Experiences of implementation of EPBD in Sweden – Towards NZEB

Rakennusten energiaseminaari
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Presentation outline

- Swedish national energy & emissions targets
- Swedish efforts towards NZEB implementation
- Energy performance assessment – current practice and future needs
- Best practice examples

EPBD - NZEB targets for new construction

The European Performance of Buildings Directive (Directive 2010/31/EU - EPBD) requires that all new construction in the EU comply with Nearly Zero-Energy Building (NZEB) performance by 1 January 2021 (by 1 January 2019 for public buildings).

EPBD definition of Nearly Zero Energy Buildings (NZEB)

Technically and reasonably achievable annual energy use of > 0 kWh/(m^2 *year) but no more than a national limit value of non-renewable primary energy, achieved with a combination of best practice energy efficiency measures and renewable energy technologies which may or may not be cost optimal.

- NOTE 1 ‘reasonably achievable’ means by comparison with national energy use benchmarks appropriate to the activities served by the building, or any other metric that is deemed appropriate by each EU Member State.
- NOTE 2 The Commission has established a comparative methodology framework for calculation of cost-optimal levels (Cost optimal).
- NOTE 3 Renewable energy technologies needed in nearly zero energy buildings may or may not be cost-effective, depending on available national financial incentives.

Swedish national environmental goal:
Good built environment (1/16)

"Cities, towns and other built-up areas must provide a good, healthy living environment and contribute to a good regional and global environment. Natural and cultural assets must be protected and developed. Buildings and amenities must be located and designed in accordance with sound environmental principles and in such a way as to promote sustainable management of land, water and other resources.”

Swedish energy/emissions goals

Sweden's national climate target is that emissions should be 40 % lower in 2020 as compared to 1990 (cf 40% by 2030 for EU). This target applies to activities not covered by the EU Emissions Trading System (EU-ETS).

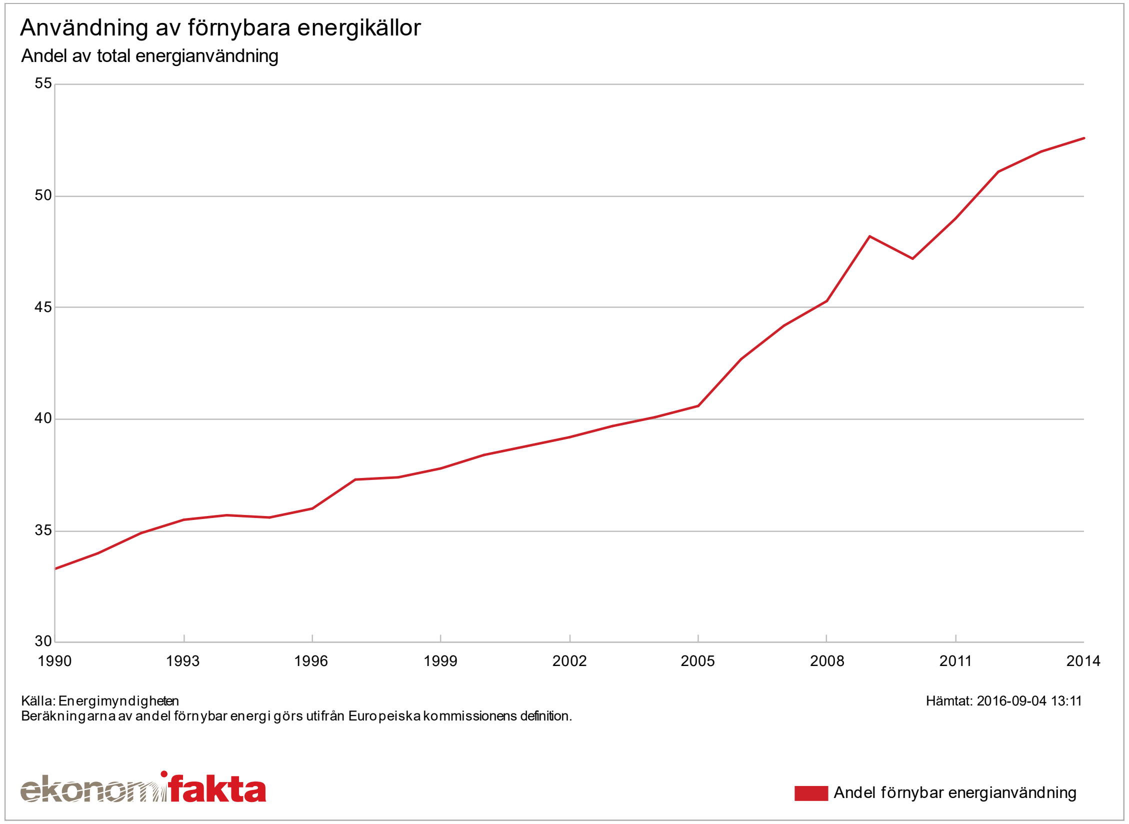
The Swedish national target is that renewable energy shall amount to at least 50 % of the total energy use by 2020 (cf 27% by 2030 for EU). This target was exceeded already in 2014 (53%).

