ZenN

Nearly Zero Energy Neighborhoods

Final report on common definition for nZEB renovation

D.1.2 Report

Publisher ZenN – Nearly Zero Energy Neighborhoods

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Foreword

This report is a deliverable of the project Nearly Zero energy Neighbourhoods (ZenN). The project is being implemented 2013 – 2017 and is funded through EU's Seventh Framework Programme (FP7). In total, 12 partners from five countries are involved in the project: Tecnalia (Spain), CEA (France), IVL Swedish Environmental Research Institute (Sweden), SINTEF (Norway), ASM (Poland), NTNU (Norway), The municipality of Oslo (Norway), Debegesa (Spain), City of Eibar (Spain), Ville de Grenoble (France) EJ-GV (Spain) and the City of Malmö (Sweden).

In the ZenN- project, residential areas in Sweden, Norway, Spain and France will function as nearly Zero energy building (nZEB) renovation demonstration projects where a number of measures will be implemented in connection with renovations. The general objectives of the project are to demonstrate the feasibility (technical, financial and social) of innovative low energy renovation processes for buildings at the neighbourhood scale; identify and disseminate promising management and financial schemes to facilitate large scale replication and launch ambitious replication plans at several scales (local, regional etc.) with the participation of local administrations.

Deliverable 1.2 is divided in two parts. First part, *Part A – Literature review,* presents the current knowledge about how to define a net ZEB definition. The other part, *Part B – Common definition of nZEB renovation,* is presenting the definition agreed upon by the ZenN partners.

Executive summary

What is a Nearly Zero Energy Neighborhood?
A nearly zero energy neighborhood is a cluster of residential units where the overall energy demand is low and is partly met by renewable energy self-produced within the neighbourhood.

This report is a delivery of the project Nearly Zero energy Neighbourhoods (ZenN). The project is being implemented 2013 – 2017 and is funded through EU's Seventh Framework Programme (FP7). This report is the deliverable D1.2 connected to WP1, Task 2.1 which has given the premises for how to define nearly zero energy buildings (nZEB) within ZenN.

The report is divided into two parts:

1) *Part A – Literature review* which presents the current knowledge about ZEB definitions.

2) *Part B – Common definition of nZEB renovation* which presents the definition agreed upon by the ZenN partners.

Five main sources have been in identified which contain state-of-art knowledge to aid in defining nZEBr which are:

- IEA SHC Task40 / EBC Annex 52: "Towards Net Zero Energy Solar Buildings" (IEA 2013, IEA\SHC 2013)
- BPIE report: "Principles for nearly zero-energy buildings" (BPIE 2011)
- EPBD – CA (*Concerted Action*) REHVA papers (Kurnitski 2013)
- EC project: "Towards nearly zero-energy buildings – Definition of common principles under the EPBD" (ECOFYS, Politechnico_di_Milano/EERG et al. 2012)
- Standard: prEN 15603:2013 Energy performance of buildings - Overarching standard EPBD and related technical reports (TR 2013, prEN15603 May 2013)

The structure of both Part A and Part B is based on the structure of IEA SHC Task 40 / EBC Annex 52 "Towards Net Zero Energy Solar Buildings" (IEA 2012), which considers five main criteria: Building system boundary, Weighting system, Net ZEB balance, Temporal energy match characteristics and Measurement and verification. In part B, a last chapter called "Net ZEB evaluation" is included, describing the pilot cases before and after renovation using the common nZEBr definition and IEA net ZEB evaluation tool. The "after-figures" are here based on theoretical values collected through BEST tables included in ZenN Annex I - Description of Work.

The building system boundary

The physical boundary may be on a single building or on a cluster of buildings. For the sites with multiple buildings and site energy centers as is the case in ZenN, the system boundary is extended so that it covers entire site with multiple buildings and decentralized production.

The balance boundary defines how the operational phase is considered in terms of energy use. ZenN partners agreed to adopt the prEN 15603 default choice (table A3 in (prEN15603 May 2013)) that includes heating, cooling, ventilation and domestic hot water; but also to open up for a second set of calculations where lighting is included as well.

Also a set of boundary conditions has been specified for each pilot case, describing functionality, space effectiveness, climate and comfort.

Weighting system

A weighting system converts the physical units into other metrics, for example accounting for the energy used (or emissions released) connected to the delivered or exported energy. Each country related to the pilot cases has set up own metrics (static, symmetric), together with a set of common factors (static, asymmetric) based on prEN 15603 (prEN15603 May 2013). The only common factor which differs from the standard is the factor for district heating. A common set of primary energy values are of interest because this makes it possible to compare the pilot cases based on the same background methodology.

Net ZEB balance

The energy balance can be determined either between delivered and exported energy or between load and generation. The decision within ZenN is to do calculations in two ways, depending on whether national or common weighting factors are used:

- With national primary energy factors, which are all symmetric, the balance will be between load and generation.
- With the common energy factors, which are asymmetric, the balance follows the calculation method in the technical report related to prEN 15603:2013 (TR July 2013) (Note: It is not sure that the technical report is illustrating the final way of doing this. If changes are done, ZenN will follow up on these)

Temporal energy match characteristics

The correlation between load and generation (load matching) will be illustrated through the indicators “Load cover factor” and “Supply cover factor” (IEA 2014). Both are to be calculated based on hourly values. The grid interaction will be illustrated through indicators introduced in (IEA 2014); “Generation multiple” and “Dimensioning rate”, and related graphs. Both are calculated based on hourly values and input on nominal grid connection capacity.

Measurement and verification

This part deals with both general and specific requirements to be addressed in order to gather the necessary data to make the balances, as well as to verify that the degree of ambition in nZEBr renovation processes has been achieved. Both data format and quality, as well as the specificities of building renovation, in both their technical and social dimensions, have been considered, in an attempt to streamline the monitoring procedures to be carried out down the line.

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PART A: Literature review

1 Introduction

What is a Nearly Zero Energy Neighborhood?
A nearly zero energy neighborhood is a cluster of residential units where the overall energy demand is low and is partly met by renewable energy self-produced within the neighborhood.

Nearly Zero Energy Building renovation is based on a number of reports which attempts to define nearly zero energy building (nZEB). The term nZEB was introduced by Energy Performance of Buildings Directive recast in 2010 (2010) which stated a general framework requesting Member States to elaborate their national approaches and implementation plans. The different national approaches make it difficult to combine a unique European nZEB definition. The term nZEB is therefore very flexible and no single and harmonised nZEB definition across Europe. In addition, the nZEB requirement addresses only new buildings which will be constructed from 2020 onwards. There are no clear plans or mandatory requirements introduced for nZEB renovations. Five main sources have been in identified which contain state-of-art knowledge to aid in defining nZEBr which are:

- IEA SHC Task40 / EBC Annex 52: “Towards Net Zero Energy Solar Buildings” (IEA 2013, IEA\SHC 2013)
- BPIE report: “Principles for nearly zero-energy buildings” (BPIE 2011)
- EPBD – CA (*Concerted Action*) REHVA papers (Kurnitski 2013)
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The work of IEA SHC Task 40 / EBC Annex 52 “Towards Net Zero Energy Solar Buildings” (IEA 2013) is used as a starting point to define nearly zero energy building renovation for ZenN. In this report, there are five criteria stated as necessary to assess if a building is nZEB which are; Building system boundary, Weighting system, Net ZEB balance, Temporal energy match characteristics and Measurement and verification. The following sections outline the five criteria in detail. The definition is expanded to be specific for nZEBr so that more than 50% reduction in yearly energy demand in the existing buildings is also included for the neighbourhood pilot projects involved in ZenN.

2 Building system boundary

Defining the building system boundary is necessary to identify what energy flows cross the boundary. The building system boundary can be seen as a combination of a physical and a balance boundary. Only energy flows that cross the system boundary, i.e. both physical and balance boundaries, are considered for the Net ZEB balance. A Net ZEB definition that does not include all operational energy services poses a challenge on building performance verification because it requires a more sophisticated measurement system (Sartori, Napolitano et al. 2012). This is discussed under chapter 7, Measurement and verification.

2.1 Physical boundary

The physical boundary may be on a single building or on a cluster of buildings. The latter case implicates that each building doesn't necessarily need to be Net ZEB by itself but that the cluster is regarded as a whole.

It is important to note though that a cluster of buildings implies a synergy between several buildings which are not necessarily Net ZEB as singles but as a whole. The physical boundary is useful to identify so called ‘on-site’ generation systems; so that if a system is within the boundary it is considered on-site, otherwise it is ‘off-site’. (Sartori, Napolitano et al. 2012)

It has to be specified which two-way grids are available at the physical boundary. A two-way grid is a grid that can deliver energy to and also receive energy back from the building(s). Without a two-way grid it is not possible to define a Net ZEB. The power grid is normally available as two-way grid. Other two-way grids may be local thermal networks, such as district heating/cooling networks. Specific conditions are normally required by the grid operators in order to accept exported energy, such as on frequency and voltage tolerances (power grid) or temperature levels (thermal network). (Sartori, Napolitano et al. 2012)

In (Kurnitski, Allard et al. 2013) detailed system boundary is modified from the definition in EN 15603:2008. As stated in EPBD recast, the positive influence of renewable energy produced on site is taken into account so that it reduces the amount of delivered energy needed and may be exported if it cannot be used in the building (i.e. on site production is not considered as part of delivered energy).

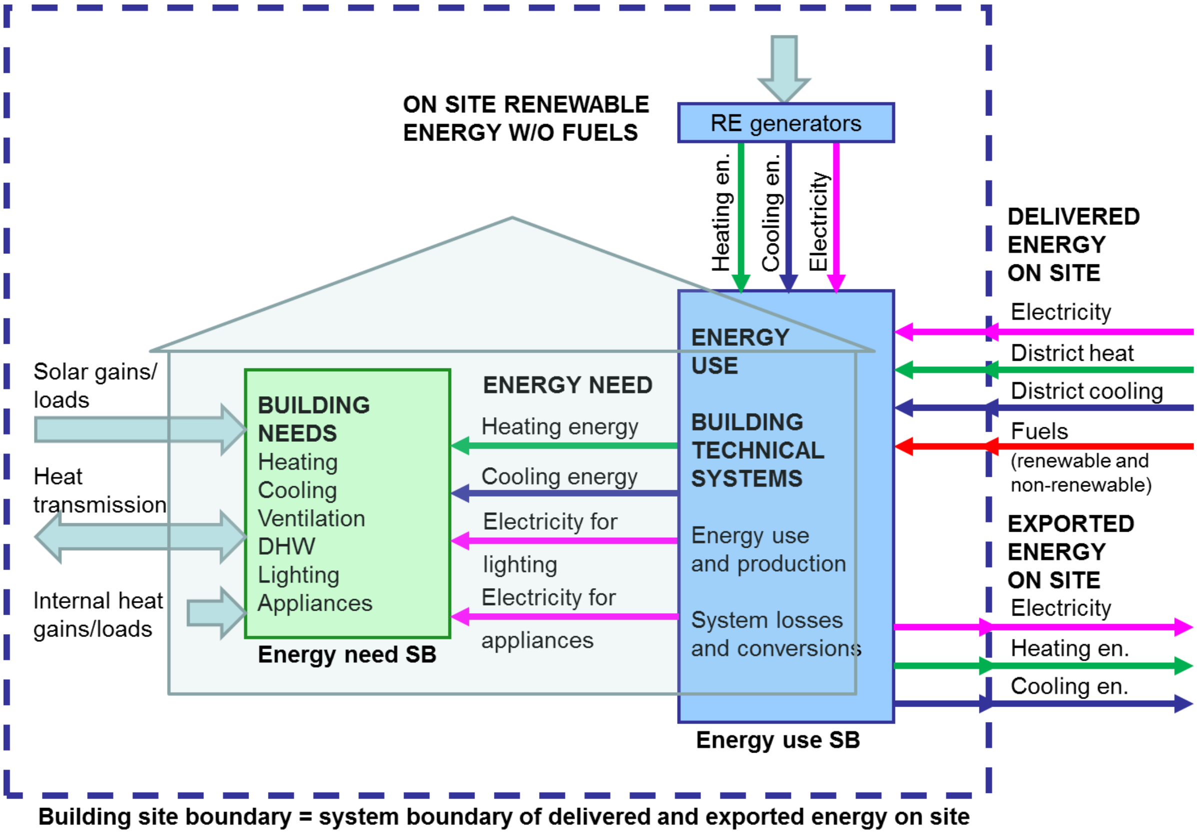


Figure 2.1 Illustration of the building site boundary

Figure 2.1 illustrates energy need, energy use and delivered and exported energy calculation. System boundary of energy use applies also for renewable energy ratio calculation with inclusion of RE from geo-, aero- and hydrothermal energy sources of heat pumps and free cooling as shown in the figure. (Kurnitski, Allard et al. 2013)

For the sites with multiple buildings and site energy centres the system boundary in Figure 2.1 has to be extended so that it covers entire site with multiple buildings and decentralized production, Figure 2.2. Buildings and site energy centre may have on site energy production and energy exchange between buildings. (Kurnitski, Allard et al. 2013)

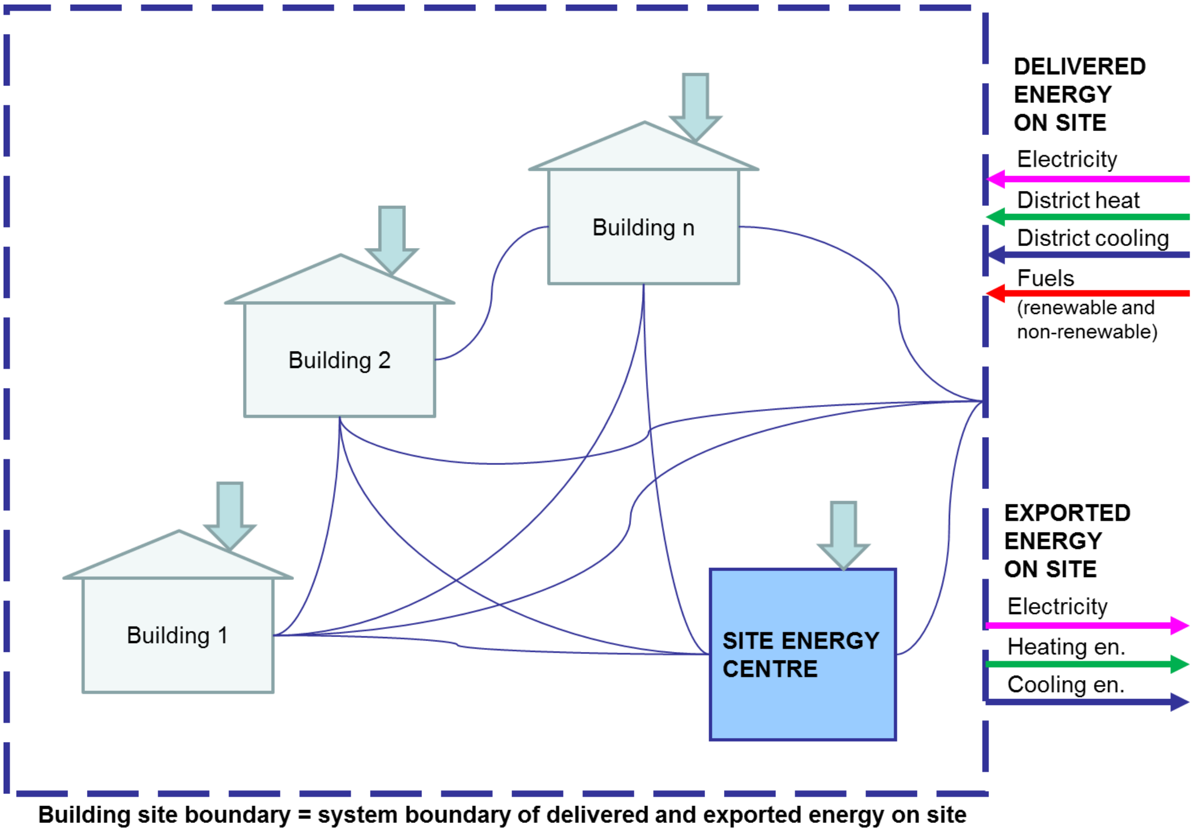


Figure 2.2 Illustration of system boundary

In (T.H. Dokka 2013) the term system boundary is understood as the boundary where delivered- and/or exported energy to or from the building (or cluster of buildings) is measured (or calculated).

The paper refers to (Marszal, Heiselberg et al. 2010) and Figure 2.3 is illustrating different options for system boundaries. Regarding system boundaries and local renewable electricity production the Norwegian Research Centre on Zero Emission Buildings ZEB has chosen to use level III in Figure 2.3 arguing that "Such solutions will reduce the need for new central electricity production in the grid" and also that " exported electricity can offset existing electricity production with higher CO2eq emissions. The eventual disadvantage of new renewable electricity production (e.g. visual, noise or other) will then have to be solved on the site, and not "exported" away."

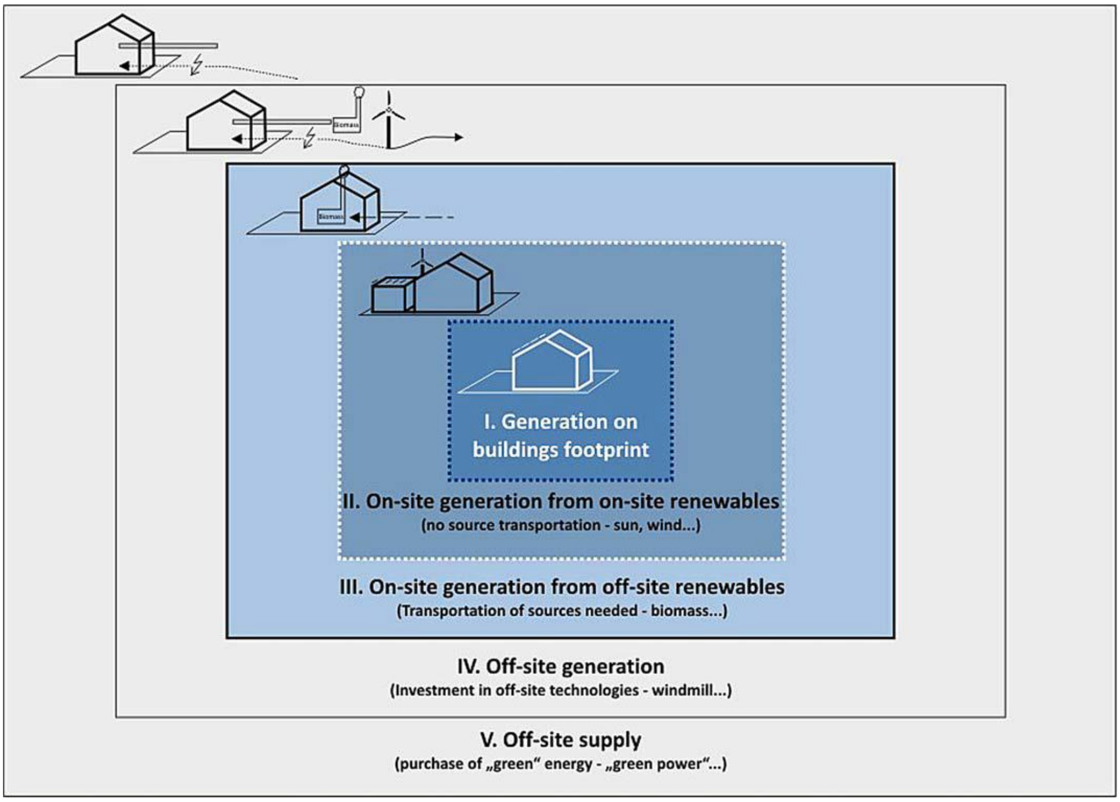


Figure 2.3 Illustration of the different levels of possible system boundaries

Regarding thermal energy production, for instance a district heating system with higher production efficiency than a smaller and local alternative, can provide a good supply solution for a zero energy building. This argues in favor of level IV on Figure 2.3, where off-site generation is also allowed.

