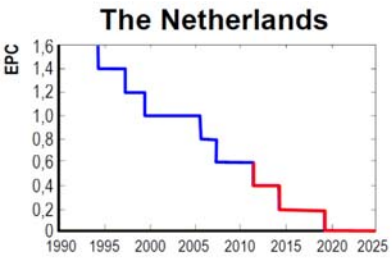
Cost optimal and nZEB – definitions and performance levels

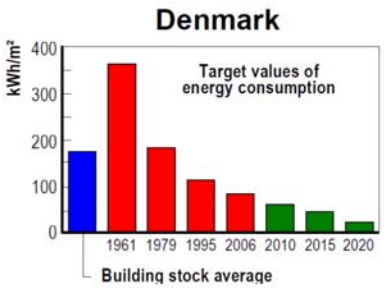
8.6.2011 Jarek Kurnitski

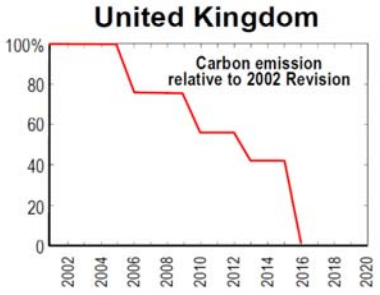
Suomen itsenäisyyden juhlarahasto Sitra

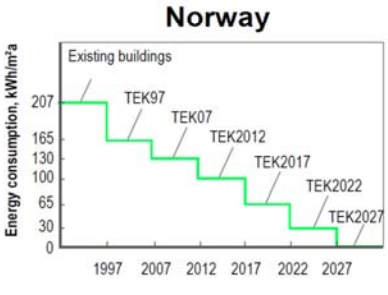
Towards nZEB:

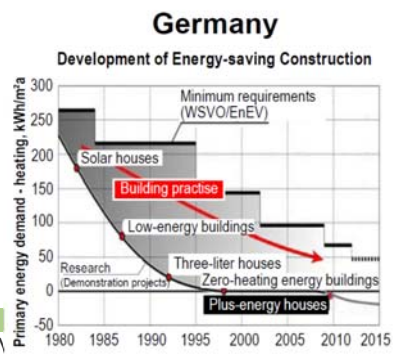
- **Roadmap of some countries towards nearly zero energy buildings to improve energy performance of new buildings**
- **Many countries have prepared long term roadmaps with detailed targets**
- **Helps industry to prepare/commit to the targets**

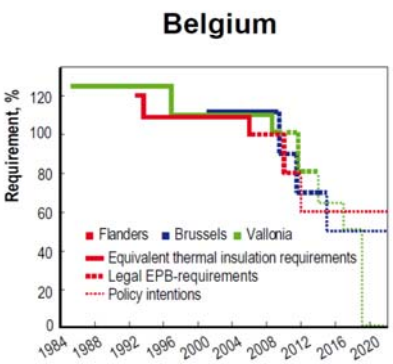












EPBD recast – major changes

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 – National roadmaps towards nearly nZEB

National roadmaps towards nearly zero energy buildings are needed for all member states

The national plans shall include, inter alia, the following elements:

a) the Member State's detailed application in practice of the definition of nearly zero-energy buildings
b) intermediate targets for improving the energy performance of new buildings, **by 2015**
c) information on the policies and financial or other measures adopted in the context of for the promotion of nearly zero-energy buildings

EPBD recast – Nearly zero energy buildings nZEB

- 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.

