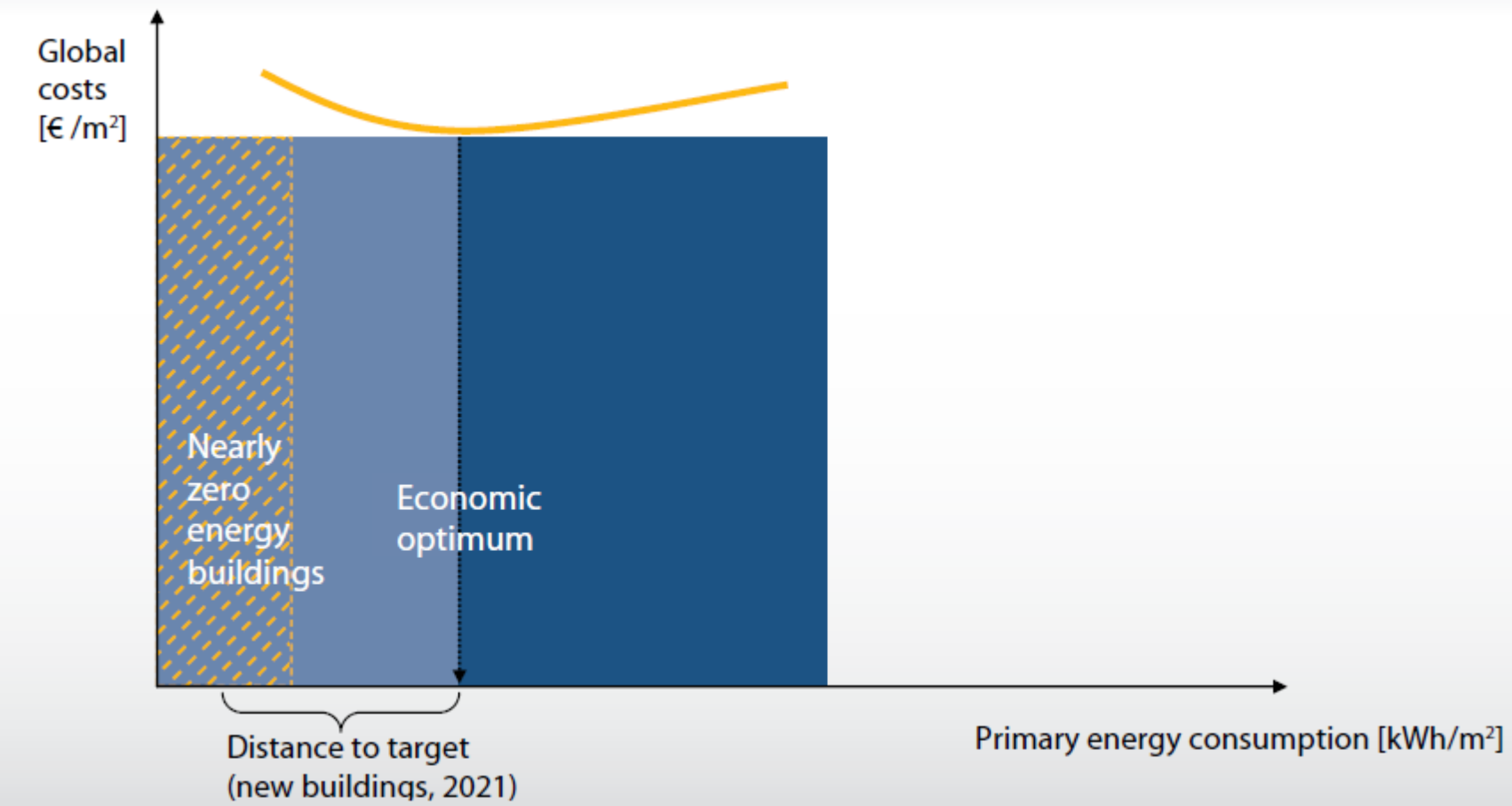
NOTE 1 A nZEB is typically a grid connected building with very high energy performance. nZEB balances its primary energy use so that the primary energy feed-in to the grid or other energy network equals to the primary energy delivered to nZEB from energy networks. Annual balance of 0 kWh/(m^2 a) primary energy use typically leads to the situation where significant amount of the on-site energy generation will be exchanged with the grid. Therefore a nZEB produces energy when conditions are suitable, and uses delivered energy during rest of the time.