[Dokka et al] concludes that "local renewable electricity production shall be produced on-site, but off-site renewables (e.g. bio-fuels) can be used in the production. Thermal energy production for the building or area (cluster of buildings) can be both on-site and off-site, but emission from the real energy mix shall be used and the total system losses from production to emission in the building shall be taken into account."

The same could be done regarding primary energy use: Primary energy from the real energy mix should be used and the total system losses from production should be taken into account.

2.2 Balance boundary

The balance boundary defines how the operational phase is considered in terms of energy use. These typically include heating, cooling, ventilation, domestic hot water, fixed lighting and plug-loads. Also energy embodied in materials and installations, together with energy used in the erection and demolition, could be included in the balance boundary.

The boundary conditions should secure a consistent Net ZEB definition allowing a meaningful comparison between similar buildings in similar climates. This requires a specified set of boundary conditions concerning functionality, space effectiveness, climate and comfort.

2.3 Boundary conditions

A consistent Net ZEB definition should allow a meaningful comparison between similar buildings in similar climates, as well as between the expected performance of a building from its design data and the measured performance revealed by monitoring data.

It is important to understand if any deviation from expected values is attributable to technical operating or design mistakes, or if it is simply due to different conditions of use. For this purpose it is necessary to explicitly specify a set of boundary conditions: functionality, space effectiveness, climate and comfort. The functionality describes what type of uses the building is designed for.

The reference climate and the comfort standards used in design also need to be specified. Variations from expected outdoor climate and/or indoor comfort conditions are important and should be taken into consideration before comparing the expected performance with the monitored one. (Sartori, Napolitano et al. 2012)

3 Weighting system

To be able to count the delivered and exported energy a conversion needs to be done by weighing factors. A weighting system converts the physical units into other metrics, for example accounting for the energy used (or emissions released) connected to the delivered or exported energy (Sartori, Napolitano et al. 2012).

Conversion factors are used to distinguish between different types of energy, e.g. electricity, gas, oil, district heating etc. These factors can help obtain a more accurate measure of the total energy use from an environmental or economic perspective (BPIE 2011).

3.1 Metrics

3.1.1 Primary energy factors (PEF) in general

EN 15603:2008 (currently under revision) specifies general framework for the assessment of energy performance. This standard explains the rationale behind primary energy rating in this way (8.3.1):

The primary energy approach makes possible the simple addition from different types of energies (e.g. thermal and electrical) because primary energy includes the losses of *the whole energy chain, including those located outside the building system boundary. These losses (and possible gains) are included in a primary energy factor.*

EXAMPLE If a building A exports heat to building B, which is located outside the assessment boundaries, this heat is taken into account in the same way as district heating. The primary energy factor used for building B includes the system losses (generation, heat losses between building A and B, etc)

...

Primary energy is calculated from the delivered and exported energy for each energy carrier:

$E_P = \sum(E_{del,i}\ f_{P,del,i}) - (E_{exp,i}\ f_{P,exp,i})$

where

$E_{del,i}$ *is the delivered energy for energy carrier i;*

$E_{exp,i}$ *is the exported energy for energy carrier i;*

$f_{P,del,i}$ *is the primary energy factor for the delivered energy carrier i;*

$f_{P,exp,i}$ *is the primary energy factor for the exported energy carrier i.*

EN 15603:2008 (8.3.3) says:

There are two conventions for defining primary energy factors:

a) *Total primary energy factor. The conversion factors represent all the energy overheads of delivery to the point of use (production outside the building system boundary, transport, extraction). In this case the primary energy conversion factor always exceeds unity.*
b) *Non-renewable primary energy factor: The conversion factors represents the energy overheads of delivery to the point of use but exclude the renewable energy component of primary energy, which may led to a primary energy conversion factor less than unity for renewable energy sources.*

The primary energy factors shall include at least:

- *Energy to extract the primary energy carrier;*
- *Energy to transport the energy carrier from the production site to the utilization site;*
- *Energy used for processing, storage, generation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy is used*

The primary energy factors may also include:

- *Energy to build the transformation units;*
- *Energy to build the transportation system;*
- *Energy to clean up or dispose the wastes.*

The standard also says that national annexes may be added to the standard, showing an example of a table in annex E (see annex I in this report).

EPBD Recast Article 9 - Nearly zero-energy buildings, 3. (EPBD 2010) requires that the national plans in each Member State of the European Union shall include:

> *the Member State's detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions, and including a* ***numerical indicator of primary energy use expressed in kWh/m² per year****. Primary energy factors used for the determination of the primary energy use may be based on national or regional yearly average values and may take into account relevant European standards;*

3.1.1.1 Methodology behind PEF and GHG emission factors

Primary energy and emission factors are based on Life Cycle Assessments (LCA). There are two major options when regarding general methodological assumptions in LCA; one is a **book-keeping[1] methodology** used to show for example the emissions from past year from a district heating network; the other is a **prospective methodology** to show what the consequences are of a certain change in some part of the system. A book-keeping LCA provides an environmental assessment of the life cycle and subsystems investigated (Ekvall et al 2005). It has more of an administrative purpose and is probably the most commonly used, for example the emissions reported to UN from each country every year (UNFCCC). However, it doesn't give any information about what the effect will be of change in the system. A main purpose of the prospective LCA is to give information to decision makers when there are several options to consider. The prospective LCA are on the other hand more uncertain since the methodology often uses a "scenario" in the calculations. Indirect effects[2] of a change can often be considered in a prospective LCA.

Other characteristics of the methodologies are that in a book-keeping method the sum of all partial inputs and outputs in the studied system will sum to the total inputs and outputs, while the prospective method in many cases can use flows from outside the studied system and therefore the total sum can be different from the sum of all the partial flows in the system. In that aspect, book-keeping is easier to understand for most people. The two perspectives can in some way also be seen as a local or global dimension where book-keeping is local and prospective is seen as more global because of the used system expansion.

[1] Also called retrospective or attributional method
[2] Like what would the land be used for if it wouldn't have been used for agricultural energy crops.

In the case of quantifying the environmental performance of the change in energy demand (or new energy supply) due to retrofitting measures both perspective could be used. A book-keeping method before and after the retrofit will show the differences when everything else is kept exactly the same as before but it won't give any information on how the retrofit will affect the energy system. To show this the prospective method is needed because it takes care of the effects in the existing and/or future energy system. Most people will find it difficult to know how a prospective method should be performed and also to understand the result, for example, which fuel decreases when the demand of district heating decreases and what would be the substitute if the need for the fuel increases. The method is only valid for a specific amount of fuel and for a certain time horizon. This must be known by the one that carry out the calculation. In case of district heating- and electricity generation two marginal perspectives are commonly used. One is the **short term marginal** which describes how the existing production technologies are affected by a small change in the demand. **Long-term marginal** describes how a certain change in the demand in a longer perspective will affect which production technologies that are dismantled or constructed, i.e. long term is a long enough time horizon in order for replacement of capital equipment to take place (Weidemaa et al 1999). There are also methodologies within prospective method that combine both these perspectives in one, i.e. **complex marginal**. A change in demand will first change the production from the existing technologies and later affect the dismantled or new constructed technologies. Scenarios that calculate the complex marginal often include a dynamic computer model that optimizes the total system cost when parameters such as the future energy demand are given or increases with certain amount compared to BAU, see for example Matsson et al 2003 and Sköldberg & Unger 2008.

3.1.1.2 Calculation of factors in reality

This previous section was more theoretical aspects of choosing environmental performance methodology, but it can be translated to more practical question to regard. In reality, the lack of available data (marginal data for example) and the time frame of the project will set the limits, together with the fact that EU-directives and standards needs to be taken into account. Another issue is that the results must be easy to communicate and a prospective method usually needs much more explanation.

Below are questions that are of importance for the result in a PEF- and GHG calculation.

1. What kind of allocation method should be used to divide the fuel input between heat and electricity in a combined heat and power plant? (Allocation is only used for book-keeping method while system expansion is used in a prospective method). The choice has a large impact on the calculated environmental performance of heat and electricity.
2. Where are the system borders for the electrical system regarded in the calculations?

3. How are electricity and heat with **guarantee of origin, GO**[3]**,** sold to customers regarded in the calculations? (Is a residual mix used for the rest of the mix?)
4. Which time-resolution should be used?
5. Where are the system borders for the primary energy included?
    a. i.e which part of the fuel chain is included and
    b. which primary energy is included (free flowing, recycled/waste, renewable, fossil)
6. Which climate gases are regarded (CO_2, CH_4 and N_2O)?
7. Should emissions for the whole fuel chain be regarded?
8. Which data source for the factors included in the calculations should be used?

The European standards, EN, used for PEF and GHG calculations answer this on the questions above:

1. There are EN-standards that regard the calculations of the **PEF** and **GHG** for a district heating network, **EN 15316:4:5:2007** together with **EN 15603:2008** that soon will be replaced when the draft prEN15603 May 2013 is accepted. The latter includes both the district and building level. The methodology used can best be explained as a mix between book-keeping and prospective perspective. The allocation method /system expansion method used is in the standards called the **power bonus method**. Using the power bonus method will give the produced heat in a **CHP plant** credit for lost emissions in the electrical energy system when electricity is exported to the grid (somewhat prospective).

2. Which electricity that should be regarded is not stated exactly in the standard but in the draft (prEN15603) a PEF of 2.5 is used (see Table A.8 in the draft). However it is not stated what system borders that are used to come up with a PEF of 2.5. Average European electricity is the most appropriate guess. It is also mentioned that a different value can be given in a national annex. In the current standard the factor can be either average regional mix or marginal.

3. The question if heat and electricity with GO shall be regarded or how is not answered in the standard.

4. In the draft (prEN15603) there is more information about the possible time resolution in the calculations. The energy need shall most preferably be calculated at an hourly time step according to the EN ISO 13790. There are also ways to account for energy carriers that are generated but used at different time steps. In table A.8 in the draft , prEN15603, there are factors for energy carriers that are "temporary exported and reimported later". *The energy overhead due electricity produced and consumed at different time steps is taken into account in the temporary exported electricity primary energy factor* (prEN15603)

[3] Different tracking systems are used, EECS GO (Guarantees of Origin), RECS certificate and information from RTS (Reliable Tracking Systems)

5a. Regarding which system borders that are used to generate the primary energy factors the standards are not clear but from the factors it can be derived that for example embodied energy to produce the PV or solar panel is not included.

5b. Question 5 is partially answered since the standard uses either **non-renewable primary energy** or **total primary energy factors.** However there are questions regarding how energy from energy recovery processes shall be regarded, for example energy from industrial surplus heat and from waste-to-energy plants.

6. In the draft it is mentioned that other climate gases than carbon dioxide **can** be used in the CO_2 emission factors used, i.e. methane.

7. The system borders used for the CO_2 emission factors are not defined in the standards.

8. In the discussed EN- standard it is clearly stated that conversion factors used can be replaced partially or totally by a nation annex. The author are however not aware of such national annexes at the present time although they might well exist.

3.1.2 Primary energy factors for the European Union

The choice of conversion factor connected to the grid is a political issue which must be decided on a national level. There are huge differences in the different European calculation methods on how weighting factors are used, and the “correct” factors will differ from country to country based on how different energy types are produced, distributed etc (BPIE 2011).

Table 3.2 shows metrics found for selected nations by Sartori et al, 2012. Table 3.3 gives the references to the metrics presented in Table 3.2.

Table 3.1 shows the table from appendix 2 in the Directive 2006/32/EC on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC (EU 2006), presenting avarage weighing factors for different energy sources within the European Union. In the footnote connected to the electricity it says that:

"*For savings in kWh electricity Member States may apply a default co-efficient of 2.5 reflecting the estimated 40 % average EU generation efficiency during the target period. Member States may apply a different co-efficient provided they can justify it*."

Figure 3.1 shows the basis for EUs Ecodesign directive (MEErP 2011), where the consensus value for the efficiency of the electric power grid is set to 40%. This is equivalent to a primary energy factor of 2.5 (PEF = 1/0.4 = 2.5). i.e. one kWh electricity use at site equals 2.5 kWh of primary energy.

Table 3.1 Energy content of selected fuels for end use – conversion table (EU 2006).

Energy content of selected fuels for end use — conversion table (1)

Energy commodity	kJ (NCV)	kgoe (NCV)	kWh (NCV)
1 kg coke	28 500	0,676	7,917
1 kg hard coal	17 200 — 30 700	0,411 — 0,733	4,778 — 8,528
1 kg brown coal briquettes	20 000	0,478	5,556
1 kg black lignite	10 500 — 21 000	0,251 — 0,502	2,917 — 5,833
1 kg brown coal	5 600 — 10 500	0,134 — 0,251	1,556 — 2,917
1 kg oil shale	8 000 — 9 000	0,191 — 0,215	2,222 — 2,500
1 kg peat	7 800 — 13 800	0,186 — 0,330	2,167 — 3,833
1 kg peat briquettes	16 000 — 16 800	0,382 — 0,401	4,444 — 4,667
1 kg residual fuel oil (heavy oil)	40 000	0,955	11,111
1 kg light fuel oil	42 300	1,010	11,750
1 kg motor spirit (petrol)	44 000	1,051	12,222
1 kg paraffin	40 000	0,955	11,111
1 kg liquefied petroleum gas	46 000	1,099	12,778
1 kg natural gas (1)	47 200	1,126	13,10
1 kg liquefied natural gas	45 190	1,079	12,553
1 kg wood (25 % humidity) (2)	13 800	0,330	3,833
1 kg pellets/wood bricks	16 800	0,401	4,667
1 kg waste	7 400 — 10 700	0,177 — 0,256	2,056 — 2,972
1 MJ derived heat	1 000	0,024	0,278
1 kWh electrical energy	3 600	0,086	1 (3)

Source: Eurostat.

(1) 93 % methane.
(2) Member States may apply other values depending on the type of wood most used in the respective Member State.
(3) For savings in kWh electricity Member States may apply a default co-efficient of 2,5 reflecting the estimated 40 % average EU generation efficiency during the target period. Member States may apply a different co-efficient provided they can justify it.

Table 3.2 Metrics for selected countries found by Sartori et al. 2012.

Appendix A – Conversion factors

		Europe		Austria	Denmark	Finland		Germany		Italy	Norway		Spain		Sweden		Switzerland	
Energy carrier	Metrics	EN 15603	PHPP	Gemis	BR 2010	BC 2012	Gemis	DIN V 18599/1	GEMIS	UNI-TS-11300/4	NS 3700	ZEB centre*	I.D.A.E.	CALENER	average*	pol. factors	SIA 2031	EnDK
		2008	2007	Vers. 4.5	2010	2011	2011	2007	Vers. 4.5	draft 9/2009	2009	2010-2060	2010	2009	2008	2008	2009	2009
Electricity	PEI, n.r.	3,14*	2.70	1,3*		1.70		2.60	2.61	2.18*							2.53	2.00
	PEI, total	3,31*		1.91	2,50*	1.70		3.00	2.96				2.28	2.60	1.50	2.50	2.97	
	$CO_{2\ equiv.}$	617,00*	680.00	389.00		329.62	331.00		633.00	531**	395	132	350*	649			154.00	
Natural gas	PEI, n.r.	1.36	1.10	1.12		1.00		1.10	1.12	1.00							1.10	1.00
	PEI, total	1.36		1.12	1.00	1.00		1.10	1.12				1.07	1.10			1.15	
	$CO_{2\ equiv.}$	277.00	250.00	268.00		202*	315.00		244.00		211		251*	204.00			241.00	-
Oil	PEI, n.r.	1.35	1.10	1.11		1.00		1.10	1.11	1.00							1.15	1.00
	PEI, total	1.35		1.13	1.00	1.00		1.10	1.11				1.12	1.08	1.20	1.20	1.24	
	$CO_{2\ equiv.}$	330.00	310.00	302.00		279*	381.00		302.00		284		342*	287.00			295.00	
Wood, pieces	PEI, n.r.	0,09**	0.20	0.01		0.50		0.20	0.01	0.00							0.05	0.70
	PEI, total	1,09**		1.01	1.00	0.50		1.20	1.01				1.25		1.20	1.20	1.06	
	$CO_{2\ equiv.}$	14**	50.00	6.00		32.40	17.00		6.00		14		0.00	0.00			11.00	
Wood, pellets	PEI, n.r.			0.14		0.50		0.20	0.14	0.00							0.30	0.70
	PEI, total			1.16	1.00	0.50		1.20	1.16					0.00	1.20	1.20	1.22	
	$CO_{2\ equiv.}$			41.00			19.00		41.00		14						36.00	
Disctrict heat	PEI, n.r.		0.80	0.76				0.70	0.76	system specific							0,81*	0.60
70% CHP	PEI, total			0.77	1,00*	0.70		0.70	0.77						0.90	1.00	0,8*	
(fossil)	$CO_{2\ equiv.}$		240.00	219.00			230.00		219.00		231						162*	

PEI = Primary Energy Indicator — $kWh_{primary}$ / $kWh_{delivered}$
n.r. = non renewable part — $kWh_{primary}$ / $kWh_{delivered}$
CO_2 equiv. = equivalent CO_2 emissions — g / $kWh_{delivered}$

Table 3.3 References to the metrics in Table 3.2 (Sartori, Napolitano et al. 2012)

PEI: primary energy indicator (kWhprimary/kWhdelivered); n.r.: non renewable part (kWhprimary/kWhdelivered); CO2 equiv.: equivalent CO2 emissions (g/kWhdelivered). * See comments for each country.