The Swedish Parliament has also adopted a target on energy efficiency, expressed as a 20 per cent reduction in energy intensity by 2020, compared with 2008 (cf 27% for EU compared to business as usual scenario), as well as a goal of at least 10% renewable energy in transport by 2020.

It is believed that the proportion of renewable energy in Sweden could be at least 60% by 2030.

Adapted from: http://www.ekonomifakta.se/Fakta/Energi/Energibalans-i-Sverige/Anvandning-av-fornybara-energikallor/, http://www.energimyndigheten.se/nyhetsarkiv/2014/viktigt-med-mal-for-energieffektivisering-och-fornybar-energi/, http://www.regeringen.se/regeringens-politik/energi/mal-och-visioner-for-energi/, as accessed 160618

Use of renewable energy in Sweden as proportion of overall energy use



In 2014, ca. 53% of all energy use in Sweden was based on renewable resources, mainly hydroelectric energy for power generation and biomass for heat or combined heat and power generation.

Source: http://www.ekonomifakta.se/Fakta/Energi/Energibalans-i-Sverige/Anvandning-av-fornybara-energikallor/, as accessed 160918

The Swedish Building Code – BBR
Defining (lowest) building energy performance

- Current energy performance requirements based on **BBR 22** (BFS 2015:3, 1 March 2015)
- Evolution of energy performance levels (purchased energy) – example: New residential buildings (multi-family apartment buildings)

New residential buildings	**2006**	**2009**	**2012**	**2015 (current BBR22)**
Electrically heated, kWh/(m^2*yr)	75	55	55	50
Non-electrically heated, kWh/(m^2*yr)	110	110	90	80

Energy performance requirements BBR 22 (BFS 2015:3, 1 March 2015)

Current energy performance requirements

(kWh/m²/år)