nearly net zero energy building (nnZEB)
national cost optimal energy use of > 0 kWh/(m^2 a) primary energy

NOTE 1 The Commission shall establish by 30 June 2011 a comparative methodology framework for calculation of cost-optimal levels (EPBD recast).

nnZEB depends on national conditions

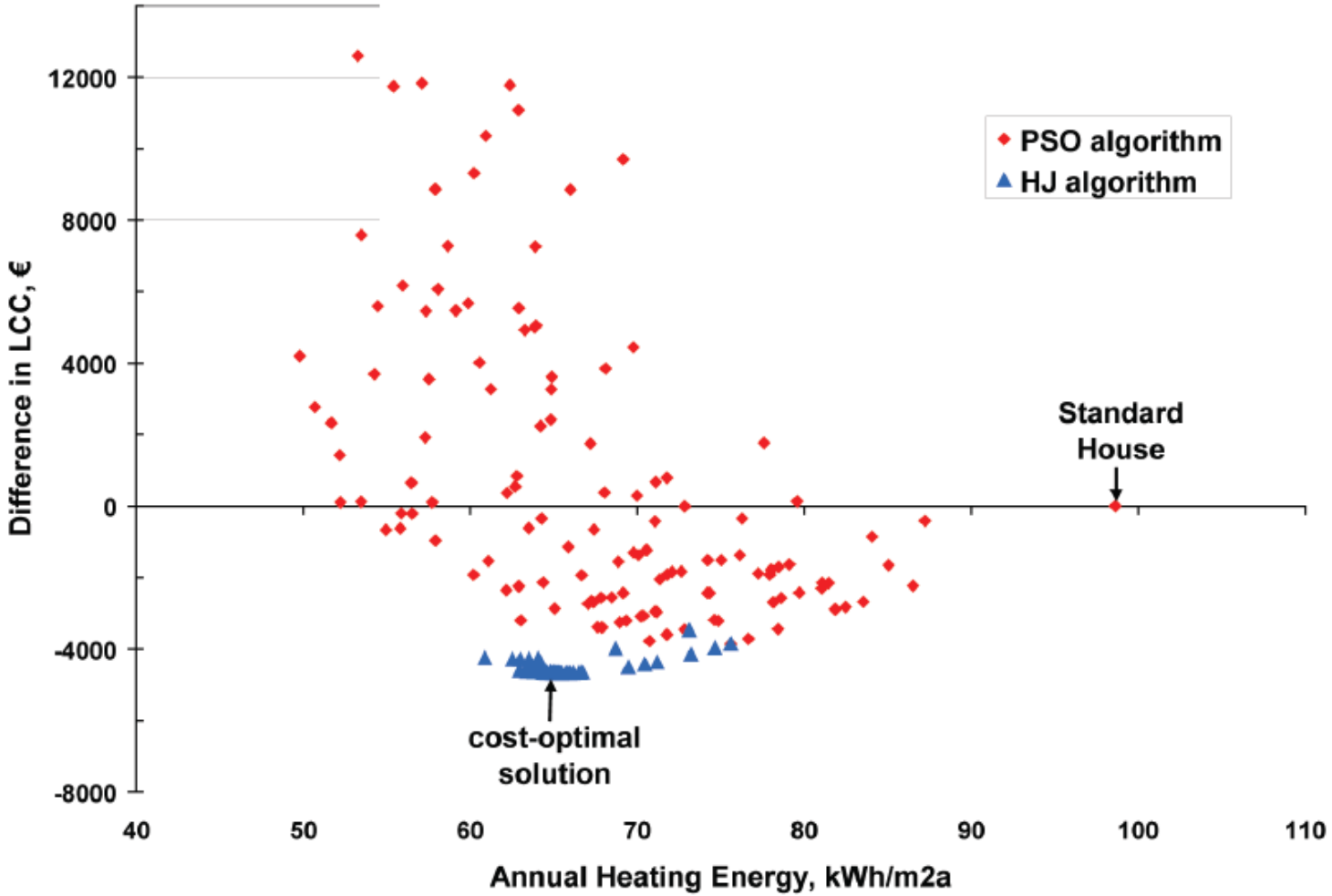
Cost optimal performance levels



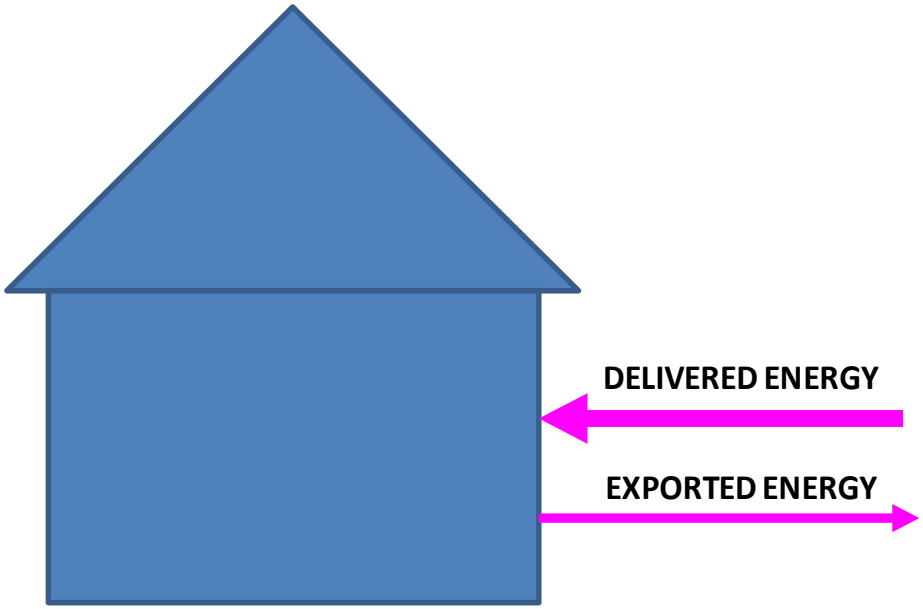
Source: The Buildings Performance Institute Europe (BPIE): http://dl.dropbox.com/u/4399528/BPIE/BPIE_costoptimality_publication2010.pdf

Example of cost optimal calculation, electrically heated house, according to Finnish code req. 2010

(Ala Hasan, REHVA Journal, Dec 2010)



REHVA TF nZEB – system boundary



$$E = \sum_i \left(E_{del,i} - E_{\exp,i} \right) f_i$$

System boundary for nearly net zero energy building definition, connecting a building to energy networks. Net delivered energy is delivered $E_{del,i}$ minus exported energy $E_{exp,i}$ accounted separately for each energy carrier i. Primary energy E is calculated with primary energy factors f_i (simplified equation with the same factors for delivered and exported energy carriers)

Primary energy: total or non-renewable?

Many countries have adopted in their regulations PRIMARY ENERGY and NON-RENEWABLE primary energy factors (e.g. 1.1 for oil and 0.2 for wood)