Country	Comments	Sources
Europe	*Power according to UCTE mix **Wood in general	EN 15603 [17] Energy Performance of Buildings – Overall energy use and definition of energy rationgs – Annex E Factors and coefficients, CEN. PHPP (2007) Passive House Planning Package, The Passive House Institute, Darmstadt, DE.
Austria	*According to the Austrian Environment Agency	Database of GEMIS, Global Emission Model for Integrated Systems, Internet page of the program: http://www.oeko.de/service/gemis/en/
Denmark	*2015 requirements use 0,8; 2020 requirements use 0,6 for district heating and 1,8 for electricity	The Danish Building Code 2010, BR 2010
Finland	*Based on Motiva report, 2004	National Building Code of Finland. Part D3 Energy-Efficiency. Ministry of Environment 2011 Database of GEMIS, Global Emission Model for Integrated Systems, Internet page of the program: http://www.oeko.de/service/gemis/en/ Motiva report, 2004, emission factors and calculation of emission factors. Available at: http://www.motiva.fi/files/209/Laskentaohje CO2 kohde 040622.pdf Motiva report, 2004, emission factors and calculation of emission factors. Available at: http://www.motiva.fi/files/209/Laskentaohje CO2 kohde 040622.pdf
Germany	The normative primary energy factors for the national building code are given with DIN V 18599, emission date are not listet; if emission data are applied the most common source is GEMIS	
Italy	*EEN3/08 resolution by AEEG - GU n. 100, 29.4.08 - SO n.107 - www.http://www.autorita.energia.it/it/docs/08/003-08een.htm www.minambiente.it/home it/menu.html?mp=/menu/menu attivita/ &m=argomenti.html|Fonti rinnovabili.html|Fotovoltaico.html|Costi Vantaggi e Mercato.html	UNI-TS 11300 Part IV,under review (last draft 2009)-LA NORMATIVA TECNICA DI RIFERIMENTO SUL RISPARMIO ENERGETICO E LA CERTIFICAZIONE ENERGETICA DEGLI EDIFICI
Norway	*EU mix scenario for nearly carbon-free grid towards 2050 (in line with IPCC 450 ppm scenario); average 2010–2060	NS 3700 (2010) Criteria for passive houses and low energy buildings – residential buildings, Standards Norway. SINTEF Energy Research (2011) CO2 emissions in different scnarios of electricity generation in Europa, Report for the Zero Emission Building research centre, TR A7058.
Spain	*Carbon emissions only	I.D.A.E., Institute for Energy Diversification and Saving, http://www.idae.es/index.php/lang.uk CALENER, software for certification of energy efficiency in buildings, http://www.mityc.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/ProgramaCalener/Paginas/Documentos Reconocidos.asp
Sweden	*Calcualted according to EN15316.	For electricity, calculations are based on Nordic electricity http://www.sweden.gov.se/content/1/c6/10/01/76/9e6cf104.pdf, download, 27 July 2011
Switzerland	*Based on waste combustion	SIA 2031 "Energieausweis für Gebäude", SIA 2040 "Effizienzpfad Energie", Schweizer Ingenieur-und Architektenverein, 2009 Gebäudeenergieausweise der Kantone – Nationale Gewichtungsfaktoren, EnDK, Bundesamt für Energie, 2009

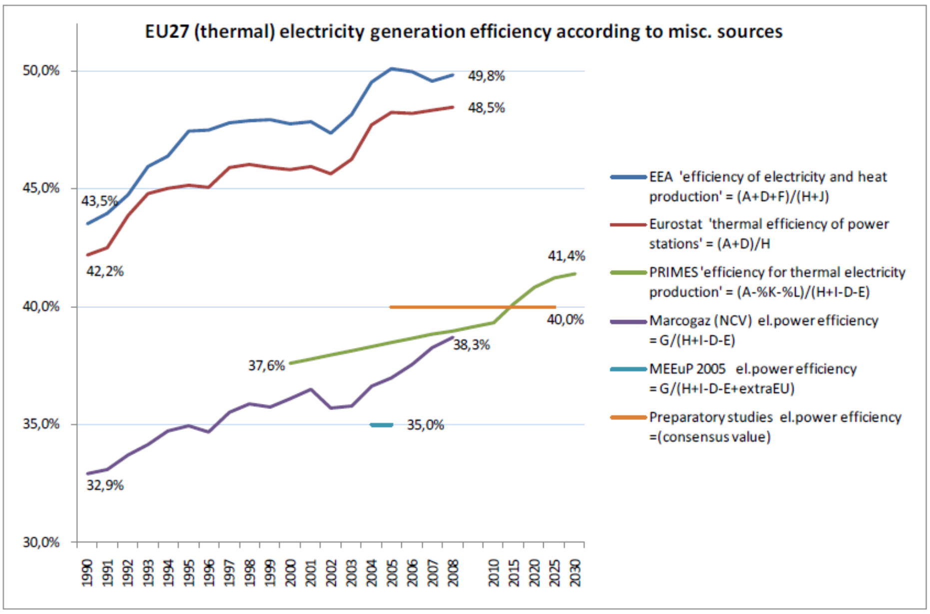


Figure 3.1 EU27 efficiency of thermal electricity generation according to miscellaneous sources (MEErP 2011)

3.2 Symmetry

Asymmetric and symmetric weighing factors are well explained in (Sartori, Napolitano et al. 2012):

The most adapted way of weighting the delivered and exported energy is to be done by a symmetric weighing factor. The rationale behind symmetric weighting is that the energy exported to the grids will avoid an equivalent generation somewhere else in the grid. Hence the exported energy has a substitution value, which is equal to the average weighting factor for that grid.

However, the main rationale behind asymmetric weighting is that energy demand and supply do not have the same value, hence delivered and exported energy should be weighted differently in order to reflect this principle. Two situations are possible:

(a) Delivered energy is weighted higher:
This takes into account the cost and losses on the grids side associated with transportation and storage of exported energy (and in case of electricity also possible earthing of feed-in power) as in the German tariff system since 2009, see [21]. This option may serve the purpose of reducing exchange with the grids–hence promoting self-consumption of on-site generation – in a scenario of wide diffusion of energy consuming and producing buildings;

(b) Exported energy is weighted higher:
This option may serve the purpose of promoting technology diffusion in a scenario of early technology adoption, e.g. the early PV feed-in tariffs adopted in Germany, Italy, Spain and other countries, where feed-in electricity is paid two to three times higher than what delivered electricity is charged for (here the asymmetric metrics is the energy cost).

3.3 Time dependent accounting

Table 3.2 gives an overview of static (and symmetric) conversion factors used in several countries. Due to the complexity of the energy infrastructure, it is often feasible to estimate the weighting factors only as average values for a period of time. This is a static accounting, and it typically applies to primary energy and carbon emission factors. (Sartori, Napolitano et al. 2012)

In reality, weighting factors will vary over time and space. Electricity, for example, may be evaluated for large regions while district heating/cooling or biomass may be evaluated at local scale, according to the actual availability of resources in the area (Sartori, Napolitano et al. 2012). In any case the evaluation of weighting factors should be updated at regular intervals to reflect the development of the grids. To this respect it is possible to consider different scenarios on the possible evolution of weighting factors,

In the evaluation of weighing factors for electricity and district heating it is also important to distinguish between average and marginal production and specify which choice is made. It is also possible to evaluate weighting factors on hourly basis, therefore leading to a dynamic accounting. As an intermediate option a quasi-static accounting would have seasonal/monthly average values and/or daily bands for base/peak load.
For energy prices it is already quite common to have seasonal or hourly fluctuating prices, while for other metrics such as primary energy and carbon emissions this is not the standard praxis today but it may become more common in future. (Sartori, Napolitano et al. 2012)

4 Net ZEB balance

4.1 Period

A proper time span for calculating the balance is assumed, often implicitly, to be a year. An yearly balance is suitable to cover all the operation settings with respect to the meteorological conditions, succession of the seasons in particular (Sartori, Napolitano et al. 2012). Selection of shorter time spans, such as seasonal or monthly balance, could be highly demanding from the design point of view, in terms of energy efficiency measures and supply systems, in order to reach the target in critical time, such as winter time (Sartori, Napolitano et al. 2012).

4.2 Type of balance

Important terms regarding the Net ZEB balance (Sartori, Napolitano et al. 2012)

Weighted demand:
The sum of all delivered energy (or load), obtained summing all energy carriers each multiplied by its respective weighting factor.

Weighted supply:

The sum of all exported energy (or generation), obtained summing all energy carriers each multiplied by its respective weighting factor.

Net ZEB balance:
A condition that is satisfied when weighted supply meets or exceeds weighted demand over a period of time, nominally a year. The net zero energy balance can be determined either from the balance between delivered and exported energy or between load and generation. The former choice is named import/export balance and the latter load/generation balance. A third option is possible, using monthly net values of load and generation and it is named monthly net balance.

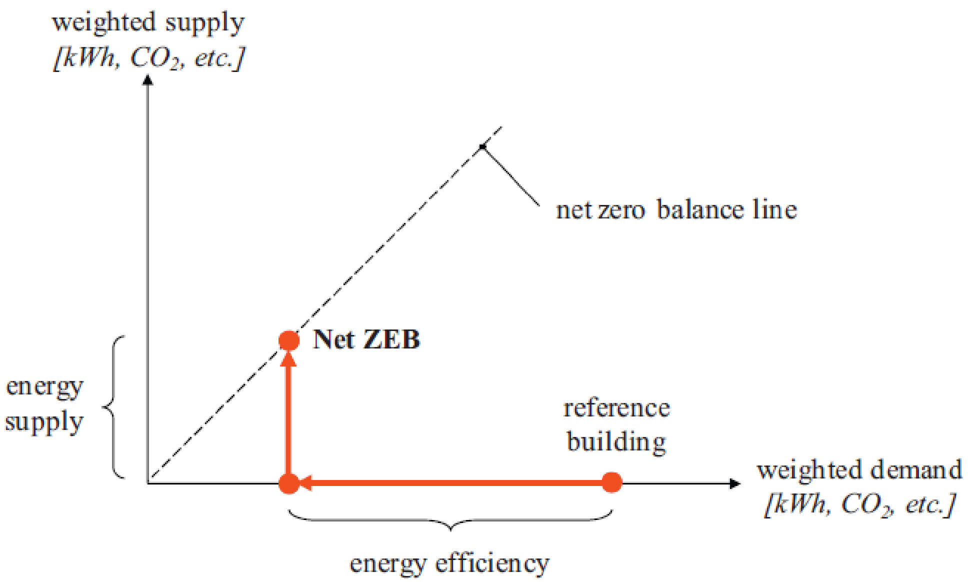


Figure 4.1 Graph representing the net ZEB balance concept (Sartori, Napolitano et al. 2012)

The Net ZEB balance is calculated as in Eq. (1):

$$|\text{weighted supply}| - |\text{weighted demand}| = 0 \qquad (1)$$

where absolute values are used simply to avoid confusion on whether supply or demand is considered as positive. The Net ZEB balance can be represented graphically as in Figure 4.1, plotting the weighted demand on the x-axis and the weighted supply on the y-axis.

The reference building may represent the performance of a new building built according to the minimum requirements of the national building code or the performance of an existing building prior to renovation work. Starting from such reference case, the pathway to a Net ZEB is given by the balance of two actions:

(1) reduce energy demand (x-axis) by means of energy efficiency measures;

(2) generate electricity as well as thermal energy carriers by means
of energy supply options to get enough credits (y-axis) to achieve the balance.

In most circumstances major energy efficiency measures are needed as on-site energy generation options are limited, e.g. by suitable surface areas for solar systems, especially in high-rise buildings (Sartori, Napolitano et al. 2012).

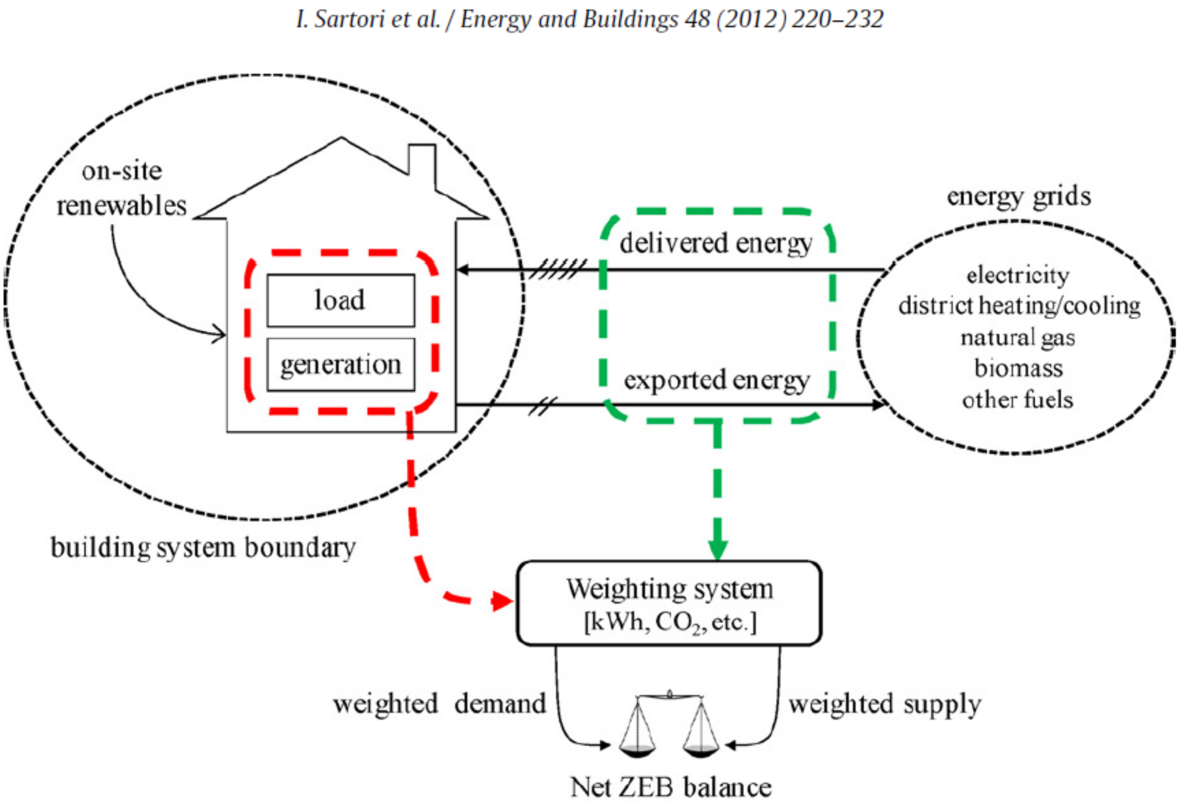


Figure 4.2 Sketch of connection between buildings and energy grids showing relevant terminology (Sartori, Napolitano et al. 2012)

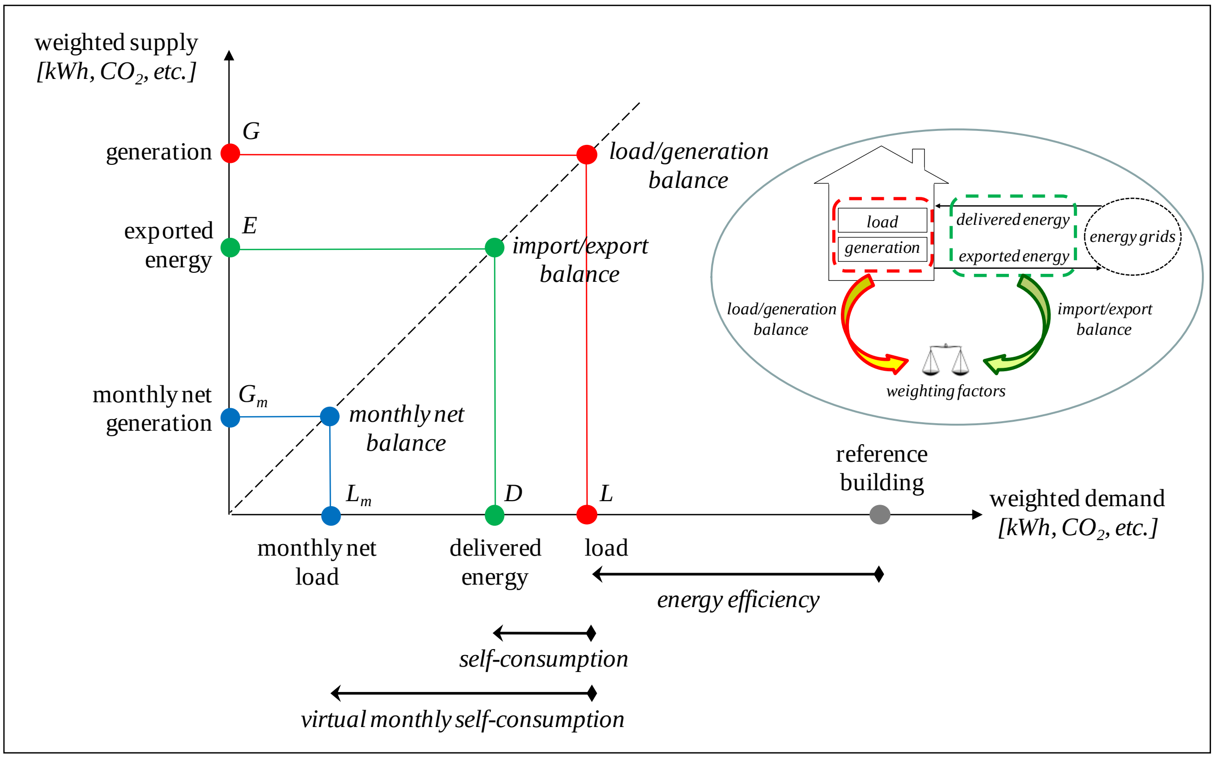


Figure 4.3 Graph representing the total net ZEB balance concept (Voss, Musall et al. 2013)

Figure 4.3 gives a graphical representation of the three types of balances: import/export balance between weighted exported and delivered energy, load/ generation balance between weighted generation and load, and monthly net balance between weighted monthly net values of generation and load (Sartori, Napolitano et al. 2012).

Figure 4.4 shows an example (Voss, Musall et al. 2013) were both generation/export and load/import is measured. This is monitoring results for a small all-electric, Net ZEB in Germany. The building is the Wuppertal University entry to the Solar Decathlon Europe 2010 in Madrid, now operated in Wuppertal (DETAIL 2011). The data based on 5-min resolution are expressed as a load/generation balance as well as an import/export balance including all on-site loads. Monitoring started in September 2011. 31% of the solar power is really consumed on-site. More examples can be found in (BPIE 2011).

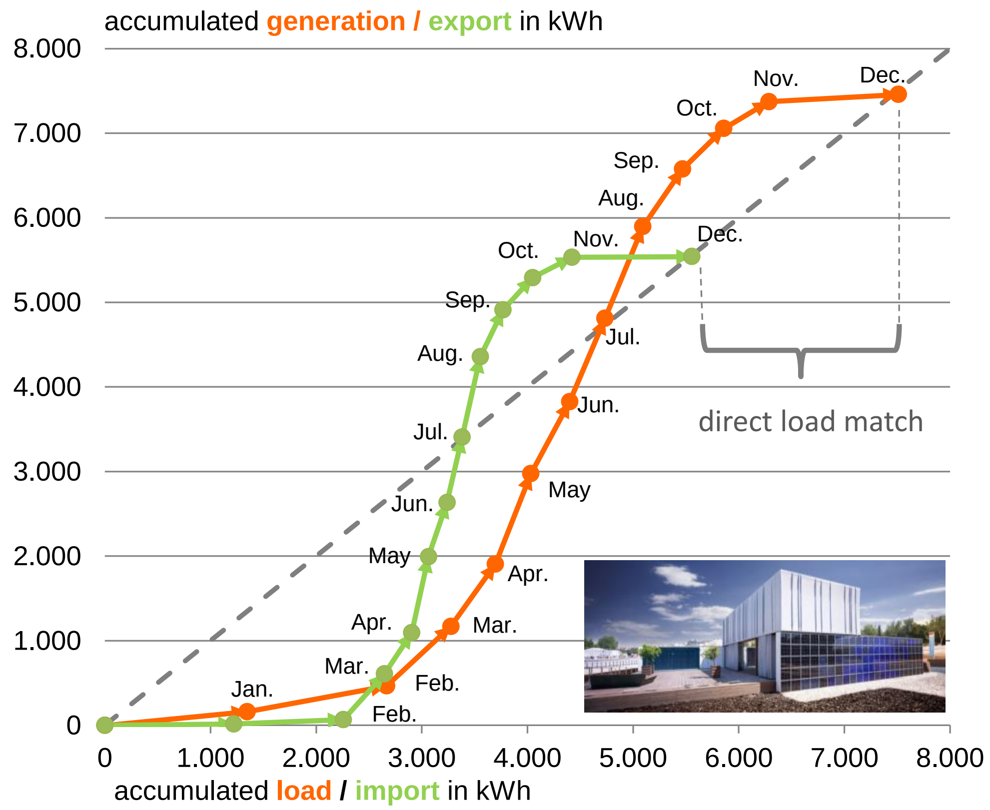


Figure 4.4 Graph illustrating the two ways of making the net ZEB Balance. Source: University Wuppertal, btga.

4.3 Energy efficiency

According to the first nZEB Principle in BPIE (BPIE 2011) "*there should be a clearly defined boundary in the energy flow related to the operation of the building that defines the energy quality of the energy demand with clear guidance on how to assess corresponding values*."

The approach for implementation is that " *this boundary should be the energy need of the building, i.e. the sum of useful heat, cold and electricity needed for space cooling, space heating, domestic hot water and lighting (the latter only for nonresidential buildings). It should also include the distribution and storage losses within the building*."

And further it is said that:

"*The electricity (energy) consumption of appliances (plug load) and of the other building technical systems (i.e. lifts, fire security lighting etc.) may also be included in the nZEB definition as an additional indicative fixed value (similar to the approach on domestic hot water demand in most of the MSs building regulations)*."

A pre-norm of the upcoming EN 15603 that will regulate the calculation of energy performance according the EPBD recast (the new EU Directive on Energy Performance of Buildings, from 2012) has been announced (May 2013). It is called “prEN 15603” and has an accompanying "TR" (Technical Report) that arrived some months later, in July 2013. The prEN 15603 defines, amongst other things, the Energy performance of technical building systems (clause 7.7).