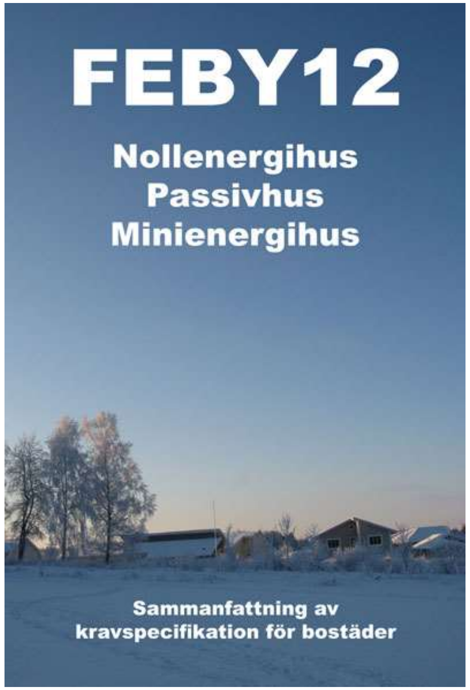
	ZONE I		ZONE II		ZONE III		ZONE IV	
Single family homes	**130** *(130)*	**95** *(95)*	**110** *(110)*	**75** *(75)*	**90** *(90)*	**55** *(55)*	**80** *(90)* *11%*	**50** *(55)* *9%*
Multi-apartment buildings	**115** *(130)* *11,5%*	**85** *(95)* *10,5%*	**100** *(110)* *9%*	**65** *(75)* *13%*	**80** *(90)* *11%*	**50** *(55)* *9%*	**75** *(90)* *16,5%*	**45** *(55)* *18%*
Commercial buildings	**105** *(120)* *12,5%*	**85** *(95)* *10,5%*	**90** *(100)* *10%*	**65** *(75)* *13%*	**70** *(80)* *12,5%*	**50** *(55)* *9%*	**65** *(80)* *18,5%*	**45** *(55)* *18%*
	Ej el	El	Ej el	El	Ej el	El	Ej el	El

Tabellen visar de föreslagna nya kravnivåerna fördelade på byggnadskategori och klimatzon. De gröna fälten redovisar kravnivåerna för icke elvärmda byggnader och de vita kravnivåerna för elvärmda byggnader. Siffrorna inom parentes anger den nu gällande kravnivån. Den nedersta siffran i varje fält visar hur stor den procentuella skärpningen blir per kategori, per klimatzon och per uppvärmningssätt. Utöver dessa generella nivåer tillkommer lättnaderna i kravnivå för bostäder över 50 m2 som innehåller smålägenheter

High-performance building energy performance guidelines issued by Swedish Center for Zero-Energy Buildings (in collaboration with the Swedish Energy Authority) - 2012

Defined for three high-performance building categories (separate guidelines for dwellings and office buildings)

- Zero energy buildings
- Passive buildings
- Mini-energy buildings



Source: http://www.nollhus.se/feby-12, as accessed 160918

FEBY 12 (dwellings) -
based on purchased energy

Passive and Zero Energy Buildings				
CLIMATE ZONE	Bldg < 400m2, Max kWh/(m^2A_{temp})		Bldg > 400m2, Max kWh/(m^2A_{temp})	
	Non-electrical heating	Electrical heating	Non-electrical heating	Electrical heating
I	63	31	58	29
II	59	29	54	27
III	55	27	50	25

"Mini"-energy buildings				
CLIMATE ZONE	Bldg < 400m2, Max kWh/(m^2A_{temp})		Bldg > 400m2, Max kWh/(m^2A_{temp})	
	Non-electrical heating	Electrical heating	Non-electrical heating	Electrical heating
I	83	39	78	37
II	79	37	74	35
III	75	35	70	33

BBR20 (2013)		
CLIMATE ZONE	Bldgs - all sizes, Max kWh/(m^2A_{temp})	
	Non electrical heating	Electrical heating
I	130	95
II	110	75
III	90	55

Select FEBY 12 – requirements (dwellings)

- Air leakage: max 0,3 l/(s*m$^{2)}$ of envelope area at an indoor-outdoor pressure difference of 50 Pa

- Average U-values (windows and glazed areas)
  - Passive building: $\leq$ 0,8 W/m^{2}K
  - Mini-energy building: $\leq$0,9 W/m^{2}K

Swedish efforts towards NZEB implementation

Proposal for dealing with nearly zero energy buildings (NZEB) in Sweden - Definition of energy performance and quantitative guideline

Förslag till svensk tillämpning av nära-nollenergibyggnader
Definition av energiprestanda och kvantitativ riktlinje