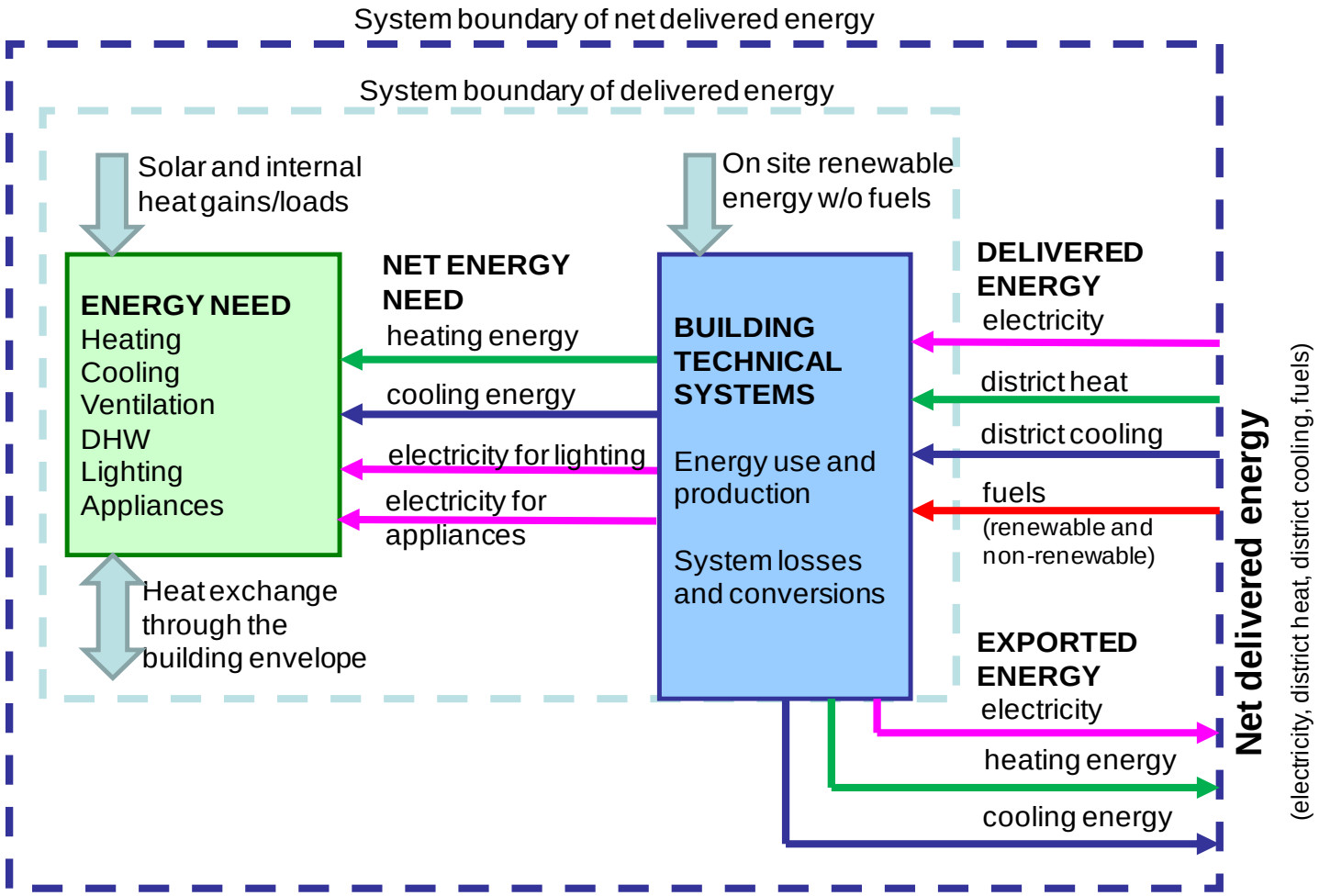
EPBD recast defines primary energy as: ”energy from **renewable and non-renewable sources** which has not undergone any conversion or transformation process”

⇒ TOTAL primary energy and TOTAL primary energy factors shall be used according to EPBD (meaning that there is no difference between bio or fossil fuel and the factor always exceeds unity)

Another detail are primary energy factors for delivered and exported energy carriers, which may or may not be equal, depending on national definition, i.e. both equations can be used:

$$E = \sum_i \left(E_{del,i} - E_{\exp,i} \right) f_i \quad \text{or} \quad E = \sum_i \left(E_{del,i} f_{del,i} \right) - \sum_i \left(E_{\exp,i} f_{\exp,i} \right)$$

nZEB – detailed system boundary



Energy boundary of net delivered energy. The box of "Energy need" refers to rooms in a building and both system boundary lines may be interpreted as the building site boundary.