According to the pre-norm the system performance indicators may cover at least the following services (sub-systems):

- heating systems;
- domestic hot water systems;
- air-conditioning systems;
- ventilation systems;
- lighting systems

It is shown in (Musall and Voss 2012) that the passive house concept is a suitable basis towards Net Zero Energy Buildings. Figure 4.5 is an illustration taken from this paper. It shows the energy performance results as primary energy consumption compared to the credits gained by energy export from on-site energy generation. Most of the buildings consume less than 120 kWh/m²a for their total primary energy demand as specified in the passive house concept.

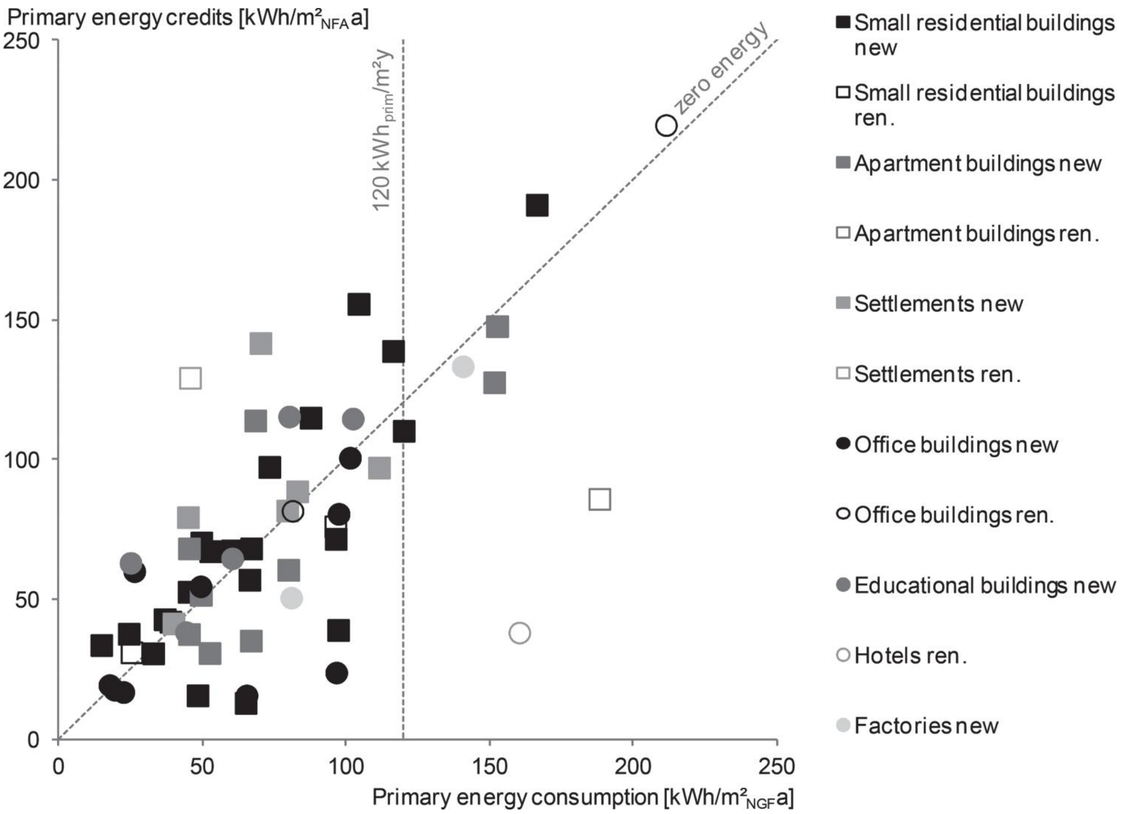


Figure 4.5 Graph illustrating the energy efficiency requirement of a Net ZEB (Musall and Voss 2012)

4.3.1 Current situation in the target countries

The report *Towards nearly zero-energy buildings: Definition of common principles under the EPBD* made by Ecofys for the European Commision (Commision 2013), the BPIE report (BPIE 2011) and the article *How to define nearly net zero energy buildings nZEB* published in REHVA (Kurnitski, Allard et al. 2013) gives input to what the status is regarding national regulations for low energy buildings in the target countries connected to ZenN.

4.3.1.1 Sweden

NGO: Passive house (FEBY). The requirements are only to "Heat load". Values are dependent on climate zone: 10-12 W/m^2 for houses less than 200 m^2 and 12-14 W/ m^2 for larger houses. Total energy consumption corresponds to 60-68 kWh/ m^2 pr. year (BPIE 2011).

From (Kurnitski, Allard et al. 2013):
The midterm goal for 2015 is that at least 25% of the floor area of all erected buildings in 2015 should fulfill the energy requirements for the year 2020. For new buildings owned or used by the state the requirements are for the year 2019 and the portion in 2015 that should fulfill them is at least 50%. The delivered energy in the energy performance value consists of heating, ventilation, cooling, and domestic/service hot water. Electricity for technical building systems is also included. Tenants' or users' electricity is excluded. Electricity to chillers in non-electrically heated buildings shall be multiplied with the factor 3 in order to make possible comparisons with district cooling. Electric heated buildings are defined as having an installed electric power for heating of at least 10 W/m². For non-residential buildings the energy performance value is depending on the average outdoor airflow rate during the heating season. The floor area used is the heated floor area (Atemp) measured inside the external walls. Sweden has three climate zones. About 80 % of the population lives in southern climate zone and less than 10 % lives in the northern climate zone.

Table 4.1 Proposed energy performance numbers for new buildings in Sweden in 2020 (Kurnitski, Allard et al. 2013)

Max energy performance [kWh/(m² & a)]	Climate Zone		
	Zone I - North	Zone II - Middle	Zone III - South
Residential (non-electric heating)	75	65	55
Residential (electric heating)	50	40	30
Non-residential (non-electric heating)	70 to 105	60 to 90	50 to 75
Non-residential (electric heating)	50 to 75	40 to 60	30 to 45

4.3.1.2 France

From (Kurnitski, Allard et al. 2013):
The new French regulation (RT2012) issued on October 26th 2010, addresses low energy buildings targets for residential buildings, office buildings, school buildings, kinder gardens etc.
The total primary energy consumption is defined for heating, cooling, hot water production, lighting, ventilation and any auxiliary systems used for these domains. It is given by an overall coefficient Cep kWh/(m2 yr) using the net floor area of the building defined by the French building code. The target maximum value of Cep, Cepmax is fixed to 50 kWh/(m2 a) with various correction coefficients depending on the climatic zone, the altitude, the total area of the building and the type of energy used. Furthermore, in order to ensure a good

quality of the design of the envelope, another constraint is added. A new parameter Bbio is added in order to check the "bioclimatic" quality of the design. This Bbio parameter measures the energy need of the building for heating, cooling and lighting for a whole year. It has no dimension and is evaluated by a certain number of points. It has to be lower to Bbio max defined in the new regulation as a function of the location, altitude, type of building etc. Finally, the air tightness of the building is also imposed to a maximum value depending of the building type and in summer, a limit for indoor summer temperature has to be checked if no cooling is used.

From 2020, according to the planned regulation all new buildings must be Energy Positive (standard called BEPOS), i.e. they have to produce more energy than they consume. Two new labels should be created and will feature two levels of performance better than the RT 2012 standards, close to BEPOS planned standard. Concerning existing buildings, an ambitious target on renovation has been set in the frame of the Grenelle: energy consumption reduction of 38% towards 2020. To reach this target, many programmes have been launched to implement 400.000 deep retrofittings per year during the period 2013-2020.

4.3.1.3 Norway

A Low Energy Commission (set up by the Ministry of Petroleum and Energy) delivered a number of suggestions for increased energy efficiency of all sectors in Norway in 2009, including suggestions of future net energy frame values for new buildings as well as for major renovations. In 2012, two White Papers from the Ministry of Environment and the Ministry of Local Government and Regional Development, respectively, announced the adoption of the passive house standard for all new buildings from 2015, and the nearly zero-energy standard from 2020.

The Norwegian Building Code, TEK, is proposed to be sharpened every fifth year. TEK07, published 2007, was the first in Norway with an energy performance approach. The net energy (energy needs) in the energy frame consists of heating, ventilation, cooling, domestic/service hot water, as well as lighting and tenants' or users' electricity. The net energy includes cooling supplied to air-cooling coils or fan coils in the rooms. The building code has already been updated in 2010 (TEK10) and will therefore be sharpened further in 2015 to implement the passive house standard that in Norway is defined by the norms NS 3700 (2010) for residential buildings and NS 3701 (2012) for non-residential buildings. The same norms contain the definition of "low-energy building", based on the same method but with less stringent parameters than the passive house standard. The low-energy building standard may be adopted as the target for major renovations (not agreed yet). Per today, major renovations have to comply with TEK10, as long as technical or architectural conditions do not make it non-economically viable. The definition of nZEB to be adopted as a standard for new buildings from 2020 is still under development.

The floor area used is the heated floor area measured inside the external walls (including internal partitions). Norway has a number of climate zones. The values given below are valid for the "standard" climate zone around Oslo, which is in the southeastern part of the country. The annual energy use of the proposed building is first modeled for the actual climate zone and then for the "standard" climate zone. The results for the standard climate zone must fulfill the energy frame. The current energy frames are specified for one-family houses, multi-family houses and eleven types of non-residential buildings (office given as a reference).

Table 4.2 Proposed future net energy frames for new buildings in Norway

		Energy frame [kWh/m^{2}y]				
Building Code	TEK07	TEK10	TEK15 - Passive house	TEK20	TEK25	TEK30
Residential (detached house)	135	130	80 (Heating: 15, Cooling: 0, DHW: 30)	nearly ZEB	Intermediate	Net ZEB
Residential (apartment block)	120	115				
Non-residential (office)	165	150	75* (Heating: 20, Cooling: 10, DHW: 5)			

* the low value is largely due to improvement in electrical appliances and adoption of demand controlled lighting and ventilation, on top of envelope improvements. Furthermore, the low amount of hot water required in offices makes the total energy need lower than for residential units.

4.3.1.4 Spain

In 2013 Spain has finished adaptation of EPBD 2002 with the implementation of the Energy certification scheme for existing buildings (new Royal Decree). The national targets (intermediate and 2020) for improved energy performance of new and existing buildings undergoing major renovations are that
a) from 2021 all new buildings should have primary energy consumption < 85% than the building stock in 2006,
b) 13% of existing homes should be renewed by 2020
c) 2020 target for overall RES-shares 20 % or 225.674 GWh (initial value in 2005 8.7%),
d) RES-Heat shares by technology in 2020: Geothermal: 0.2%; Solar: 11.4%; Biomass: 87.5%; Heat pumps: 0.9%.

Elements of policy packages for the promotion of nZEB (new and existing buildings undergoing major renovations) are based on the Spanish regulations:
a) EE Action Plan for state General Administration’s buildings (minimum saving objective 20% by 2016),
b) RITE (Technical Building Code), minimum solar contribution to sanitary hot water (no figures),
c) Regulation on Thermal Installations in Buildings (use of RES required),

d) Recast procedure of existing CTE (Código Técnico de la Edificación) affecting new buildings and integral retrofitting projects start 2011 and finish in 2012 (no nZEB introduced, but some concepts aiming at becoming starting steps).

4.4 Energy supply

A Net ZEB definition may set requirements on energy supply. A straightforward requirement is proposed in (BPIE 2011) by setting a threshold for the minimum share of renewable energy that has to be used for covering the building's energy demand (Sartori, Napolitano et al. 2012).

A distinction can be made between 'on-site' and 'off-site' power generation. The building system boundary has to state what the hierarchy of options is.

From (Sartori, Napolitano et al. 2012):

In (P. Torcellini, S. Pless et al. 2006) the renewable energy supply options are prioritized on the basis of three principles:

(1) emissions-free and reduced transportation, transmission, and conversion losses;
(2) availability over the lifetime of the building;
(3) highly scalable, widely available, and have high replication potential for future Net ZEBs.

These principles lead to a hierarchy of supply options where resources within the building footprint or on-site (e.g. PV and CHP) are given priority over off-site supply options, (e.g. import of biofuel for cogeneration or purchase of green electricity). Reasons for supporting such a hierarchy are extensively discussed in the report.

In (A.J. Marszal and Napolitano 2011) a similar categorization of supply options is given according to their distance from the building, even though no hierarchy of preferences is expressed. However, it is worth mentioning that the meaning of off-site varies depending on whether the focus is on the origin of the fuel (P. Torcellini, S. Pless et al. 2006) or on the location of the actual generation system (A.J. Marszal and Napolitano 2011).

...

Another area that requires further thought by policy makers, if renewable energy supply is to be prioritized, is defining 'supply-side' renewable generation separately from 'demand-side' generation. As defined in (P. Torcellini, S. Pless et al. 2006), supply-side renewable energy can be commoditized, exported, and sold like electricity or hot water for district systems, while demand-side renewable are only available in connection with reducing building energy demand on-site. Examples of demand-side generation include CHP systems, ground source heat pumps, and passive solar systems. Restrictions on the use of some supply option, such crediting of electricity from gas fired CHP, can be a direct requirement of a Net ZEB definition or a consequence of the assigned weighting factor. For example, assigning a 'politically' or 'strategically' low value to electricity generated by gas fired CHP would reduce the attractiveness of such a choice. However, it should be considered that in areas with poor *performance of the grid (high share of fossil fuels and high carbon emission in the generation mix) it may be reasonable to allow solutions that make a very efficient use of natural gas, such as gas fired CHP, especially if the gas grid is already in place.*

The pre-norm of the upcoming EN 15603 that will regulate the calculation of energy performance according the EPBD recast (the new EU Directive on Energy Performance of Buildings, from 2012) that was announced in May 2013, and in July a related Technical Report (TR) was announced. These do both describe a Renewable Energy Ratio (RER), there seems to be a difference between the method proposed in prEN and that in the TR. The TR method looks more correct and is the method that should be followed.

RER is dependent on

a) The assessment boundaries;
b) The energy balance;
c) The energy flows taken into account

The total renewable energy ration RER is given by:

$$RER = \frac{E_{p,ren,del}}{E_{p,tot}} \qquad (1)$$

The annual amount of delivered primary energy from renewable sources $E_{p,ren,del}$ in kWh divided on $E_{p,tot}$, the total primary energy (TR July 2013, prEN15603 May 2013). Both are calculated with formulas using total primary conversion factors (further explained in prEN 15803 and TR)

NOTE $E_{p,tot}$ is not necessarily the same as the energy performance rating

The total renewable energy ratio, RER, can be differentiated according to the different geographical perimeters (see 7.4.1 in prEN 15603) and the related delivered energies or energy productions.

These factors are further explained in prEN 15603 and related TR. In the TR is also a calculation example. More examples will come in the final draft of the prEN 15603, including a flow diagram and excel sheets for demonstration and validation.

4.4.1 Choice of energy source

For power generation, the most common renewable energy used for net ZEBs are solar power systems. For small buildings without additional power generating capacity, an installed PV capacity of 40 kWp/m2 NFA is enough to cover the whole energy consumption (Figure 4.6) (Musall and Voss 2012).

For projects with larger energy demand (non-residential buildings or renovated buildings) this value is greater. This is due to the fact that the useful roof area decreases in comparison to the net floor area. Especially in office buildings, further power systems like CHP plants or (external) wind turbines are used (Voss and Musall 2011).

For heat generation it is clearly more differentiated than for power generation. Systems range from compact ventilation device through to heat pumps using energy from the ground, the ground water or coupled with solar energy for "all-electric-buildings", or rather biomass boilers and co-generation plants. However, more than 60% of the zero-energy buildings have solar thermal systems to assist in the hot water and space heating, unless other concepts are especially preferred. (Musall and Voss 2012)

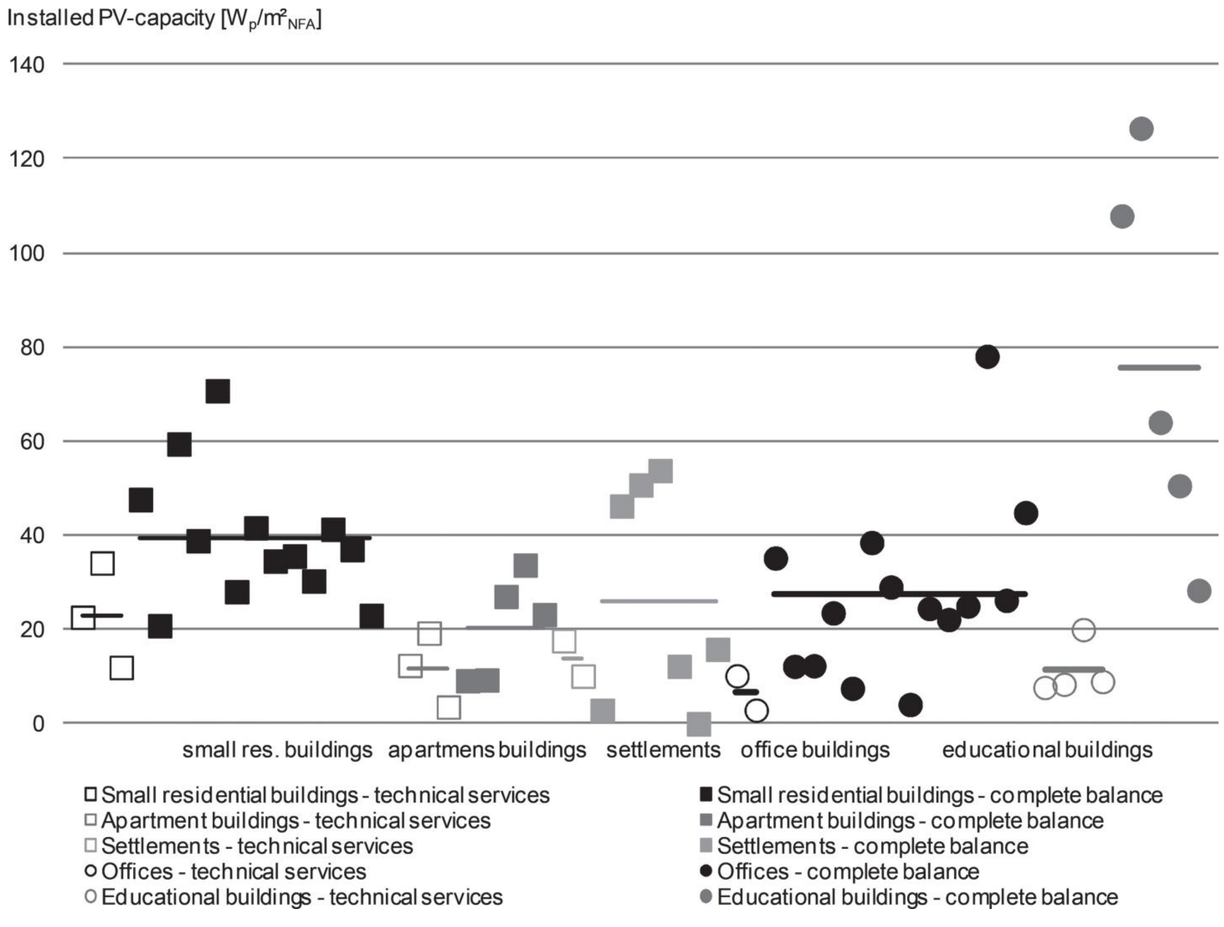


Figure 4.6 Graph illustrating the amounts of installed PV-capacity (power/m^2 $_{NFA}$) (Subdivisions in buildings which balance includes the technical building services or all energy consumers) University of Wuppertal (Voss and Musall 2011)

5 Temporal energy match characteristics

Different terms are used for the topic of energy match characteristics. *Transient characteristics* (K. Voss 2013) or *mismatch factors* (T.H. Dokka 2013) are two. But they all describe the same issues regarding nZEBs interaction with the grid.