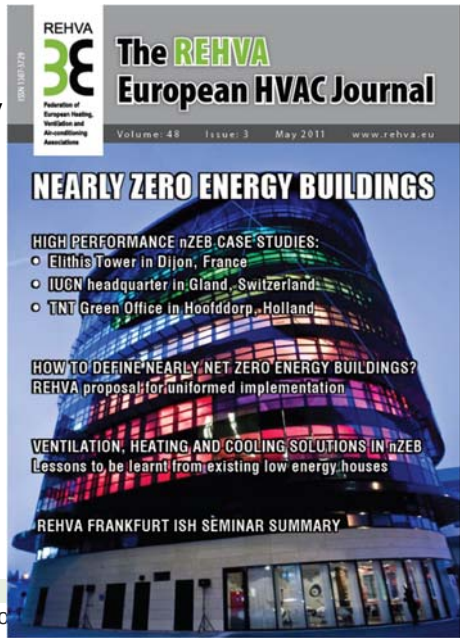
⇒ **nZEB = very high energy performance + on-site renewables**

- Definition of "a very high energy performance" and "significant extent of renewables" let for Member States

nZEB in practice

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

- See special issue of REHVA Journal 3/2011 on ZEB, nZEB case studies (**www.rehva.eu**):
  - Elithis Tower in Dijon, France
  - IUCN headquarter in Gland, Switzerland
  - TNT Green Office in Hoofddorp, Holland



Proposed nZEB 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).
NOTE 2. Not all renewable energy technologies needed for nearly zero energy building have to be cost-effective, if appropriate financial incentives are not available.

nnZEB depends on national conditions

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Japanilainen nollaenergiatalokonsepti

- Japanissa rakennetaan yli 10 000 lähes nollaenergiataloa vuodessa
- PV 5000 eur/KW, esim. 4...8 kW katolle (mallitalossa myös tuulimylly)
- Lämmitys/käyttövesi/jäähdytys lämpöpumpuilla
- Järjestelmässä myös polttokenno (kaasu) ja akku (n. 6 kWh)

Energiamonitori:
- Vasemmalla tuulen ja auringon tuotto
- Alhaalla akku (lataus käynnissä)
- Oikealla verkkosähkö ja polttokenno (polttokennoa ei voi ajaa, koska ei ole juurikaan lämmitystarvetta)

Asuinrakanennuksia

- **Luukku talo: plusenergiatalo Solar Decathlon 2010 kilpailussa Madridissa, E<0**
- **Järvenpään ja Kuopion lähes nollaenergiakerrostalot E<50**
- **2012 Tampereen asuntomessujen lähes nollaenergiapientalo**
- **muitakin pientaloja**

Luukku talo – plusenergiatalo Suomessakin

Towards nnZEB in Finnish office buildings

- Viikki Ympäristötalo, Jätkäsaari Low2No, Viikki Synergy and some other buildings have ended up that in addition to demand reduction measures about 15% of electrical energy use can be produced by PV
- Extra investment cost about 10%
- Current BAU level in offices is about E=160...170 (according to 2012 code, D3 2012), in **nnZEB E ≤ 100 kWh/(m² a) primary energy**
- National project for nnZEB E-value determination under preparation

Preliminary EP targets for Low2No

EP in OFFICES	Net delivered energy use, kWh/(m² a)	Energy carrier factor, -	Primary energy use, kWh(m² a)
Space and ventilation heating	30	0,7	21
Domestic hot water (D3 2012)	6	0,7	4
Cooling (district cooling COP=1)	20	0,4	8
Fans and pumps (HVAC)	7	1,7	12
Lighting	15	1,7	26
Appliances (D3 2012)	22	1,7	37
PV	-9	1,7	-15
Total	91		**93**

Cost optimal vs. nZEB

- EPBD recast: Commission's regulation/guidance document on **cost optimal** methodology framework given on or close June 30th 2011
  - instructs MS for the first time on how to set minimum requirements – **cost optimal policy** – shift away from only upfront investment cost
  - a global cost approach established, guidance will be provided, and some room left for national adjustment
  - Draft 6 May 2011 document available