Example – Low energy house

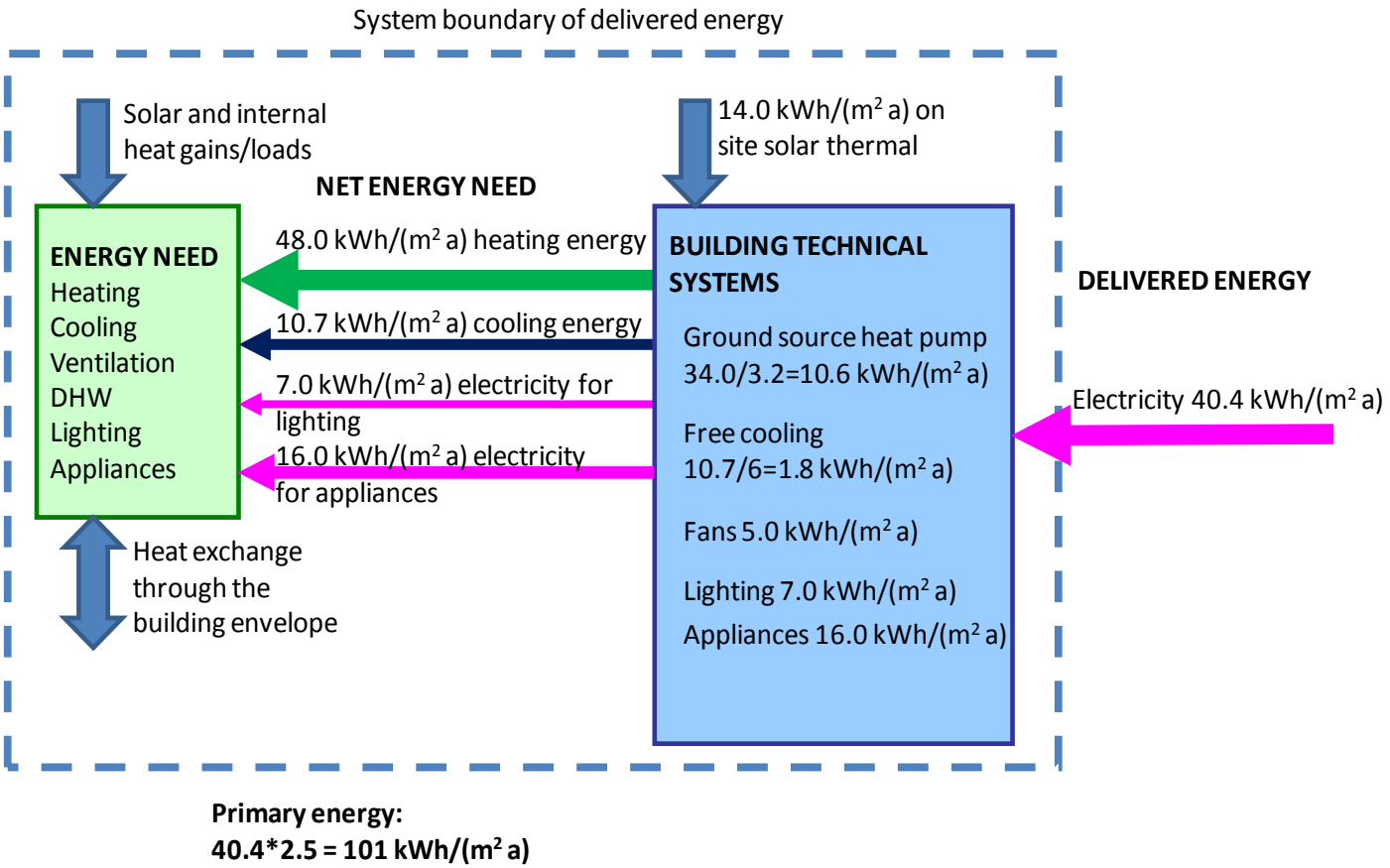
Low energy detached house

Net energy needs:

- 48.0 kWh/(m^2 a) net energy need for heating (including ventilation and DHW)
- 10.7 kWh/(m^2 a) net energy need for cooling
- 7.0 kWh/(m^2 a) electricity for lighting
- 16.0 kWh/(m^2 a) electricity for appliances

- solar thermal provides 14.0 kWh/(m^2 a) domestic hot water
- the rest of heating need is supplied with ground source heat pump system, which has the seasonal performance factor of 3.2.