As nZEB buildings are typically grid connected buildings there might be a need to measure grid interactions as a part of nZEB performance with additional indicators. Grid interactions may affect primary energy factors for exported energy as well as exported energy price. nZEBs might differ drastically in terms of:

- load matching (the match of the energy generation on site with the building load)
- grid interaction (the match of the energy transferred to a grid with the needs of a grid)

Some energy concept may intensify stress on the local grid for example on the seasonal level, thereby worsening its energy or emission performance. The temporal match/mismatch occurs on the hourly/daily level - e.g. excess solar power generation during daytime with electricity needs from the grid during night -as well as on the seasonal level (in most climates). (Kurnitski, Allard et al. 2013)

Buildings using on-site generating systems have different abilities to match the load and benefit from the availability of energy sources and the demands of the local grid infrastructure. (K. Voss 2013)

Beside an annual energy or emission balance Net ZEBs are characterized by their different ability to match the load and to work beneficially with respect to the needs of the local grid infrastructure. (Sartori, Napolitano et al. 2012)

In the case of multiple buildings, the interaction of multiple buildings on a site requires load matching index of the thermal and electrical energy services both, for each individual building and also for the site energy centre. (Kurnitski, Allard et al. 2013)

5.1 Load matching

The temporal match between load and generation for an energy carrier gives a first insight on a building's ability to work in synergy with the grid. When there is a poor correlation between load and generation, e.g. load mainly in winter and generation mainly in summer, the building will more heavily rely on the grid. If load and generation are more correlated, the building will most likely have higher chances for fine tuning self-consumption, storage and export of energy in response to signals from the grid.

Load matching can be addressed in design by separate calculations or simulations on load and generation, without need to know or estimate self-consumption. For this reason indicators of load matching fit well for being used in combination with a load/generation balance. (Sartori, Napolitano et al. 2012)

Load matching and grid interaction have to be discussed with respect to the form of energy and the temporal resolution. Load matching and grid interaction is almost irrelevant in the context of fuel-based energy supply but is of major importance for the electricity grid. (K. Voss 2013)

In order to characterize a nearly ZEB beyond its mere annual balance (and annual share of renewable) other indicators may be considered that address the match between load and generation in a building (or neighbourhood) and the interaction with the local grid. A report from IEA Task40/Annex 52 on such indicators is now ready (IEA 2014).

The indicators for load match presented in the report are:

- *supply cover factor* = $\frac{C}{B+C}$, also called "self-consumption"
- *load cover factor* = $\frac{C}{A+C}$, also called "self-generation"

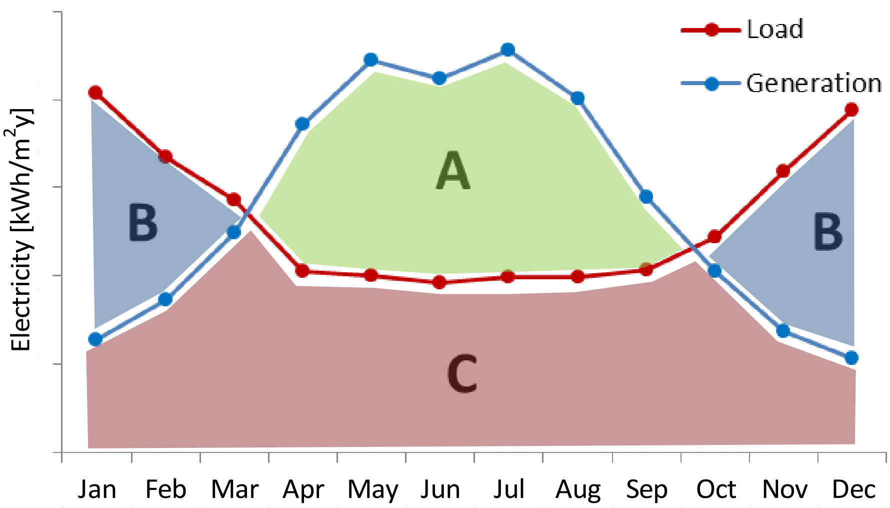


Figure 5.1 Graph showing load and generation for a building

Figure 5.1 shows a typical situation for an all-electric building (Heat Pump and PV) in a cold/temperate climate. Buildings using other thermal carriers (e.g. gas or district heating) would have a more flat load throughout the year. The areas indicated in the figure are useful to understand the meaning of formulas. Note that the total load is given by B+C, while the total on-site generation is given by A+C. A is excess generation that has to be exported to the grid. B is excess load that need to be delivered by the grid. C is the load self-covered by the generation (or vice versa, the generation self-covered by the load). The graph shows monthly values for simplicity. However, calculations should be performed on hourly values.

5.2 Grid interaction

To assess the exchange of energy between a Net ZEB and a grid versus the grid's needs one must know at least the import/export profile from the building.

The grid interaction can be addressed based on metering or simulation data of delivered and exported quantities. Therefore, indicators of grid interaction fit well for being used in combination with an import/export balance.

Several indicators have been proposed to analyze the interaction between buildings and grids, with a viewpoint from either the building, the grid interaction index, or the grid perspective, grid interaction flexibility (J. Salom 2011).

The grid interaction index represents the variability (standard deviation) of the energy flow (net export) within a year, normalized on the highest absolute value. The net export from the building is defined as the difference between exported and delivered energy within a given time interval.

The report from IEA Task40/Annex 52 (IEA 2014) presents two indicators for grid interaction:

- *Generation Multiple* (GM) = peak generation / peak load (highest "blue point" / highest "red point" in the graph, but with hourly values, not monthly)
  GM says how much the connection capacity should be increased (if GM>1) because of the on-site generation system.
- *Dimensioning Rate* (DR) = ratio between maximum net-export (or net-import) over the nominal grid connection capacity.

The grid interaction flexibility (J. Salom 2011) of a Net ZEB, is understood as the ability to respond to signals from the grid (smart grids). Therefore, to be meaningful the grid interaction flexibility has to be evaluated with a time resolution of an hour or preferably even lower.

What is actually in the hands of designers is to design the building and its energy systems to enhance grid interaction flexibility. The flexibility could be quantified using suitable indicator(s) evaluated in two opposite extreme situations. (Sartori, Napolitano et al. 2012)

It is worth noting that for building designer to design Net ZEBs with high grid interaction flexibility, it is necessary to have data on end users temporal consumption patterns, e.g. for lighting, electrical appliances, cooking, hot water use. Such data should be statistically representative for the type of building in analysis (i.e. residential, office, school, etc.) or better such data should be even normative.

In the same way as weather data are standardized to provide designers with a reference climate, user profile data may be standardized to offer designers a reference temporal consumption pattern (with hourly and seasonal variations) for each type of building. Furthermore, evaluation of different strategies for the control of load, generation and storage need the support of advanced dynamic simulations tools. (Sartori, Napolitano et al. 2012)

6 Measurement and verification

Most current certification procedures of energy performance in buildings largely depend on design data and do not reflect the actual energy performance. And although theoretical calculations based on these data are essential in the design phase there also needs to be installed a proper system for monitoring and verifying the energy flows in real time.

This summary is based on the work of [Napolitano et al, 2010] that presents monitoring requirements for different Net ZEB definitions, paving the way for a standard monitoring procedure to be put in place once a common Net ZEB definition is agreed upon in our consortium.

6.1 Case studies

Most of the methodologies in the cases studied in [Napolitano et al, 2010] include all the building energy uses in the balance and also assume a balance with renewable energy sources (RES) on a yearly basis. The global reference diagram has been made to visualize all monitored systems and flows, as shown in Figure 6.1. The legend for all figures is shown in

Table 6.1.

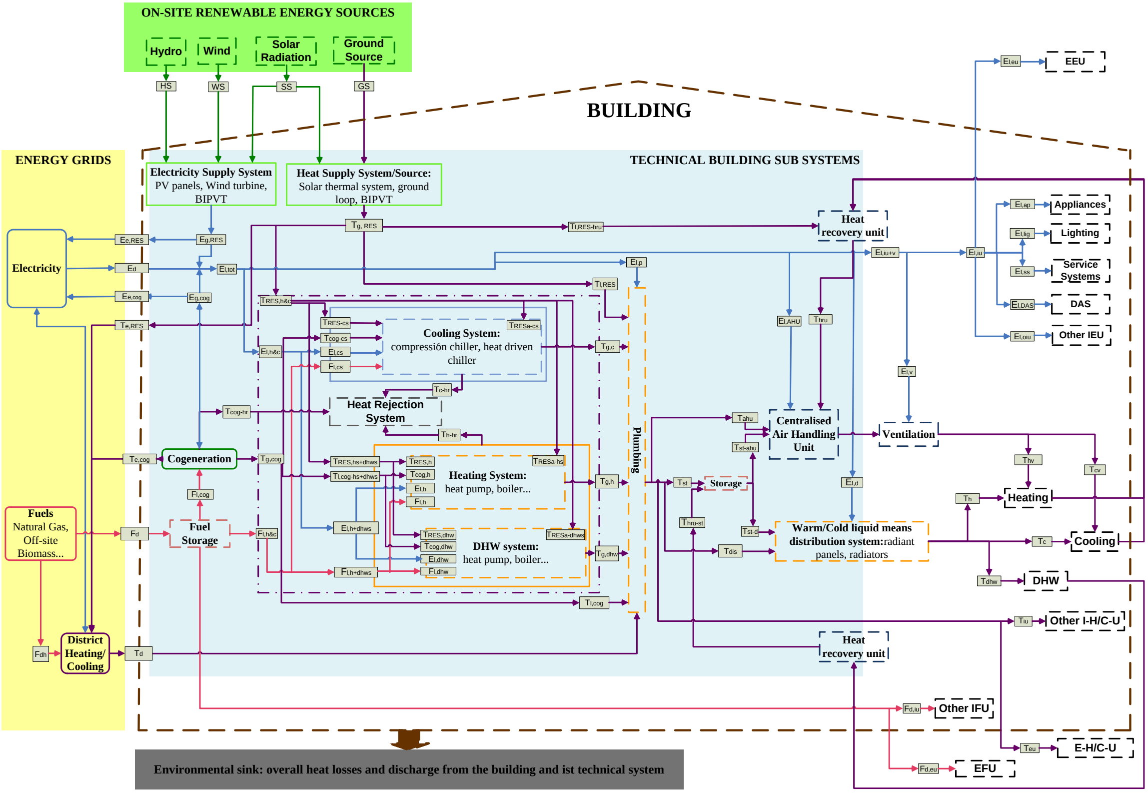


Figure 6.1 Global reference diagram for monitoring

Table 6.1 Legend for Figure 6.1

LEGEND

Energy carriers	Reneawable energy sources	Environmental sink
Building	Technical Building SubSystems Room	Heat and cold production subsystem
Cold production subsystem	Heat production subsystem	Heat rejection system
Ventilation ducts	Hydraulic ducts	Energy dissipator
Fuel flows	Electricity flows	Thermal flows
Tn° Measured thermal flow	En° Measured electricity flow	Fn° Measured fuel flow
Rn° Measured RES flow		
Other IEU Other Internal Electricity Use	Other I-H/C-U Other Internal Heat/Cold Use	Other IFU Other Internal Fuel Use
EEU External Electricity Use	E-H/C-U External Heat/Cold Use	EFU External Fuel Use

There are basically two ways to measure and check the balance. Either to compare the energy use and renewable energy generation (load-generation balance) or to compare delivered and feed-in energy (import-export balance). The advantage of monitoring the load-generation balance is the possibility to directly compare measurements with calculated performance, which is an important feature in a pilot project because it allows identifying where discrepancies are. The advantage of monitoring the import-export balance is the simplicity of the monitoring system. This will be more thoroughly discussed under criterion 3 of the definition framework, covering the net ZEB balance.

Figure 6.2 shows the monitoring scheme for a load-generation approach. The red and yellow boxes indicating energy generated and loads respectively. Because of the matching with RES on a yearly basis it is not important to separate the energy uses.

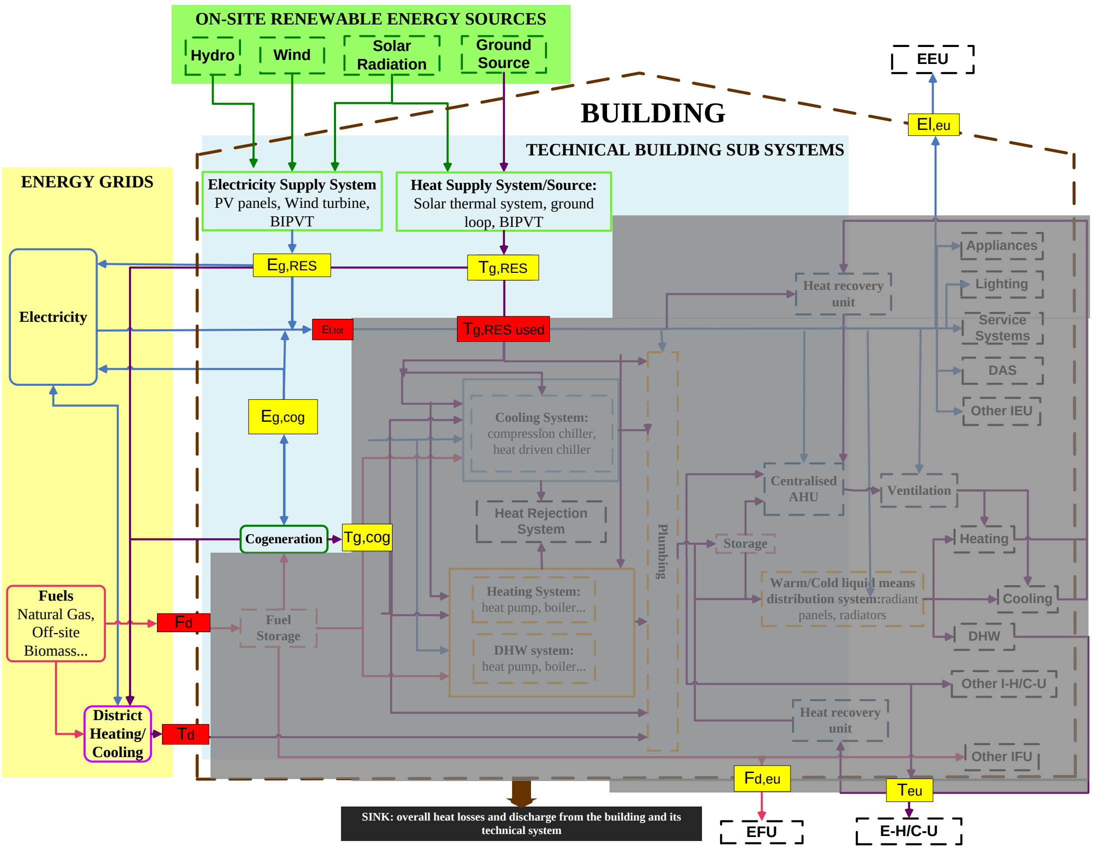


Figure 6.2 Monitoring scheme for load/generation balance

If the balance is checked on a yearly basis it is not important to differ between the types of energy. But if mismatch is going to be a part of the definition there will be a need for hourly measurements - if not even more frequently.

In order to make sure frequent measurements are possible smart metering should be included in all projects within the ZenN-project. Smart metering log average data every 15 min (usually) and communicate every hour to the grid. Several countries already have laid plans for this and this could be possible to include in all ZenN-cases.

The other alternative is the import-export balance which is easier to obtain since this method requires a simpler monitoring system. However, the measurements will differ from a load-generation balance because of the part of energy which is generated and self-consumed, for example by instantaneous matching of generation and load. This, in turn, depends on the user behavior (when plug loads are in use). Therefore the import-export measurements are not directly comparable with calculated values, since the latter usually do not include assumptions on temporal pattern of user behavior.

Figure 6.3 shows the import-export balance. Red boxes indication imported energy and yellow indication exported energy.

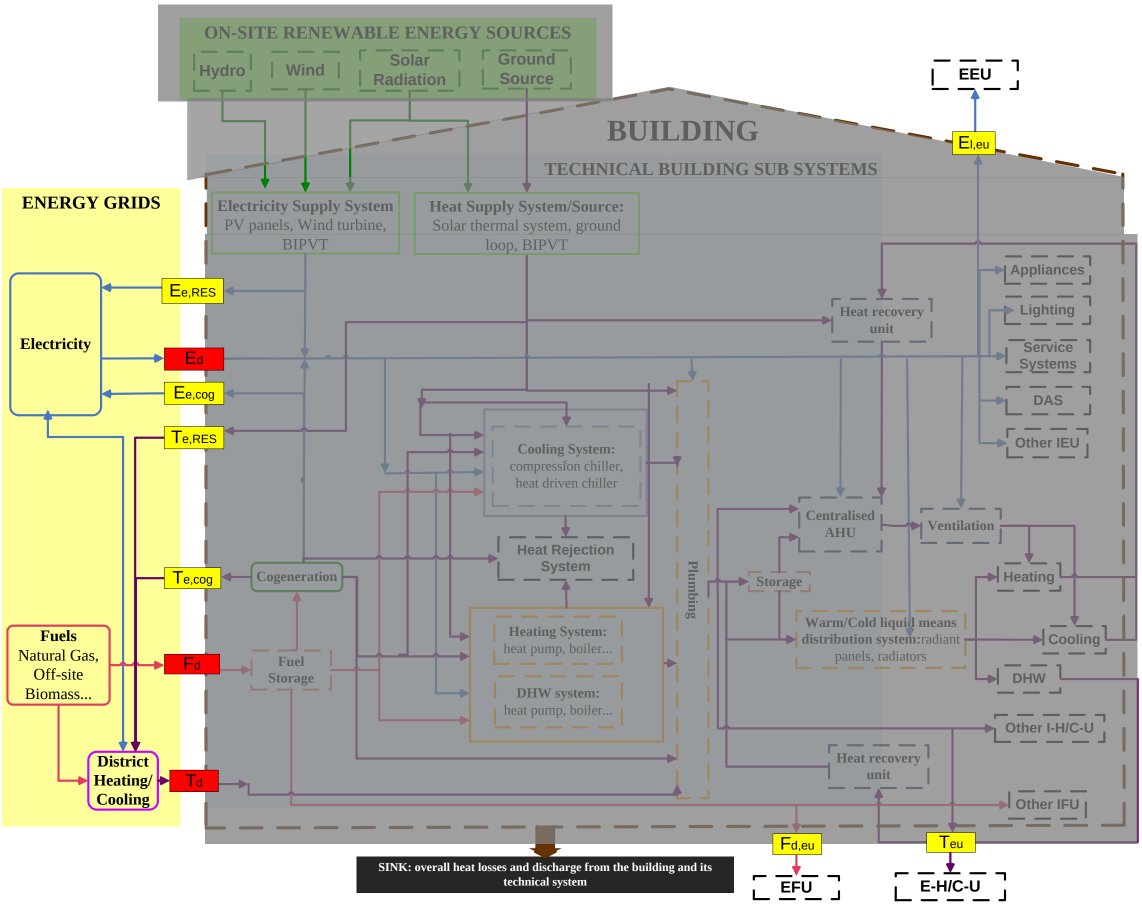


Figure 6.3 Monitoring scheme for import-export balance

Examples to illustrate the two different options are shown in Figure 6.4, the German case: import-export balance with whole-building monitoring; and Figure 6.5, the Danish EnergyFlex house: load-generation balance with sub-metering.

In Figure 6.4 orange boxes are indication energy imported and exported. Respectively the orange boxes in Figure 6.5 indicate both loads and generation but it is important to emphasize that the Danish case has a more complex monitoring system (orange boxes are sensors actually installed) but it allows to compare calculated and measured values, separating generation and load measurements and with the load broken down per energy use.