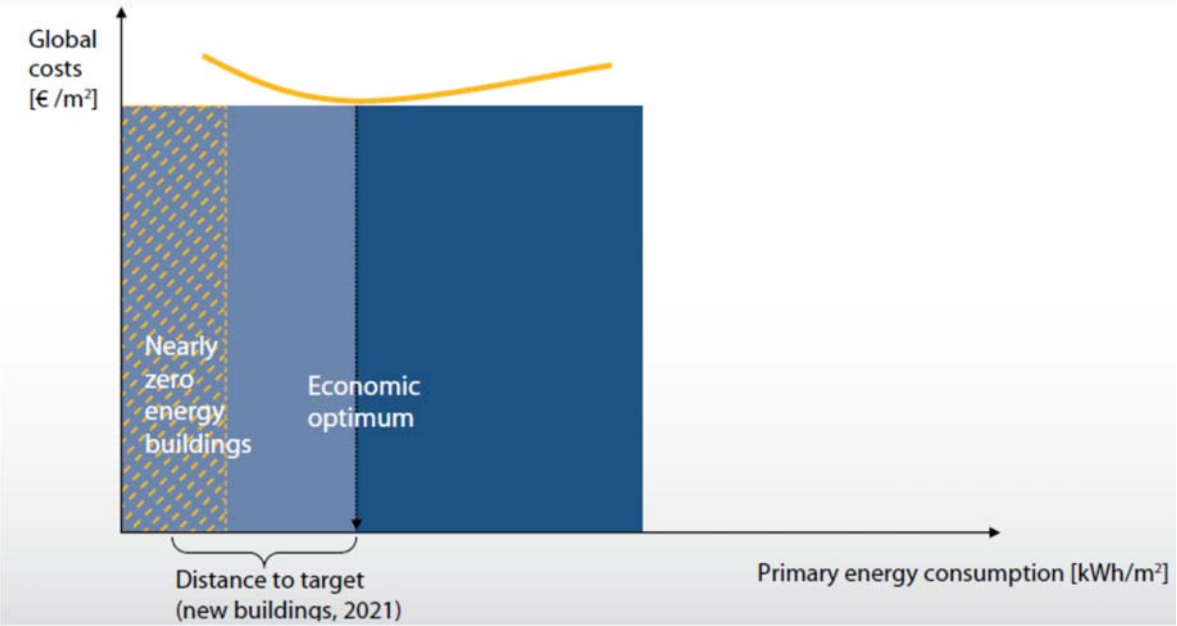
- EPBD recast established the political target of nearly zero energy buildings for all new buildings by 1 Jan 2021. Both requirements will have to be reconciled so that a smooth transaction from cost optimal requirements to nearly zero energy buildings could be guaranteed.

Cost optimal = a global cost approach

- Cost optimal defined as the energy performance level expressed in primary energy leading to the lowest global cost
- Global cost sums construction cost and discounted energy and maintenance etc. costs for 30 years period – NPV calculation
- To be rather a cost optimal for society, reasonably low interest rate of 3% and long period of 30 years used
- Escalation of energy cost can be read from the graph given in the Commissions draft document, being between 2 and 3%