Example – Low energy house



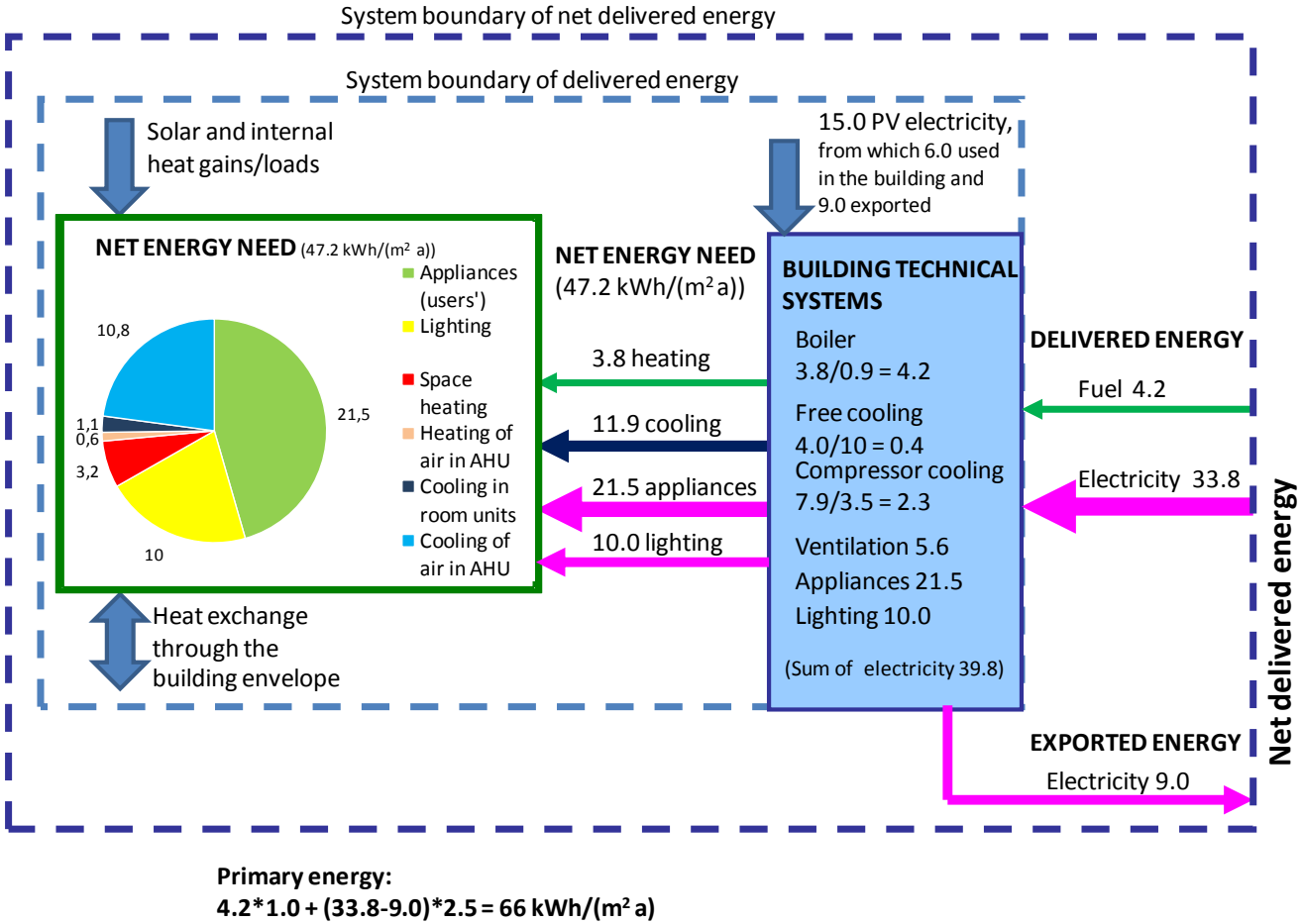
- On site thermal energy 14.0 kWh/(m² a) is reduced from the net energy need of 48.0 kWh/(m² a). Heat pump produces 34.0 kWh/(m² a) thermal energy with electrical energy input of 10.6 kWh/(m² a).
- There is no exported energy. Primary energy is 101 kWh/(m² a)

Example – nnZEB Office building

- a gas boiler for heating with seasonal efficiency of 90%
- free cooling from boreholes (about 1/3 of the need) is used and the rest is covered with mechanical cooling
- for borehole cooling, seasonal energy efficiency ratio of 10 is used and for mechanical cooling 3.5
- Ventilation system with specific fan power of 1.2 kW/(m^3/s) will use 5.6 kWh/(m^2 a) fan energy.

- a solar PV system providing 15.0 kWh/(m^2 a), from which 6.0 is utilized in the building and 9.0 is exported to the grid.

Example – nnZEB Office building



Primary energy:
4.2*1.0 + (33.8-9.0)*2.5 = 66 kWh/(m² a)

- Electricity use of cooling, ventilation, lighting and appliances is 39.8 kWh/(m² a)
- Solar electricity of 15.0 kWh/(m² a) reduces the net delivered electricity to 24.8 kWh/(m² a)
- Net delivered fuel energy (caloric value of delivered natural gas) is 4.2 kWh/(m² a) and primary energy is 66 kWh/(m² a)

Conclusions

General definition format is proposed to clarify the exact technical meaning of EPBD recast requirements in order to support national implementation

It is proposed to the Member States to use the system boundary shown in Figure 4 and primary energy definition given by Equation 1 in defining the performance levels of nearly net zero energy buildings. (refers to REHVA J)

Net zero energy requirement has exact performance level of 0 kWh/(m^2 a) primary energy use. The performance level of “nearly” net zero energy use depends on national conditions. The following definitions were proposed:
net zero energy building (nZEB)
energy use of 0 kWh/(m^2 a) primary energy
nearly net zero energy building (nnZEB)
national cost optimal energy use of > 0 kWh/(m^2 a) primary energy

The proposal is to be published in REHVA Journal 2011/3 May issue.