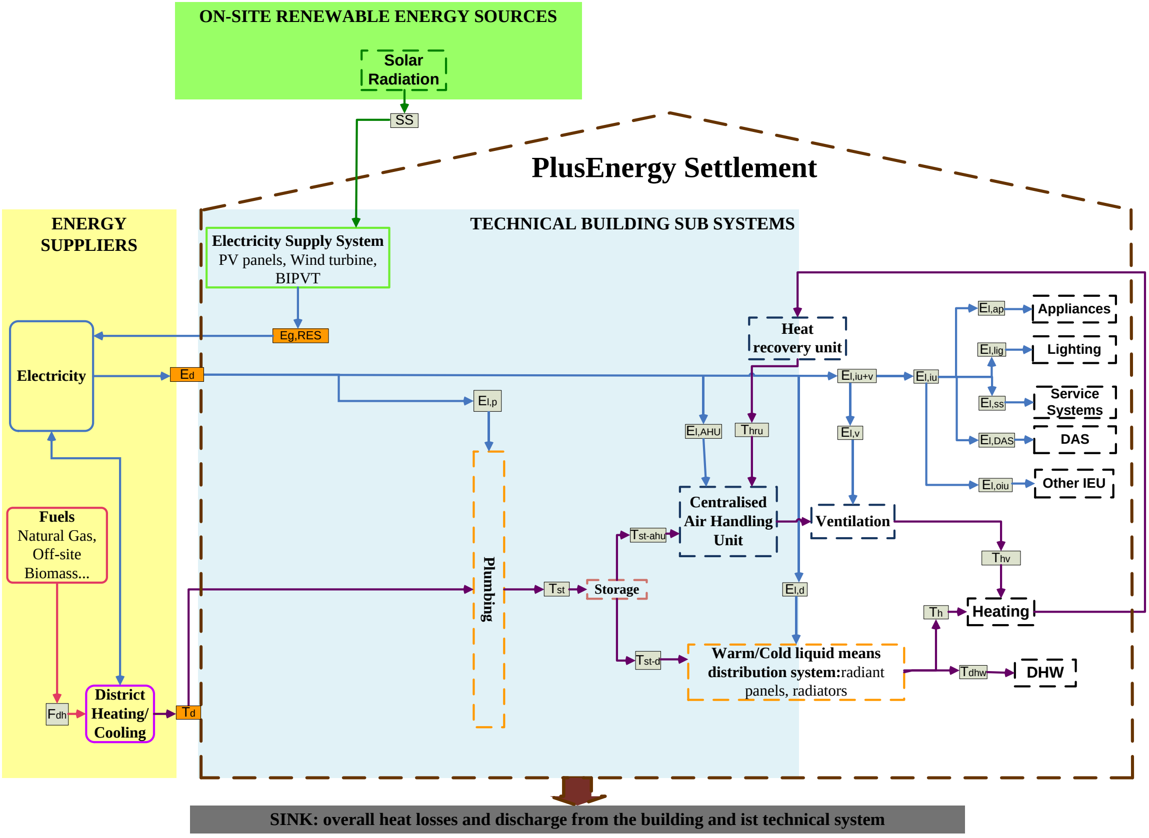


Figure 6.4 The German PlusEnergy Settlement

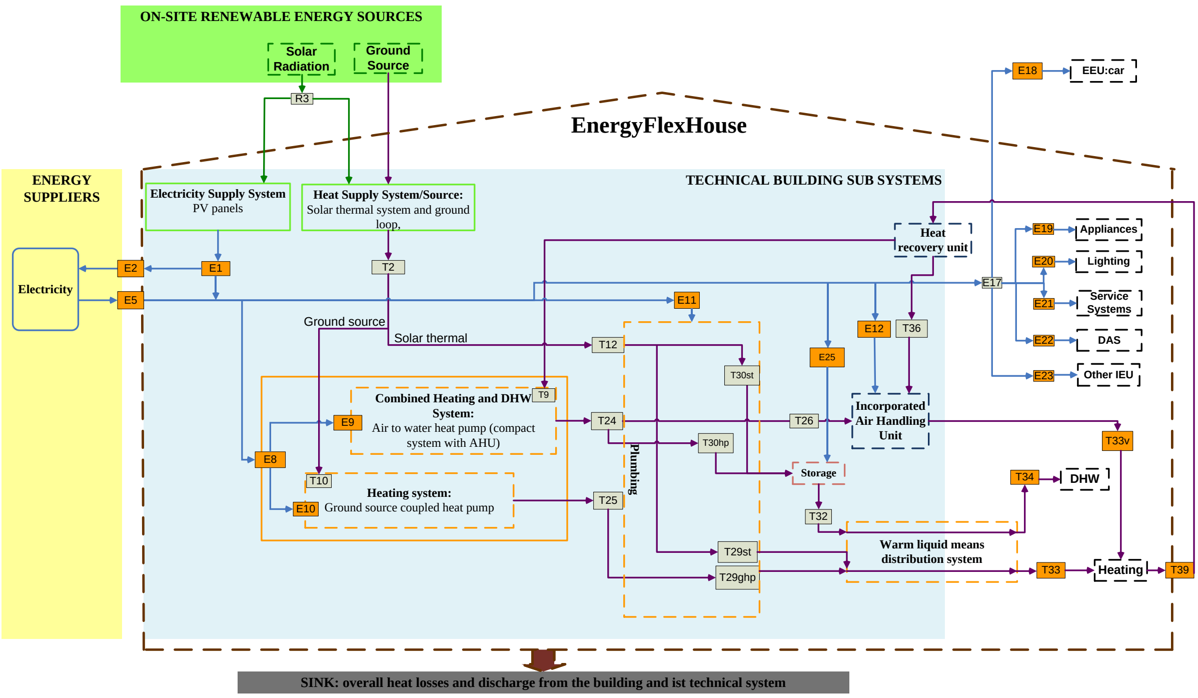


Figure 6.5 The Danish EnergyFlex House

6.2 Conclusions regarding measurement and monitoring

For an easily verifiable Net ZEB definition it is preferable to include all operational energy uses in the balance boundary. The exclusion of an energy use from the balance boundary, e.g. the electricity use for plug-loads, would require the installations of additional meters, moving from a whole building monitoring approach to sub-metering, therefore increasing the complexity of the monitoring system.

On the other hand in a pilot project the possibility to directly check differences between calculated and measured values may be worth the extra complexity. Furthermore, installation of meters with hourly and sub-hourly data logging would provide valuable information on the user behavior and the temporal pattern of energy demand. This is true on a whole-building level (i.e. smart meters), as well as on the level of each energy use (or energy generation) that is wished to be investigated in deeper detail.

Comfort requirements are not taken into the Net ZEB-definition. But these requirements need to comply with the (different) national legislation and some kind of measurements should be included in the procedure.

ZenN

Nearly Zero Energy Neighborhoods

D1.2

Final report on common definition for nZEB renovation

PART B: Common definition on nZEB renovation

7 Introduction

Part B presents the nZEB decisions taken by the partners within ZenN.

The structure of the report is similar to Part A and are based on the structure of IEA SHC Task 40 / EBC Annex 52 “Towards Net Zero Energy Solar Buildings”(IEA 2012) considering five main criteria:

1. Building system boundary
2. Weighting system
3. Net ZEB balance
4. Temporal energy match characteristics
5. Measurement and verification

The last chapter is presenting a first evaluation of the pilot buildings using the net ZEB tool developed within the same IEA Task.

8 Building system boundary

8.1.1 Physical boundary

The physical boundary may be on a single building or on a cluster of buildings. The latter case implicates that each building doesn't necessarily need to be Net ZEB by itself but that the cluster is regarded as a whole.

For the sites with multiple buildings and site energy centers as is the case in ZenN, the system boundary has to be extended so that it covers entire site with multiple buildings and decentralized production, Figure 8.1. Buildings and site energy center may have on site energy production and energy exchange between buildings. (Kurnitski, Allard et al. 2013)

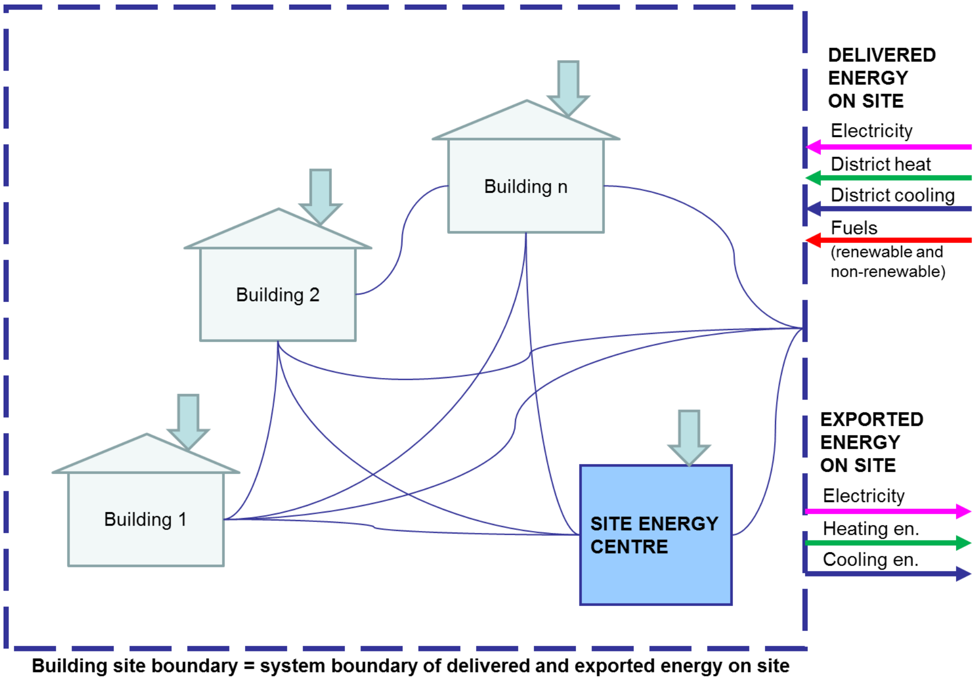


Figure 8.1 Illustration of system boundary

8.1.2 Balance boundary

The balance boundary defines how the operational phase is considered in terms of energy use. These typically include heating, cooling, ventilation, domestic hot water, fixed lighting and plug-loads.

In ZenN it is agreed to

1. adopt the prEN 15603 default choice (see table A3 in (prEN15603 May 2013)), which is the same as is stated in the EPBD. That means that lighting is to be included only in the Norwegian demos Økern sykehjem and Oppsal sykehjem that are non-residential buildings. Appliances are never included.

   But also;
2. open up for a second set of calculations where lighting is included. This is because some of the first energy calculations have been done using low energy lighting.

8.1.3 Boundary conditions

It is important to understand if any deviation from expected values is attributable to technical operating or design mistakes, or if it is simply due to different conditions of use. For this purpose it is necessary to explicitly specify a set of boundary conditions: functionality, space effectiveness, climate and comfort.

	SPAIN				
	l/s				ac/h
Regular ventilation		Per person	Per m2	Per room	
	Bed room	5	-	-	
	Living room	3			
	Toilet			25	
	Kitchen		2	50	
	Common areas		0,7		
Extra ventilation*	Building	-			4**

Table 8.1 -

Table 8.7 gives parameters related to these topics for each country. Chapter 8.1.3.1, 8.1.3.2, 8.1.3.3 and 8.1.3.4 presents an explanation of where the parameters are taken from for each country (also describing the numbers and dots in superscript).

Functionality: Residential buildings, except Norwegian demos which are nurseries.

Space effectiveness: Occupancy numbers are presented for all cases in table

Table 8.1. The area in prEN 15603 refers to "Internal Dimension (ID)" which is a dimension measured from wall to wall and floor to ceiling inside a room of a building. If only the Overall Internal Dimension (dimension measured on the interior of a building, ignoring internal partitions) or External Dimension is known for a building, Table A.4 of the standard prEN 15603 (prEN15603 May 2013) gives a formula to convert it to ID.

The number of inhabitants of each case is theoretical. It is the sum of bed units intended in each bed room for the building.

Table 8.1 Table presenting occupancy numbers for each pilot case

	SWEDEN		SPAIN	FRANCE	
Name of building	**Lorensborg**	**Lindängen**	**Mogel**	**40 Arlequin - SDH**	**50 Arlequin - ACTIS**
Number of inhabitants [persons]	1200	1000	450	531	304
Total heated gross area [m2]	28070	20445	13125	12624	8382
Total [persons/m2]	0,05	0,05	0,03	0,04	0,04
Internal Dimension (ID)	25 263	18 401	10500	11030	6794

	NORWAY			
	Økern		**Oppsal**	
	Day	*Night*	*Day**	*Night*
Number of inhabitants (pasients)	140	140	197	152
Number of employees	50	12	60	16
Total [persons]	190	152	257	168
Total [m^2/person]	39	49	23	34
Total heated gross area [m^2]	9 357		7 236	
Internal Dimension (ID)	7 486		5 789	

*In addition to the inhabitants, Oppsal has an amount of 45 day care users

Climate: Cooling Degree Days (CDD) and Heating Degree Days (HDD) are collected for each location. Heating -> 17 Celsius

Table 8.2 shows average values for each place of interest, set with these cooling and heating temperatures:

Cooling -> 24 Celsius
Heating -> 17 Celsius

Table 8.2 Heating and cooling degree days for the four places of interest

	OSLO, NORWAY		MALMÖ, SWEDEN		EIBAR, SPAIN		GRENOBLE, FRANCE	
	HDD	*CDD*	*HDD*	*CDD*	*HDD*	*CDD*	*HDD*	*CDD*
Jan	643	0	518	0	200	0	401	0
Feb	612	0	457	0	191	0	354	0
Mar	544	0	451	0	146	1	278	0
Apr	365	0	311	0	120	2	194	0
May	177	0	176	0	57	11	78	5
Jun	68	6	90	0	11	17	34	21
Jul	43	5	47	1	2	16	20	31
Aug	56	6	36	2	1	30	17	39
Sep	169	0	109	0	6	19	64	7
Oct	328	0	240	0	34	11	136	1
Nov	494	0	361	0	130	0	302	0
Dec	603	0	481	0	189	0	393	0
Total	**4102**	**17**	**3277**	**2**	**1087**	**107**	**2271**	**103**

Comfort: Important parameters for comfort are temperature for space heating and cooling, ventilation rate, temperature of ventilation air for both heating and cooling, DHW demand, energy for lighting and appliances.

Table 8.4 -

	SPAIN				
	l/s				ac/h
Regular ventilation		Per person	Per m2	Per room	
	Bed room	5	-	-	
	Living room	3			
	Toilet			25	
	Kitchen		2	50	
	Common areas		0,7		
Extra ventilation*	Building	-			4**

Table 8.7 shows these parameters for each country, while

Table 8.3 shows what standard the parameters are taken from.

Table 8.3 Low energy standards for each country

	NORWAY	SWEDEN	SPAIN	FRANCE
Energy demand	Standard: NS 3701:2012, Low Energy building, class 1 (nursing home)	FEBY and SVEBY (zero energy and passive houses, new residential buildings)	Spanish Technical Building Code (Royal Decree 314/2006) Updated by FOM/1635/2013, 10 September 2013	RT 2008 corresponds to the thermal regulations in France for the renovation of the existing buildings more 1000 m²
Internal gains	idem	idem	idem	idem
Ventilation flow rates	idem	idem	idem	idem
Operating hopurs	idem	idem	idem	idem

Table 8.4 Energy demand

Parameter	NORWAY		SWEDEN		SPAIN		FRANCE	
	kWh/m2a	W/m2	kWh/m2a	W/m2	kWh/m2a	W/m2	kWh/m2a	W/m2
Lighting	29,1	5,0	6.3[1]	1,2	-	12*	-	2
Equipment	-	4,0	24	3,4	-	-	-	-
DHW	30,0	-	25[2]	-	2309,5*** 2194,0****	13,2*****	-	-

Table 8.5 Internal gains

Parameter	NORWAY		SWEDEN		SPAIN		FRANCE	
	kWh/m2a	W/m2	kWh/m2a	W/m2	kWh/m2a	W/m2 (average)	kWh/m2a	W/m2
Lighting	29,1	5,0	6.3[1]	1,2	9,6**	1,1	-	-
Equipment	-	4,0	21[4]	2.4[4]	9,6**	1,1	-	3,8 including (a)
DHW	-	-	5	0,6	-	-	-	-
Persons, work day	-	3,0	-	1[3]	22,1***	2,05	-	(a)
Persons, holiday						3,51		

Table 8.6 Ventilation flow rates

	NORWAY	SWEDEN	FRANCE
	[m3/(m2*h)]	[m3/(m2*h)]	[m3/h]
Mean air flow in operating hours	7	1,4*	*
Mean air flow in non-operating hours	3	1,4**	**

	SPAIN				
	l/s				ac/h
Regular ventilation		Per person	Per m2	Per room	
	Bed room	5	-	-	
	Living room	3			
	Toilet			25	
	Kitchen		2	50	
	Common areas		0,7		
Extra ventilation*	Building	-			4**

Table 8.7 Operating hours

	NORWAY	SWEDEN	SPAIN	FRANCE
Heating and tech. equipment	16/7/52	24/7/52	24/7/32*	16/5/52 + 24/2/52
Lights	16/7/52	3/7/52	24/7/52	5/5/52 + 15/2/52
Ventilation	16/7/52	24/7/52*	24/7/52	24/7/52
Persons	24/7/52	14/7/52	24/7/52	16/5/52 + 24/2/52
Heating temperature set point	21°C during occupation, 19°C at non-operating hours	21°C during occupation, 21°C at non-operating hours	16/7/20**	19°C during occupation, 16°C at non-operating hours

8.1.3.1 Norway

Climate: HDD and CDD are calculated using according to the standard NS 3031:2010.
Comfort: Standard: NS 3701:2012, Low Energy building, class 1 (nursing home)

8.1.3.2 Sweden

Climate: There is no standard HDD or CDD defined in Sweden. The Swedish regulation (BBR) states that normal year correction should be based on a longer period of time, for example 30 years.

The data provided here is based on data from Meteonorm for a normal year based on climate 1996-2005.

(Calculation of hourly temperature difference and accumulated hourly temperature differences according to SS-EN ISO 15927-6.)

Sweden suggests that individual building base temperature should be used for normalisation of historic building energy use if data is available. For climate normalisation of measured data from renovated low energy buildings, individual base temperature should be used to give relevant results.

Comfort:
Energy demand and Internal gain
There is no Swedish regulation or standard for energy performance in nearly zero energy building. There is a suggestion of a regulation level in a report from Swedish Energy Agency and the Swedish National Board of Housing, Building and Planning from 2010. The report states the maximum level of delivered energy to the building for both new and retrofitted nZEB buildings. For Malmö this would correspond to a level of 75 kWh/m^2 Atemp/year (excluding household energy).

Just now a new investigation has started by the same authorities that will come up with Swedish definition of nZEB buildings. The work will be finished in year 2015.

In order to get any idea of the figures for Sweden the suggested level of delivered energy from the report from 2010 is taken and the criteria's from the FEBY (Forum för Energieffektiva Byggnader)

Values used in FEBY and SVEBY

The numbers refers to the numbers in

Table 8.4 and Table 8.5:

1) 21 % of the total 30 kWh/m^2 Atemp is assumed ro be lighting according to preliminary measurement in over 600 apartments. In the comment reference values for (staircases, corridors, laundry rooms and HVAC spaces). Specified per illuminated area, i.e. not total floor area. Not a regulation! 100 % of the heat is assumed to be utilized if there is a heat demand
2) 25 kWh/m^2 Atemp DHW for multi family dwellings. Note that this is a reference value not a regulation.
3) In FEBY a general reference value if the occupancy level is not known 1 W/m2 can be used. There is no Swedish regulation nor standard that prescribes how to account for the internal heat gain from persons in residential buildings. However, there is a widely used industry standard for energy calculations called Sveby (www.sveby.org , only in Swedish). In 2012 four trade organizations in the building sector signed a cooperation agreement where they recommend their members to use Sveby in energy calculations. The four organizations are The Swedish Property Federation, Byggherrarna, The Swedish Construction Federation and SABO (the Swedish Association of Public Housing Companies).
When it comes to internal gains from persons in residential buildings, Sveby recommends the values in the table 1 and 2 below.
4) Sveby recommends 30 kWh/m²a as a reasonable value for domestic electricity use. 70 % is considered to add to the internal gain. The gain from the equipment is considered to be evenly distributed over the year.