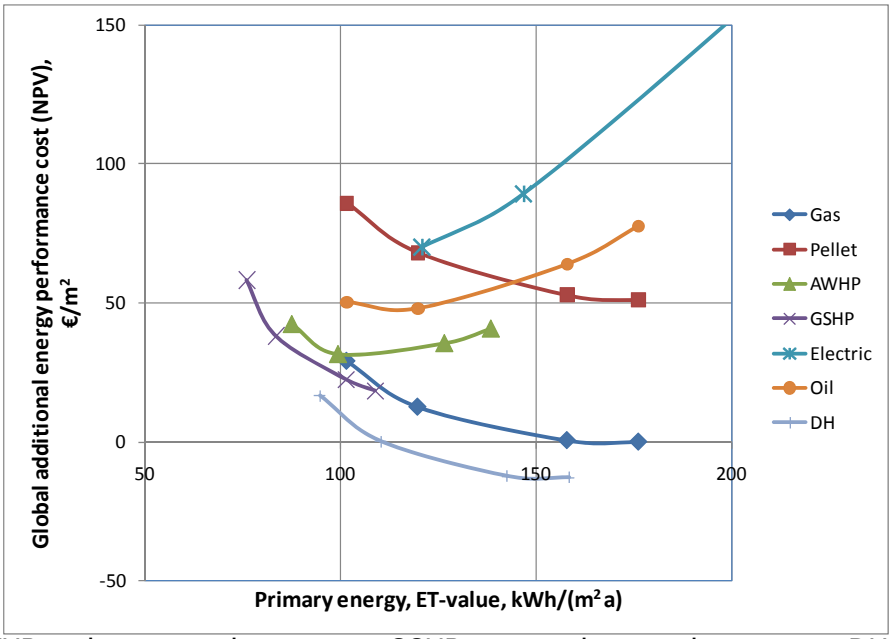
- nZEB is not covered by the cost optimal document, thus EPBD recast has to be followed for nZEB specification

nZEB is not cost optimal yet



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

Example of cost optimal calculation: Detached house, 3% interest rate and 2% escalation (Estonian ongoing study, REHVA AM 2011)



- AWHP – air to water heat pump, GSHP – ground source heat pump, DH – district heating
- W/o PV, 4 insulation levels from left to right: 0.42, 0.58, 0.76 and 0.96 specific heat loss
- Distance to nZEB 224 €/m² investment cost/ nZEB=40 kWh/(m² a) primary energy

How to integrate nZEB into energy certificate scale?

nZEB as technically reasonable achievable

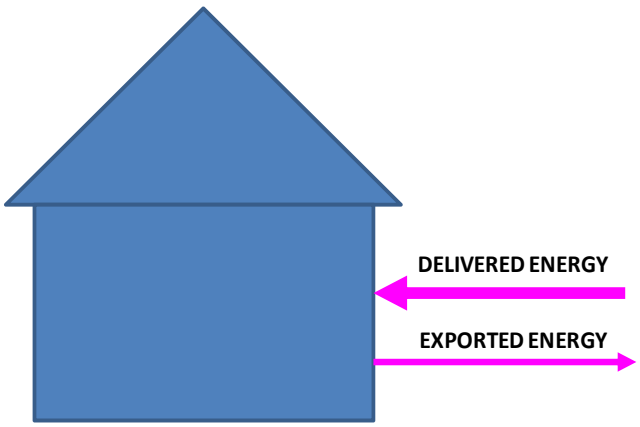
cost optimal for new buildings, category B or C

req. for new buildings (typically not cost optimal yet)

Revision of certificates scales needed:

- Cost optimal requirements for new buildings cannot be any more in D category, as calculated for 30 years period with 3% interest rate
- Existing A may be split (A+, A++) or changed

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 0.5 for wood)