National Board of Housing, Building and Planning (Boverket), June 2015
Report No.: 2015:26, 1st Edition (128 pages)
ISBN hard copy: 978-91-7563-271-1
ISBN pdf: 978-91-7563-272-8
http://www.boverket.se/globalassets/publikationer/dokument/2015/forslag-till-svensk-tillampning-av-nara-nollenergibyggnader-2.pdf

Searching for consensus on Swedish NZEB definition

	General evaluation of different levels of energy performance		
	Multi-apartment buildings (not heated by electricity)	**Single family homes (heated by electricity)**	**Commercial buildings (not heated by electricity)**
Purchased energy, kWh/(m^2*yr)	Energy performance requirement according to BBR22 = 80 kWh/(m^2*yr)	Energy performance requirement according to BBR22 = 55 kWh/(m^2*yr)	Energy performance requirement according to BBR22 = 70 kWh/(m^2*yr)
70	Highly positive outlook	Not relevant	Neutral
50	Somewhat positive outlook with regard to availability of technologies and expertise, somewhat negative with regard to cost.	Highly positive outlook	Highly positive outlook
40	Very negative outlook with regard to availability of technology, somewhat negative with regard to expertise, very negative with regard to cost.	Somewhat positive outlook with regard to availability of technologies, somewhat negative with regard to technical expertise, somewhat positive with regard to cost.	Somewhat positive outlook with regard to the availability of technology and technical expertise. Neutral with regard to cost.
<30	Significant negative consequences	Significant negative consequences	Significant negative consequences

Boverket
Myndigheten för samhällsplanering, byggande och boende

Adapted from: Boverket: RAPPORT 2015:26 REGERINGSUPPDRAG,
Förslag till svensk tillämpning av nära-nollenergibyggnader,
Definition av energiprestanda och kvan-titativ riktlinje

Stakeholder perception of NZEB challenges

- **The larger industrial stakeholders** consider the availability of expertise as a major challenge (for all types of buildings).
- The lack of expertise is already highly noticeable and likely to become worse if energy performance requirements are increased. This is mainly expected to affect sub-contractors and smaller players in the area of real estate management.

- **Smaller developers** seem to rely more on their sub-contractors and appear more confident that NZEB performance can be achieved in the specified timeframes (2021) - possibly underestimating the required increase in competence levels.

Swedish NZEB definition – key criteria
NZEB techno-economical levels

#1 Cost-optimal level 2015

#2 Cost-optimal level 2021

#3 Technically available level = Best commercially available technology with a proven record of reliable use in practice

#4 Technically feasible level (Best possible techology)

#5 Technology level requiring further development

The EPBD specifies that NZEB technical solutions should exceed current cost-optimal levels, thus #1 & #2 are not acceptable in NZEB contexts.

#4 & # 5 are considered to be too risky and costly and may lead to decreased construction in an already stressed housing situation

Swedish NZEB definition – key criteria
System boundary: Purchased/delivered energy