Comments related to the numbers in the table Energy demand:

- According to preliminary results from measurements in Sweden about 21 % of this electricity is used for lighting (inside apartments). This factor is used to get kWh/m2a for equipment (formula: 30*(1-0.21)).
- W/m2 for equipment includes lighting because there are difficulties to extract only one kind of use from the total sum.
- Lighting, kWh/m2a: 2-8.8 for the illuminated area in corridors etc.

Comments related to the table Internal gain:

- DHW, W/m2: A very general reference value that can be used before the actual losses depending on the length and the insulation of the DHW circular.

Ventilation flow rates

Comments to the table:
*The lowest outdoor airflow for residential buildings is 1.4
**However it is legal to reduce the airflow in individual dwellings to a minimum of 0.4 m^3/m^2*h (for a demand controlled ventilation).

Operating hours

Comments to the table:
* In reality there are not many demand controlled ventilation systems in use for apartment buildings so Sweden have decided not to give any operating hours here.

8.1.3.3 Spain

Climate: The standard used for the HDD and CDD calculations are UNE 100002-88.

Comfort: Comments to the tables:

Energy demand

* Maximum installed capacity. Only for common areas.

** Normative values for residential buildings in Spain are related to DHW flow consumption, i.e. 28 l/d person
*** Calculated value for one flat with two bedrooms (typical Mogel situation). Decentralized system
**** Calculated value for one flat with two bedrooms (typical Mogel situation). Centralized system
***** According to Energy Certification reference value

Internal gain
* Often only a fraction of lighting and equipment is considered to turn into internal gains, at least in residential buildings
** Living areas
*** Sensible heat gain 61%; Latent heat gain 39%

Ventilation flow rates
*June - September. 1am - 8am
**Due to infiltrations. It includes regular ventilation values

Operating hours
* October - May. Different hourly set point temperatures (Table 8.8)
** June - September. Different hourly set point temperatures (Table 8.8)

Heating/Cooling Set point temperatures, SPAIN (ºC)					
Time of day	**1-7**	**8**	**9-15**	**16-23**	**24**
January - May	17	20	20	20	17
June - September	27	-	-	25	27
October - December	17	20	20	20	17

Table 8.8 Set point temperatures, Spain

8.1.3.4 France

Space effectiveness: Total heated gross area in

Table 8.1 corresponds to the external surface or SHON is used in the French town planning code.

The SHON is equal to the sum of the surfaces of the floors of every level less all which is not converted (basements and non-converted attic, flat roofs, balconies, loggias, not closed surfaces of the ground floor and the garages).

Climate: The HDD and CDD have been calculated using Grenoble weather data file delivered with the software Designbuilder.

Comfort: Parameters for energy requirements and internal gains are taken from RT 2008 which corresponds to the thermal regulations in France for renovation of existing buildings of more than 1000 m².

Operating hours

Comments to the table:

*Decree of 24/03/1982 : "Measures relative to the ventilation of housing"
Statutory flows with a system of "classic" ventilation (max/min) for the different departments (T1-T5) within the building:
T1 : 105 m3/h / 35 m3/h
T2 : 120 m3/h / 60 m3/h
T3 : 150 m3/h / 75 m3/h
T4 : 180 m3/h / 90 m3/h
T5 : 195 m3/h / 105 m3/h

**Decree of 28/10/1983 : "Measures relative to the ventilation of housing"
When humidity-sensitive ventilation the flows can be reduced to the following value (min) for the different departments (T1-T5):
T1 : 10 m3/h
T2 : 10 m3/h
T3 : 15 m3/h
T4 : 20 m3/h
T5 : 25 m3/h

9 Weighting system

9.1.1 Metrics

To be able to count the delivered and exported energy a conversion needs to be done by weighing factors. A weighting system converts the physical units into other metrics, for example accounting for the energy used (or emissions released) connected to the delivered or exported energy. These factors are different in all countries depending on methodology and political issues. Each country has therefore an own set of weighing factors based on national agreements.

Primary energy factors

Both total energy factors and non-renewable energy factors are collected for each country, but it is decided that only calculations based on total energy factors is mandatory for each pilot case. All national factors are presented in Table 9.1. Chapter 9.1.1.1, 9.1.1.2, 9.1.1.3 and 9.1.1.4 gives an explanation to where the factors are taken from for each country.

A common set of primary energy values are also of interest because this makes it possible to compare the pilot cases based on the same background methodology. The partners of ZenN have decided to adopt the factors presented in standard prEN 15603 (

Table 9.2). The only factor which differs from this is the factors for district heating. This is set to 0.4 instead of 1.3 (prEN 15603) because this is closer to the national factors.

The grey columns represent the factors to be used in the balance calculations. The others are to be used for the RER-calculations (see chapter 4.4 Energy supply). The common weighing factors are based on recommendations from prEN 15603, except Delivered from nearby, District heating which are changed because of note a) and looking at the national values.

CO_2 factors
It is agreed to include CO_2 calculations based on national factors (Table 9.3). Chapter 9.1.1.1, 9.1.1.2, 9.1.1.3 and 9.1.1.4 gives an explanation to where the factors are taken from for each country.

Table 9.1 Weighing factors for each country (MJ/MJ)

	NORWAY		**SWEDEN**		**SPAIN**		**FRANCE**	
	Total	*Non-renewable*	*Total*	*Non-renewable*	*Total*	*Non-renewable*	*Total*	*Non-renewable*
Electricity	1,36	0,24	2,26	0,97	2,46	1,6	2,58	-
Gas			1,09	1,09	1,07	1,07		
District heating	0,78	0,68	0,27 - 0,48	-			0,6	-
Biomass			1,01 - 1,18	0,01 - 0,18	1,25	0,25		

Table 9.2 Common weighing factors (all except Delivered from nearby, District heating are based on recommendations from prEN 15603) (MJ/MJ)

	Delivered from distance		**Delivered from nearby**		**Delivered from onsite**	
	Total	Non-renewable	Total	Non-renewable	Total	Non-renewable
Electricity	2,5	2,3	1,5	0,5	1	0
Natural Gas	1,05	1,05				
District heating [a)]			0,4 (1,3)	0,4 (1,3)		
Bio	1,05	0,05				
Bio (liquid)	1,5	0,5				

	Exported to the grid		**Temporary exported and reimported later**		**Exported for immediate use**	
	Total	Non-renewable	Total	Non-renewable	Total	Non-renewable
Electricity	1,6	1,6	2	2	2,5	2,5
Natural Gas						
District heating						
Bio						
Bio (liquid)						

a) The prEN 15603 shows conservative values for District heating, based on gas fired district heating boiler plant. It also makes note that different values, taking in account e.g. cogeneration units, can be calculated according to EN 15316-4-5. The values chosen here fall within the range of values reported in EN 15316-4-5 and are simply indicative of a District heating with low PE factors, for example due to a combination of cogeneration and use of renewable sources.

Table 9.3 Weighing factors for each country: GHG (kg CO2 eq./kWh)

	NORWAY	**SWEDEN**	**SPAIN**	**FRANCE**
Electricity	0,05	0,26	0,33	0,04-0,18
Natural Gas	-	0,25	0,20	-
District heating	0,30	-	-	0,06
Biomass	-	5,9-18,6	0	-

9.1.1.1 Norway

There are no official primary energy and emission factors in Norway. The factors connected to district heating are collected from a master thesis recently made on district heating in Oslo (Berget 2013). The study was a comparison between a hydronic heating system based on district heating and direct electrical heating, installed in a low energy building in Oslo. The factor is a mean value for the years 2010-2012.

The factors related to electricity are based on the Norwegian supply mix, import and export included. It is based on a mean energy mix for the years 2007-2011, collected from the web site supplied by European Network of Transmission System Operators for Electricity (ENTSO-E) (ENTSO-E 2007-2011).

Appendix, chapter 16.1 presents the table where primary energy, GHG emission factors and related references for Norway are listed.

Table 9.4 Description of the used methodology for calculation of the GHG and PEF for Oslo

Parameter	**Description**	**Comment**
Underlying methodology	Book-keeping	
System borders for the electrical system	Norwegian consumer electricity mix including import and export.	
Guarantee of origin regarded in the calculations	No	
Time-resolution	Yearly values, mean numbers based on the years 2007-2011 for el and 2010-2012 for DH	
Type of primary energy included	Free flowing energy sources (sun, wind, free flowing water) is set to 0, primary energy used to generate industrial surplus is allocated to the produced product, waste has factor of 0.66 where the fraction that could have been recycled or reused is regarded as PEF = 1.	
Climate gases included	CO_2 (carbon dioxide); CH_4 (methane) and N_2O (nitrous oxide) GWP_{100} are 1,25 and 298 respectively (IPCC, 2007).	GWP_{100} means that a 100 years time horizon is used when calculating the GWP compared to CO_2
System border for the emission factors	Whole fuel chain. Upstream emissions and incineration emissions (1 % cut-off rule is used in the LCA-data)	
Data source for the factors	Background data: Ecoinvent Information regarding energy mix: ENTSO-E Information regarding DH: Master thesis.	

9.1.1.2 Sweden

Appendix, chapter 16.2 presents the complete table where primary energy, GHG emission factors and related references for Sweden are listed.

Sweden is not a country where the primary energy calculations have been rooted. The Swedish national board of housing has ignored the EU policies of introducing PEF in the building regulations. The Swedish District Heating Association (SDHA) have been using the book-keeping method (attributional LCA) since 2009 to calculate the yearly average PEF and the GHG-factor for the district heating networks in the past year. The conversion factors for fuels and energy carriers are in most parts from the Swedish National Inventory Report (Swedish NIR 2009) and from the report *"Miljöfaktaboken 2011"* which contains estimated emission factors for fuels, electricity, heat and transport in Sweden (Gode et al 2011). Another source for primary energy factors often used is the Swedish "energy efficiency survey" (2008:25) that used primary energy factors to quantify the primary energy savings.

Suggested calculation method in ZenN for district heating and electricity

This section only regards the used PEF- and GHG calculation for the district heating in Malmö. The used method is a combination of the factors for different energy carriers used in the yearly calculation of PEF and GHG factors of Swedish district heating networks and the EN 15316:4:5:2007 where the power bonus method is used. Because of the factors used, it is mainly a book-keeping method to calculate the historical environmental performance. Note that this cannot be considered as the official Swedish methodology.

Table 9.5 Description of the used methodology for calculation of the GHG and PEF for Malmö

Parameter	**Description**	**Comment**
Underlying methodology	More book-keeping than prospective method	Conversion factor used (See Appendix, chapter 16.2) are book-keeping factors.
Allocation method in CHP	Power bonus method (EN 15316:4:5:2007)	More commonly used in a prospective LCA.
System borders for the electrical system	Nordic consumer electricity mix including import and export. PEF = 2.26 in 2011.	The residual mix is used where the electricity sold as GO is excluded from average mix
Guarantee of origin regarded in the calculations	Yes	The available book-keeping factor for electricity regards Guarantee of origin
Time-resolution	Monthly values	Only possible for the district heating network in this case.
System borders for the primary energy factors for fuels	Embodied energy used to build used infrastructure below 1 % of the total primary energy flow is disregarded (e.g. construction of the CHP)	
Type of primary energy included	Free flowing energy sources (sun, wind, free flowing water)	

	is set to 0, primary energy used to generate industrial surplus is allocated to the produced product, waste has factor of 0.66 where the fraction that could have been recycled or reused is regarded as PEF = 1.	
Climate gases included	CO_2 (carbon dioxide); CH_4 (methane) and N_2O (nitrous oxide) GWP_{100} are 1, 25 and 298 respectively (IPCC, 2007).	GWP_{100} means that a 100 years time horizon is used when calculating the GWP compared to CO_2
System border for the emission factors	Whole fuel chain. Upstream emissions and incineration emissions (1 % rule is used in the LCA-data)	
Data source	IVL, SEPA[4], Swedish Energy,	See Appendix, chapter 16.2

In order to be more of a prospective method, the chosen conversion factor for electricity could be switched to short term marginal or complex marginal if possible. However, the same will not be possible to do for used district heating in the project because of the limited timeframe to calculate it. Short term or complex marginal for the north European electricity can be found in Sköldberg & Unger 2008. The CO_2 emissions factor for complex marginal in the “north European electricity grid” is estimated to around 620 g CO_2/kWh.

9.1.1.3 Spain

Appendix, chapter 16.3 presents the complete table where primary energy, GHG emission factors and related references for Spain are listed.

In Spain, Primary energy calculations have been introduced in building regulations only recently, through changes derived from the EPBD implementation in national regulations. Data in Table 9.6 has been taken from the Last PEF and CO_2 conversion table published by IDAE (Institute for Energy Saving and Diversification), and completed with inputs from REE (Spanish Electric Network). Specific tables in Building regulations[i] are derived from this data source, in its current or previous versions.

Table 9.6 Description of the used methodology for calculation of PEF and CO2 factors for Eibar

Parameter	**Description**	**Comment**
Underlying methodology	Book-keeping	Conversion Factors are book-keeping factors, regularly updated (2-3 years)
Data source	IDAE, REE	See Appendix, chapter 16.3 and References
Type of primary energy included	According to the methodology, all losses in fuel	

[4] Swedish Environment Protection Agency

	transformation/refinement and transport are included	
System borders for the electrical system	Spanish electricity Mix	
Guarantee of origin regarded in the calculations	Yes	
Climate gases included	Only CO_2	
System border for the emission factors	Whole fuel chain to consumption point.	

9.1.1.4 France

Appendix, chapter 0 presents the complete table where primary energy, GHG emission factors and related references for France are listed.

The Bilan Carbone® method was initially developed for the ADEME by Jean-Marc Jancovici, of the MANICORE engineering office. The development of the Authorities version has received the support of the Groupe Caisse d'Epargne.

The supplement to the emissions factor guide for the French overseas departments, New Caledonia and Corsica has been produced by the EXPLICIT engineering office.

Bilan Carbone® is a registered trademark of the ADEME.

Calculation of greenhouse gas (GHG) emission factors

For electrical energy systems

The context: In France the evaluation of electricity's carbon content represents a major objective for the evaluation of actions in the fight against climate change. While this issue does not raise any major difficulty for many countries, it is a complex one to define in our country given the specific nature of the French electricity sector (ADEME 2001-2010).

The method: Joint work has therefore been carried out between ADEME and EDF since summer 2003. This work has led to shared conventions, methodology and results (ADEME 2001-2010).

The following main principles have guided this work (ADEME 2001-2010):

- Choice of a method that respects the additive effect criterion, i.e. that over a year the sum of the CO2 emissions for all the different uses is equal (no more, no less) to the total emissions of the production park.
- Choice of a method based on shared historical. The period retained (1998-2003) is an intentionally long one in order to smooth over variations due to specific situations, both in terms of operation of the park and in terms of climate.

- The scope retained is that of mainland France excluding self-consumed production: this is not a question of evaluating the kWh of a specific actor for a commercial approach but of defining the content of one kWh consumed in our territory to help implement public policy in France.
- Use of monthly step data: on the one hand, the “variation” in the CO2 contain is largely explained by the seasonal component (unlike hourly variations within a week) and on the other the finer time step studies are less robust and hard to reproduce.

The results: The results enable distinction to be made between 4 levels of emission.

These 4 indicators offer a vision that can be easily shared for the most common uses (these emission factors include the inline losses) (ADEME 2001-2010)

- The use of electricity for residential and tertiary heating (electric heating and fuel and gas boiler circulation pumps), exclusively in winter, is given the CO_2 content for the seasonally adjusted production, i.e. 180 g/kWh.
- Lighting, whether residential, tertiary, public or industrial has a CO_2 content of around 100 g/kWh.
- The industrial uses (cooking, washing and brown goods), the tertiary and industrial uses other than lighting have a consumption that follows the overall charge curve and are therefore attributed a CO_2 content more or less equal to the national average, i.e. 60 g/kWh.
- Finally, the other basic uses (cooling, DHW, other residential uses, agriculture, transport, building sector and armed forces), whose variations are not seasonal and air conditioning in the tertiary sector (whose seasonality is reversed in relation to the electricity production cycle) are given a CO_2 content of around 40 g/kWh.

“Green” electricity: Since the liberalization of the electricity sector, consumers can now subscribe to “green” electricity offers whose content is supposed to be based on renewable energies.

In France, the development of renewable energies is financed through the buy-back tariff, as a financing basis in the CSPE (Contribution to the Public Electricity Service) paid for by all consumers. Therefore, all renewable production that falls within the buy-back tariff is part of the national electricity mix.

From now on, only supplier offers which guarantee additional renewable electricity production (i.e. production which is not financed through the buy-back scheme but by individual contracts between producer and supplier) may be accounted for in the Bilan Carbone based on the LCA content of the different production resources used.

For district heating

Purchases of steam: Emission factors published by the MEEDDAT and used for the Bilan Carbone does not specify whether emissions from the combustion of domestic waste are included in the calculation, while the incineration of plastics – contained in domestic waste – generates fossil CO_2 emissions.

Inline steam: As it is the casefor electricity, the transportation and distribution of steam, from the steam producing installation to the consumer, generate losses through the Joule effect (ADEME 2001-2010).

These losses represent on average 10% of the final steam consumed. In other words, when the consumer takes 1 kWh from the network, the production appliance has to inject an average of 1.1 kWh (ADEME 2001-2010).

As for electricity, except where stated to the contrary, the emission factor provided by the producer concerns the "greenhouse gas content" on output from the installation. If this emission factor is applied directly to the consumption read at the consumer’s premises, the losses are not covered although the steam dissipated in the network has been produced.

10% should therefore be added to the emissions calculated from the final consumption and the emission factors on output from the installation to lead to the correct estimate of the real emissions (ADEME 2001-2010).

Of course, this loss percentage will be zero if the emission factor is given at the ground floor of a building by the producer who has already integrated losses related to distribution.

Table 9.7 Description of the used methodology for calculation of PEF for Grenoble

Parameter	Description	Comment
Underlying methodology	Very detailed book-keeping approach	
Data sources	Various sources : from French most important energy producers or energy transfer companies	
Type of primary energy included	Free flowing energy sources (sun, wind, free flowing water) are set to 0, primary energy used to generate industrial surplus is allocated to the produced product.	
Allocation method for CHP		
Electricity		
System borders for the electrical system	French consumer electricity mix including import and export. The coefficients of transformation of the final energy in primary energy are taken by agreement : For electricity PEF = 2.58 in 2008 (RT 2008 for the renovation).	Decree of 13 June 2008 on the energy performance of existing buildings with an area greater than 1 000 square meters, which are subject to major renovation.
Guarantee of origin regarded in the calculations	Yes	
Time-resolution		
District heating		
System borders for the primary energy factors to fuels	The transformation coefficients primary energy are taken by convention equal to: 2.58 for consumption and electricity production; 0.6 for consumption of wood; 1 for other consumption.	Decree of 13 June 2008 on the energy performance of existing buildings with an area greater than 1 000 square meters, which are subject to major renovation.

Table 9.8 Description of the used methodology for calculation of CO_2 eq for Grenoble

Parameter	Description	Comment
Underlying methodology	Very detailed book-keeping approach	
Data sources	Yes	
Climate gases included	Most of the emission factors associated with energy corresponds to CO_2 emissions (ADEME 2001-2010).	Other gases as methane or N2O are generally marginal.