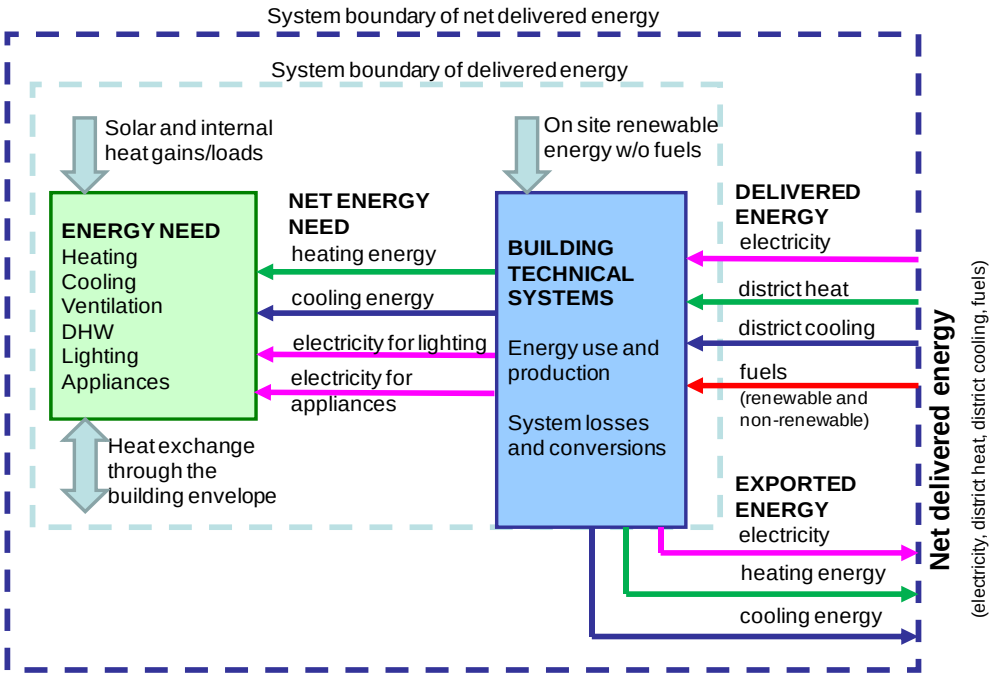
EPBD recast defines primary energy as: ”energy from **renewable and non-renewable sources** which has not undergone any conversion or transformation process”

⇒ 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 – nZEB Office building

- an office building in Paris
- 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.

	Basic reference building	Advanced building	Low energy building
External wall W/K,m^2	0,43	0,3	0,3
Infiltration dm^3/s,m^2	0,33	0,165	0,165
Window W/K,m^2	2,6	1,1	1,1
Window g-value	0,48	0,31	
Solar shading	No	External overhang of 500mm	External overhang of 500mm
Lighting load W/m^2	15	12	6
Lighting control	Time	Time, day light	Time, day light, Occupancy
Room terminal unit	Traditional active chilled beam	Adaptable active chilled beam	Adaptable active chilled beam
Chiller plant with air cooled condensers	One common chiller (2 °C)	2 chillers: beams (10°C),AHU(2°C)	2 chillers: beams (10°C),AHU(2°C)
Room unit inlet water temperature	15 °C	15 °C	15 °C
Room control	P	PI	PI
Room temp. set value	20,5 / 24 °C	20,5 / 25 °C	20,5 / 25 °C
Boiler plant	Condensing boiler	Condensing boiler	Condensing boiler
Airflow rates	DOAS: 1,5 l/s,m^2 in offices, 4,2 l/s,m^2 in meeting rooms	DOAS: 1,5 l/s,m^2 in offices, 4,2 l/s,m^2 in meeting rooms	DOAS: 1,5 l/s,m^2 in offices, 4,2 l/s,m^2 in meeting rooms
Airflow design	CAV in all spaces	CAV in offices, VAV in meeting rooms	CAV in offices, VAV in meeting rooms
Ductwork	Balanced	Constant pressure	Constant pressure
SFP kW/m^3,s	2,0	1,8	1,2
AHU cooling water temperature	7 °C	7 °C	7 °C
Supply air temperature	16 °C (External T > 20 °C) 20 °C (External T < 10 °C)	16 °C (External T > 20 °C) 20 °C (External T < 10 °C)	16 °C (External T > 20 °C) 20 °C (External T < 10 °C)
Heat recovery	Hydronic (40%)	Plate (60%)	Wheel (80%)
Filtration	EU7 in supply and EU 3 in exhaust	EU7 in supply and EU 3 in exhaust	EU7 in supply and EU 3 in exhaust
Night purge ventilation	No	yes	yes