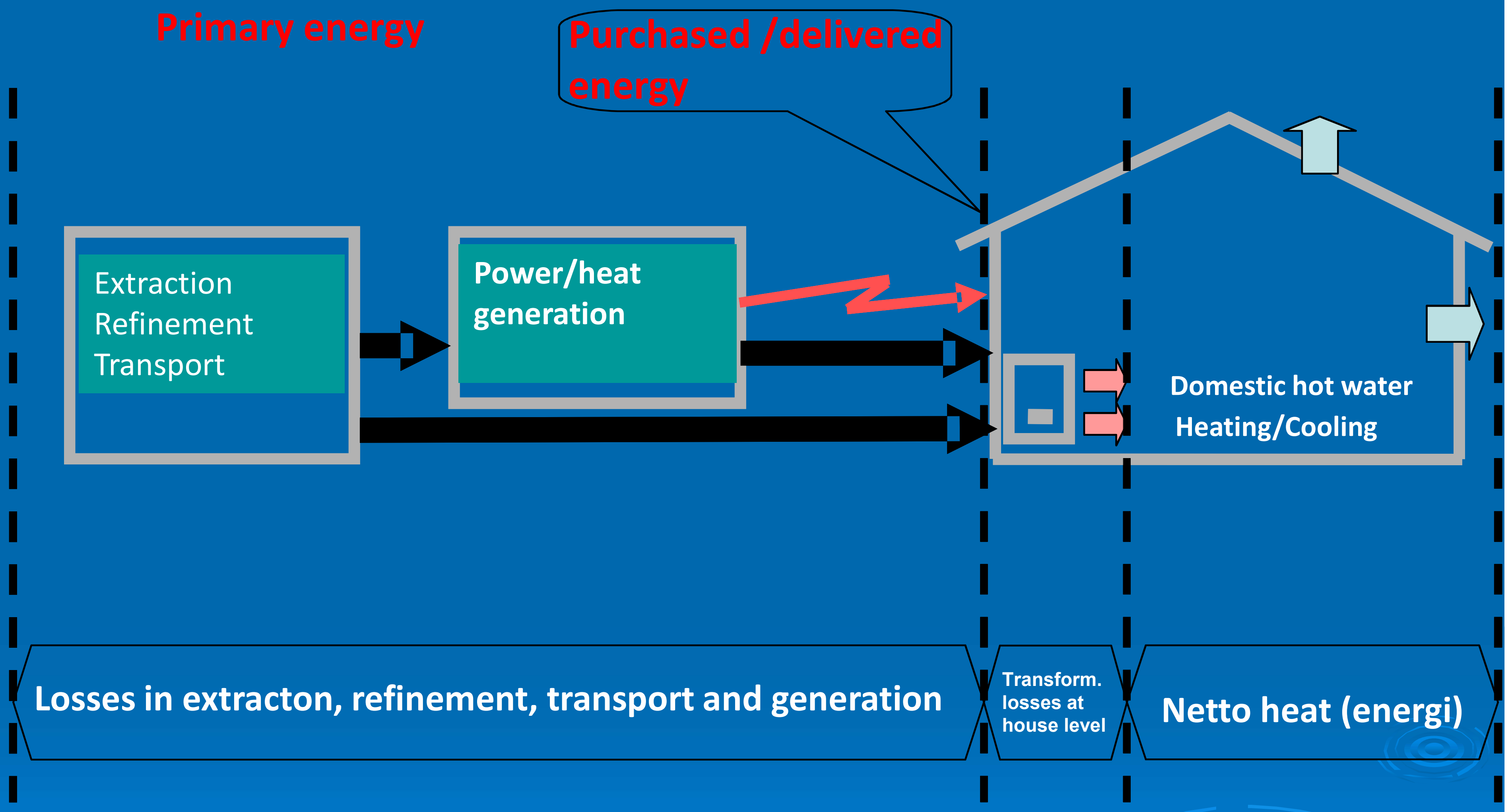
- The Swedish National Board of Housing (SNBH, Boverket) proposes that the system boundary “purchased/delivered energy” be used for evaluating building energy performance in NZEB contexts.

- “Purchased/delivered energy” comprises purchased amounts of energy delivered to building service systems for heating, domestic hot water generation, comfort cooling and building operation (e.g. pumps, fans, motors, builcing control and management systems, lighting in common areas etc.). It does not include free energy available on-site or nearby.

- In support of EPBD objectives to promote the use of renewable energy resources, energy freely available on-site transformed into heat or comfort cooling shall not be counted as part of the energy allowances prescribed by energy performance criteria.

- On-site or nearby is intended to mean that energy transformation systems under certain circumstances can be placed outside the building site.

BBR 22 and proposed NZEB System boundary: Purchased/delivered energy



Swedish NZEB definition – key criteria
Weighting factors in lieu of primary energy factors

- The Swedish National Board of Housing (SNBH, Boverket) further proposes the use of so-called weighting factors.

- Electricity used for heating, comfort cooling and domestic hot water generation is weighted with a factor 2,5, whereas it is recommended that all other energy sources use the weighting factor 1.