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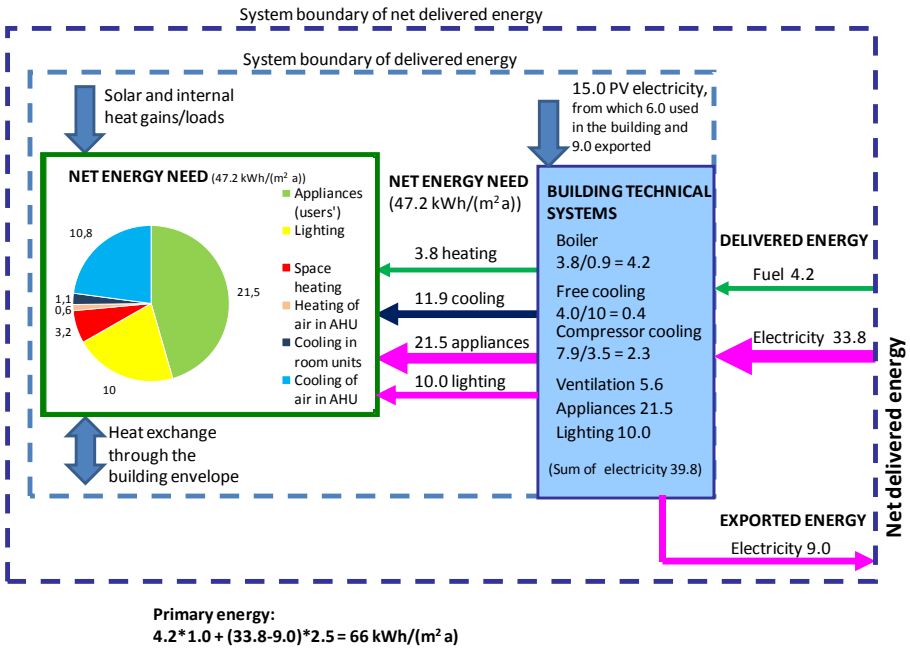
Example – nZEB Office building



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)

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2012 määräysvalmistelussa käynnistettyjä kehityshankkeita Ympäristöministeriön ja Sitran Energiaohjelman rahoittamana

1. Energiamuodon huomioon ottaminen määräyksissä: päästö- ja primäärienergiakertoimien taustaselvitys
2. Laskennassa käytettävien säätietojen tarkistaminen: uuden energialaskennan testivuoden kehittäminen
3. Kylmäsiltojen huomioon ottaminen määräyksissä taulukkoarvoilla + yksityiskohtaisempi laskentaopas
4. Lämmitys- ja LKV- järjestelmien hyötysuhteiden taulukkoarvojen päivitys + yksityiskohtaisempi laskentaopas
5. Aurinkolämmön ja -sähkön laskentaohjeet + laskentaopas
6. Lämpöpumppujen laskentaohjeet + laskentaopas
7. Jäähdytysjärjestelmien laskentaohjeet + laskentaopas
8. Määräysvalmistelun projektisihteeri
9. 2012 E-lukujen vaatimustasojen arviointiprojekti – RT
10. ...

- Myös muita oppaita kuten RIL:n matalaenergiaoppaat

Johtopäätökset

- 7-9 vuotta aikaa lähes nollaenergiarakentamiseen
- 1 vuosi aikaa nykyisten (2012) E-lukujen kustannusoptimaalisuuden tarkastelun suorittamiseksi ja nZEB suoritustason määrittämiseksi
- 2015 mennessä annettava välitavoitteet uusille rakennuksille
- nZEB rakentaminen edellyttää verkkoon syöttämisen pelisääntöjen selkeyttämistä – netto-ostoenergian taseraja/muualle viety energia jäi pois RakMK D3 2012
- Muuten D3 2012 on ”nollaenergiakelpoinen” ja siinä on kv- uutuusarvoakin mm. innovatiivisten järjestelmien käsittelyn ja kaupallisten laskentatyökalujen osalta
- Tekninen nZEB rakentamisen valmius syntymässä pilottihankkeiden ja suunnittelu- ja laskentaohjeistuksen valmistumista myöten