- The weighting factor for electricity is mainly used to avoid the use of electrical energy for heating.

- The weighting factors are intended to be used in lieu of primary energy factors to satisfy EPBD requirements.

Joint evaluation of achievable energy performance levels (zone III, Stockholm)

Type of building	BBR22, kWh/(m^2*yr)	Joint evaluation of achievable building code (BBR) requirements, kWh/(m^2*yr)	Percentage of performance increase compared to BBR22
Multiapartment buildings (not heated by electricity)	80	50	38%
Single family homes (heated by electricity)	55	45	18%
Commercial buildings (not heated by electricity)	70	40-50	43-29%

Type of building	Energy performance requirement, kWh/(m^2*yr)	Expected additional cost
Multiapartment buildings (not heated by electricity)	45-60	3-7 %
Single family homes (heated by electricity)	45	1,5-4 %
Commercial buildings (not heated by electricity)	50-60	0-5 %

Boverket
Myndigheten för samhällsplanering, byggande och boende

Adapted from: Boverket: RAPPORT 2015:26 REGERINGSUPPDRAG,
Förslag till svensk tillämpning av nära-nollenergibyggnader,
Definition av energiprestanda och kvan-titativ riktlinje

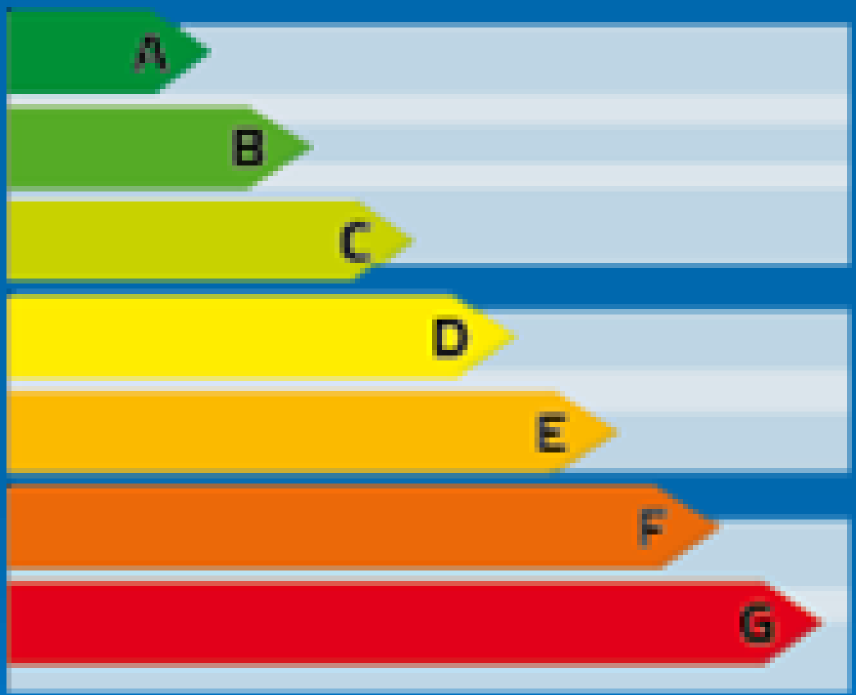
Energy performance assessment – Energy Performance Certificates (EPCs)

EPCs provide information on:

- Heated area in a building (t>10°C), so-called A_{temp}
- Energy use (purchased/delivered energy) for heating, domestic hot water generation, comfort cooling and electricity for building operation
- Energy class (A-G, from 1 Jan 2014)
- Energy efficiency measures (if any) proposed by the energy performance evaluator
- Whether a measurement of indoor radon concentrations has been carried out and what concentrations were recorded
- Other information, including about the heating and ventilation system

Swedish energy performance certificates (EPC) focus on the performance of single buildings and are valid for 10 years.

Energy performance certificates – energy classes (from 1 January 2014)



A = EP ≤ 50 %

B = EP > 50 - ≤ 75

C = EP > 75 - ≤ 100 %

D = EP > 100 - ≤ 135 %

E = EP > 135 - ≤ 180 %

F = EP > 180 - ≤ 235 %

G = EP > 235 %

(EP: Energy performance in % of energy performance values specified by BBR - currently BBR22)

Swedish EPCs provide **no information** about:

- Continuous building energy performance with real-time relevance to building control and operation
- Power load profiles and power use
- Occupant needs, behaviour patterns and levels of satisfaction (e.g. indoor climate, perceived, comfort, health, productivity, etc) – ”product quality”
- Energy quality aspects (exergy efficiency)
- Performance of portions of a building (e.g. single apartments)

EPCs provide information on **how much** purchased energy was used **without any information about the benefits of its use.**

Efficient NZEB management and operation throughout the operational phase requires:

- Accurate and continuous monitoring of building performance (BMS) – high accuracy and resolution particularly important considering low energy flows in NZEB

- Integrated energy performance assessment (Big Data, Internet of Things) considering factors including
  - Power loads
  - Measured indoor climate quality
  - Perceived indoor climate quality and other user-related parameters
  - Environmental impact
  - Energy/exergy quality
  - Cost
  - …

On-going work/discussions towards including indoor climate requirements in the EPBD

- "The definition of net zero energy and positive energy buildings would include indoor climate requirements, given that the risk of potential negative effects is higher for buildings with very high performance."

- "Requirements for indoor air climate would focus on temperature, air quality and daylight, all of which can be easily integrated in building codes."

- "The balance between performance and indoor climate requirements could be monitored and controlled using smart systems technologies (e.g. ventilation controlled using CO_2 sensors, etc.)."

Adapted from: COMMISSION STAFF WORKING DOCUMENT
IMPACT ASSESSMENT
Accompanying the document "Proposal for a Directive of the European Parliament and of the Council amending Directive 2010/31/EU on Energy Performance of Buildings"

Two examples of what can be achieved with:

- Appropriate expertise
- Best available technologies
- Willingness to invest and recognize value in high life-cycle building performance
- Ambition and commitment

Väla Gård positive energy building (Skanska Helsingborg HQ) - Leed Platinum

Väla Gård building service systems in a nutshell:

- Ground heat pump system for heat and domestic hot water generation (dimensioned for serving a total of four buildings)
- Comfort cooling mainly accounted by free borehole coolth, heat-pump assisted when needed (excess heat rejected into a refrigeranting medium cooler)
- VAV ventilation system in every building segment, operated based on occupancy, indoor temperatures and CO^2-concentrations in conference rooms; ventilation in use Mon-Fri 6-18
- PV-solar system consisting of a total of 288 PV-modules and 5 inverters; installed peak power: 70kW, generated an estimated 64000 kWh/year, accounting for 37 kWh/(m^2A_{temp}*year).

ALBANO – An Emerging Zero Carbon District
Optimization of energy systems and services in building clusters and districts

ALBANO - MODEO
From NZEB to NZED

Key objectives:
- **Optimizing system boundaries**
- **Renewables, residual heat & energy quality**
- **Energy storage/distribution**
- **Innovative economic models**

New Albano district (150 000 m^2 Atemp)

Sponsors/Partners
Swedish Energy Agency, Akademiska Hus, Ebab, Equa Simulation, Folkhem, Humlegården, NCC, SP, White, WSP, Fortum, Sustainable Innovation, Fraunhofer Institute IBP (Kassel)

4,71 MSEK (2014-2017)
Swedish Energy Agency

International partners
CRC for Low Carbon Living, Sydney, AU
Swinburne University, Melbourne, AU
University of Melbourne, Melbourne AU
Zhejiang University, Hangzhou, CN
Aalto University, Espoo, FI; VTT, ESPOO, FI

Sustainability is a moving target – push the limits!