System border for the emission factors		

9.1.2 Symmetry

The most adapted way of weighting the delivered and exported energy is to be done by a symmetric weighing factor and this is also what each country have provided in Table 9.1. The rationale behind symmetric weighting is that the energy exported to the grids will avoid an equivalent generation somewhere else in the grid. Hence the exported energy has a substitution value, which is equal to the average weighting factor for that grid. (Sartori, Napolitano et al. 2012)

The common factors could be asymmetric, as in prEN 15603, to differentiate self-consumption to grid export (see table

Table 9.2)

9.1.3 Time dependent accounting

Due to the complexity of the energy infrastructure, it is often feasible to estimate the weighting factors only as average values for a period of time. This is a static accounting, and it typically applies to primary energy and carbon emission factors. (Sartori, Napolitano et al. 2012) In ZenN it is decided to use static weighing factors.

10 Net ZEB balance

10.1.1 Period

A proper time span for calculating the balance is assumed, often implicitly, to be a year. A yearly balance is suitable to cover all the operation settings with respect to the meteorological conditions, succession of the seasons in particular (Sartori, Napolitano et al. 2012). Selection of shorter time spans, such as seasonal or monthly balance, could be highly demanding from the design point of view, in terms of energy efficiency measures and supply systems, in order to reach the target in critical time, such as winter time (Sartori, Napolitano et al. 2012).

In ZenN the agreement is to consider a yearly calculation balance.

10.1.2 Type of balance

Balance is a condition that is satisfied when weighted supply meets or exceeds weighted demand over a period of time, nominally a year. The net zero energy balance can be determined either from the balance between delivered and exported energy or between load and generation.

The agreement is to follow the pre-norm prEN 15603 as long as it's possible. The prEN 15603 (May 2013) proposes a method to calculate this balance (clause 11). The Technical Report (TR) related to this pre-norm (July 2013), makes amend and proposes a modified method. In the meantime, the pre-norm has been out for public enquiry and has received comments. This means that it can be that the final calculation procedure for electricity balance will be different from both those mentioned.

Furthermore, the norm talks about a balance between delivered and exported energy (each carrier with proper conversion factors). This sounds like an “import/export” balance, according to the terminology used in the literature survey, Part A of this report. But, if looking at the formulas and graphs in clause 11 (both prEN and TR) and in Appendix H in TR, what can be seen is that you are supposed to calculate a sort of “load/generation” balance. At least as long as one uses symmetric factors: the balance is load/generation, because there is no difference in “weighting” electricity generated on-site and immediately used electricity in the building vs. that exported to the grid.

In conclusion, there may be possible changes if new information about the EN 15603 becomes available while we are still doing our calculations. For the time being the situation is like this:

- With national primary energy factors, which are all symmetric, the balance will be between load and generation.
- With the common energy factors which are decided to be asymmetric, the balance follows the calculation method in the TR.

10.1.3 Energy efficiency

Energy balance and other indicators related to the building envelope and technical system are described according to prEN 15603: Point 3. Clause 7.7. Focus: Net energy use (goodness of envelope) and delivered energy (goodness of technical systems).

(a) Minimum energy efficiency requirements for each case are expressed in

Table 10.1.

Chapter 10.1.3.1, 10.1.3.2, 10.1.3.3 and 10.1.3.48.1.3.4 gives a deeper explanation of where the parameters are taken from for each country (also describing the numbers and dots in superscript).

10.1.3.1 Norway

All parameters are collected from the standard NS 3701:2012, Low Energy building, class 1 (nursing home).

10.1.3.2 Sweden

Comments to the table Energy requirements:

1) From FEBY (Forum for energy efficient buildings)
2) 15 W/m^^ Atemp in climate Zone III (southern Sweden(at DVUT 12 days average value. (approx. -8 Celsius degrees for Malmö)
3) 0,3 l/s m^2 Aom if Aom/Atemp <1.7 , elseif Aom/Atemp> 1.7 = =>0.5 l/s/m^2 Aom , air leakage with 50 Pa pressure difference according to SS-EN 13829. No air-changes included.
4) Average U-value for windows and glass facades . 0.9 for minergi buildings, U value should be measures according to SS-En 14351-1:2006
5) 50 % including the horizontal shading from the surroundings. Recommended value from SVEBY. Real shading from the surrounding should be used if it is substantial
6) System efficiency = (Tin – Texitair)/(Tin – Tout), recommended
7) Political Weighting factors (2.5 for el, 0.8 for district heating, 0.4 for district cooling and 1 for fuels or other energy carriers) For minenergi buildinsgs additonal 20 KWh weigted energy is accepted.
8) Delivred energy to building (heating, comfort cooling and building electricty) in climate zone III. No factors used (1 for all) . A suggested level for renovation to nZEN correspond in this case to 75 kWh/m^2 Atemp

9) The value should be obtained in the case of alteration (renovation) of the building envelope in an existing building.
10) Recommended value for an ESX system. 1.0 kW/(m3/s) is recommended in an exhaust system with heat recovery and 0.6 kW/(m3/s) in an exhaust system without heat recovery.

10.1.3.3Spain

(b) Note: The last three parameters in

Table 10.1 are values for new residential buildings in D1 climatic zone. These are not actually applicable for retrofitting.

Other specific comments to the table:
* For D1 climatic zone (Eibar). Values for 11-20% glaze to opaque wall ratio. Actual numbers depends on window orientation
** Sensible heat. Depends on external flow rate and hourly working hours
*** Energy demand for the whole heated area of the building (Anet)
**** Heating + Cooling + DHW (excluding renewable energy consumption)

10.1.3.4France

Specific comments to

10.1.3.5

Table ***10.1***:
*Conductivity of each insulation material composing walls has been decreased by 30% of its initial value.
**Fresh air is provided according to zone relative humidity (called "VMC Hygro A" in France)
*** Minimal performances are required for a series of components (insulation, ventilation, system of heating), when these are modified by renovation work.
**** The values by default are tabulées of thermal bridges of connection for existing buildings built after 1948 in the case of weakly or strongly insulated walls, or not insulated.

(c) The initial energy consumption of the building is estimated by calculation. This one allows to estimate the initial performance of the building, to direct the choices of renovation and to estimate the energy saving realized thanks to the works compared with the previous situation.
(d) After the works, the global consumption of energy of the building for the posts of heating, domestic hot water, cooling, the auxiliaries, as well as the lighting must be lower than the reference consumption of this building. This one corresponds to the consumption that would have the same building for imposed performances of the works and the equipments which make up this building.
(e) For housing, the regulations introduce a maximal value of consumption. The energy consumption of the building renovated for the heating, the cooling and the domestic hot water must indeed be lower than a limit.

Table 10.1 Energy efficiency requirements for each country

Parameter	**NORWAY** Standard: NS 3701:2012, Low Energy building, class 1 (nursing home)	**SWEDEN** Standard: FEBY[1] (zero energy and passive houses , new residential buildings)	**SWEDEN** Standard: Offical buildning code , BBR 20 (regulations for all residential buildings)	**SPAIN** Standard: Spanish Technical Building Code (Royal Decree 314/2006). Updated by FOM/1635/2013, 10 September 2013	**FRANCE** Standard: RT 2008 corresponds to the thermal regulations in France for the renovation of the existing buildings more 1000 m²
Peak heating load [W/m2] ≤		15[2]			
Air tightness n50 [ach] ≤	1,5	0.3 l/s, m2[3]			I4 : 1,7 (m^3/h/m²)**
Air tightness 100Pa [m3/h·m2] ≤				27	
U-value outer wall [W/m2K] ≤	0,18		0.18[9]	0,66	(40 Arlequin: 0,16)***
U-value roof [W/m2K] ≤	0,13		0.13[9]	0,38	(40 Arlequin: 0,10)***
U-value floor [W/m2K] ≤	0,15		0.15[9]	0,49	(40 Arlequin: 0,16)***
U-value window and doors [W/m2K] ≤	1,2		1.2[9]	3-3,5*	(40 Arlequin: 1,4)***
U-value windows and glass facades, [W/m2K] ≤		0.8[4]			
U-value average, [W/m2K] ≤			0.4		
Thermal bridges ψ [W/m2K] ≤	0,05				****
effectiv. (S, E, W) ≥		0.5[5]			
Opaque env. displacement (S,E,W, Hor.) [h] ≥					
Thermal admittance Y [W/m²K] ≤					
Heat recovery efficiency ≥	70 %	80 %[6]		40 - 75%**	no *
Specific Fan Power SFP [kW/(m3/s)] ≤	2		2.0[10]	0,5 - 2	
heating [kWh/m2a] ≤	30			27-(2000/A_{net})***	a + b + c (40 Arlequin: 35)
Energy need for cooling [kWh/m2a]≤	9,2			15	a + b + c (40 Arlequin: 0)
Primary energy [kWh/m2a] ≤		63[7]	90[8]	60+ (3000/A_{net})****	a + b + c (40 Arlequin: 21)

10.1.4 Energy supply

A straightforward requirement is proposed in (BPIE 2011) by setting a threshold for the minimum share of renewable energy that has to be used for covering the building's energy demand (Sartori, Napolitano et al. 2012).

The agreement between the ZenN partners is to include the RER (Renewable Energy Ratio) indicator introduced by prEN 15603 and related Technical Report (TR).

RER is not a performance indicator (does not say anything about the goodness of a building) and shall be used only as a secondary indicator (after the energy balance etc).

11 Temporal energy match characteristics

11.1.1 Load matching

The temporal match between load and generation for an energy carrier gives a first insight on a building's ability to work in synergy with the grid. When there is a poor correlation between load and generation, e.g. load mainly in winter and generation mainly in summer, the building will more heavily rely on the grid. If load and generation are more correlated, the building will most likely have higher chances for fine tuning self-consumption, storage and export of energy in response to signals from the grid.

Load matching can be addressed in design by separate calculations or simulations on load and generation, without need to know or estimate self-consumption. For this reason indicators of load matching fit well for being used in combination with a load/generation balance. (Sartori, Napolitano et al. 2012)

There is an agreement to include the indicators "Load cover factor" and "Supply cover factor" from IEA Task40/Annex 52 "Towards Neat Zero Energy Solar Buildings". Both are calculated based on hourly values from calculations.

As can be seen in chapter 5.1 of the literature review (Part A), the formulas are easy and do not require long calculation procedures. However, it should be noted that they require hourly data and an additional input on nominal grid connection capacity. Hopefully this is easily retrievable for each of the pilots. Also, whenever possible all these indicators should be calculated for both a single building and the entire neighbourhood.

11.1.2 Grid interaction

To assess the exchange of energy between a Net ZEB and a grid versus the grid's needs one must know at least the import/export profile from the building.

To illustrate the grid interaction it is agreed to calculate the indicators introduced in Part A; "Generation multiple" and "Dimensioning rate", and eventually related graphs presented in a report made by IEA SHC Task 40 / EBC Annex 52 (IEA 2014). Both are calculated based on hourly values from calculations.

12 Measurement and verification

This part will be described in detail through work package 3, Deliverable 3.2: "Monitoring platform definition".

13 Net ZEB evaluation

Table 12.1 and 12.2 shows delivered energy with and without lighting for all pilot buildings, both describing figures related to before and after renovation. The "after" figures are based on the BEST tables described in ZenN - Description of Work and are representing the theorethical improvements related to renovation.

Table 12.1 Delivered energy without lighting for all cases (excl. NO-cases because they are non-residential buildings)

		Energy demand [kWh/m2yr]	Energy generation [kWh/m2yr]	Balance [kWh/m2yr]	Savings (energy demand)
NO-Økern	Before	357	0	357	66 %
	BEST table	120	10	110	
NO-Oppsal	Before	334	0	334	66 %
	BEST table	114	10	104	
SE-Lorensborg	Before	123	0	123	44 %
	BEST table	69	4	65	
SE-Lindängen	Before	158	0	158	55 %
	BEST table	71	2	69	
FR-Arlequin	Before	174	0	174	76 %
	BEST table	42	10	32	
ES-Mogel	Before	86	0	86	51 %
	BEST table	43	8	35	

Table 12.2 Delivered energy with lighting for all cases

		Energy demand [kWh/m2yr]	Energy generation [kWh/m2yr]	Balance [kWh/m2yr]	Savings (energy demand)
NO-Økern	Before	357	0	357	66 %
	BEST table	120	10	110	
NO-Oppsal	Before	334	0	334	66 %
	BEST table	114	10	104	
SE-Lorensborg	Before	129	0	129	41 %
	BEST table	76	4	72	
SE-Lindängen	Before	164	0	164	55 %
	BEST table	74	2	72	
FR-Arlequin	Before	178	0	178	76 %
	BEST table	43	10	33	
ES-Mogel	Before	97	0	97	45 %
	BEST table	53	8	46	

For doing the net ZEB calculations it is agreed to use the tool developed within the IEA - SHC Task 40/ECBCS Annex 52 - "Towards Net Zero Energy solar Buildings". The pilot buildings are evaluated with numbers describing generation/load both before and after renovation, based on theoretical calculations.

The net ZEB balance is evaluated in several ways, all which are presented in the generation/load graphs Figure 12.1-12.6: Delivered energy, delivered energy using primary energy factors exl. lighting, delivered energy using primary energy factors incl. lighting, delivered energy using common European primary energy factors, delivered energy using national primary energy factors and delivered energy using national carbon factors. Table 12.3 presents the weighing factors used.

Table 13.3 Weighting factors used in the calculations using the nZEB evaluation tool

	PE national			PE common EU			CO_2		
	electricity	gas	district heating	electricity	gas	district heating	electricity	gas	district heating
Norway	1,360	n.a.	0,780	2,500	1,050	0,400	0,047	n.a.	0,295
Sweden	2,260	n.a.	0,450				0,260	n.a.	0,144
France	2,580	n.a.	0,600				0,100	n.a.	0,055
Spain	2,464	1,070	n.a.				0,330	0,201	n.a.

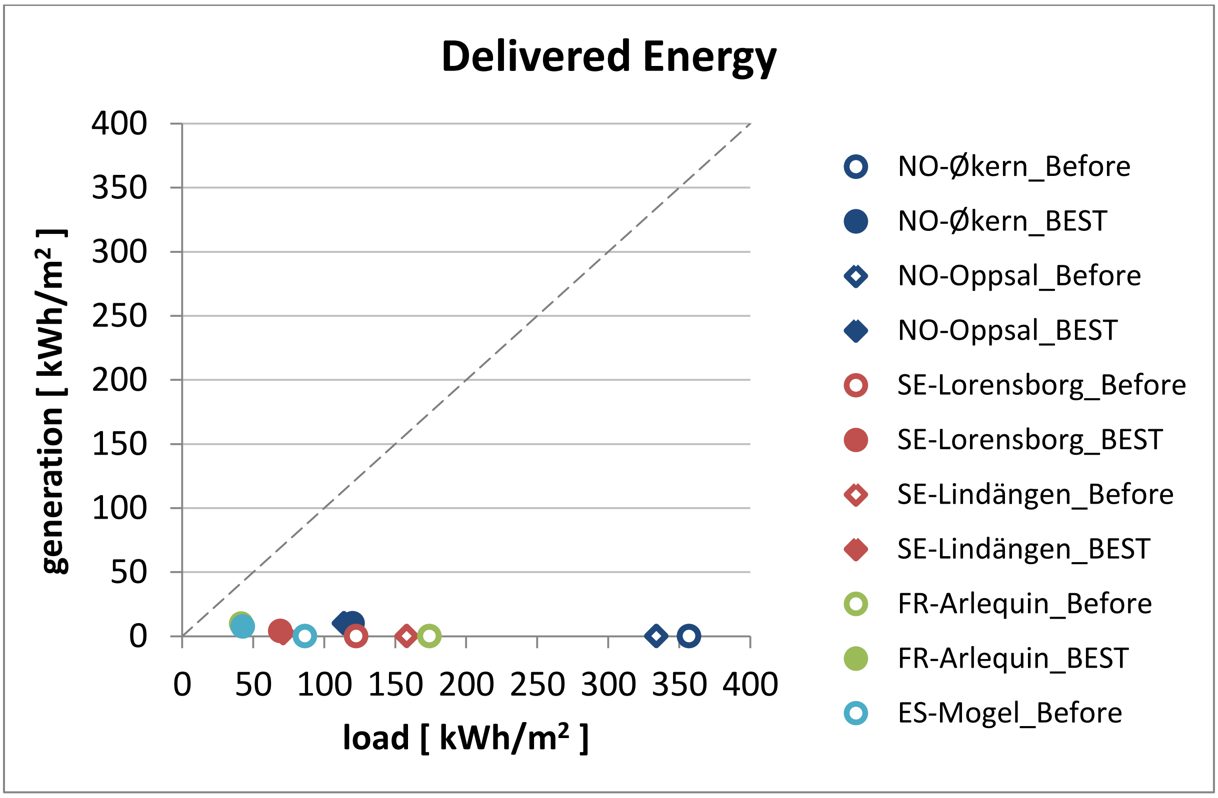


Figure 12.1 nZEB evaluation based on delivered energy

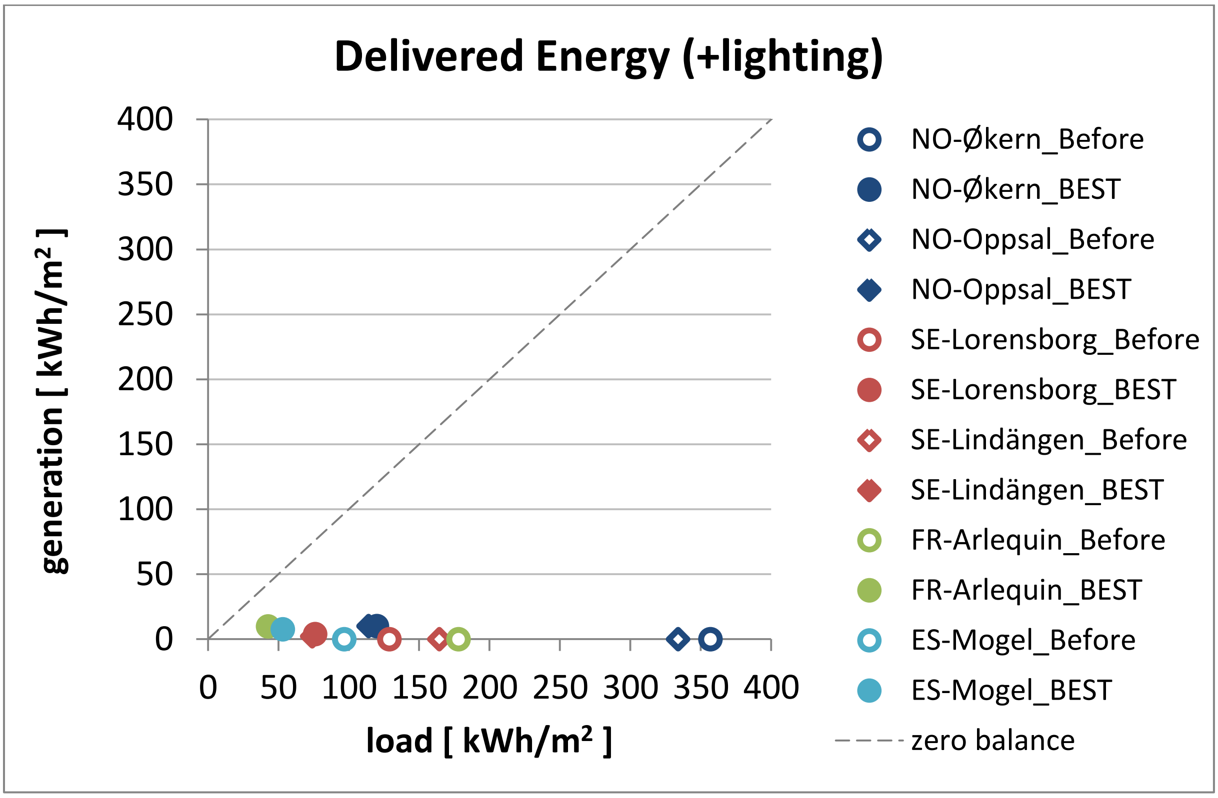


Figure 12.2 nZEB evaluation based on delivered energy including lighting

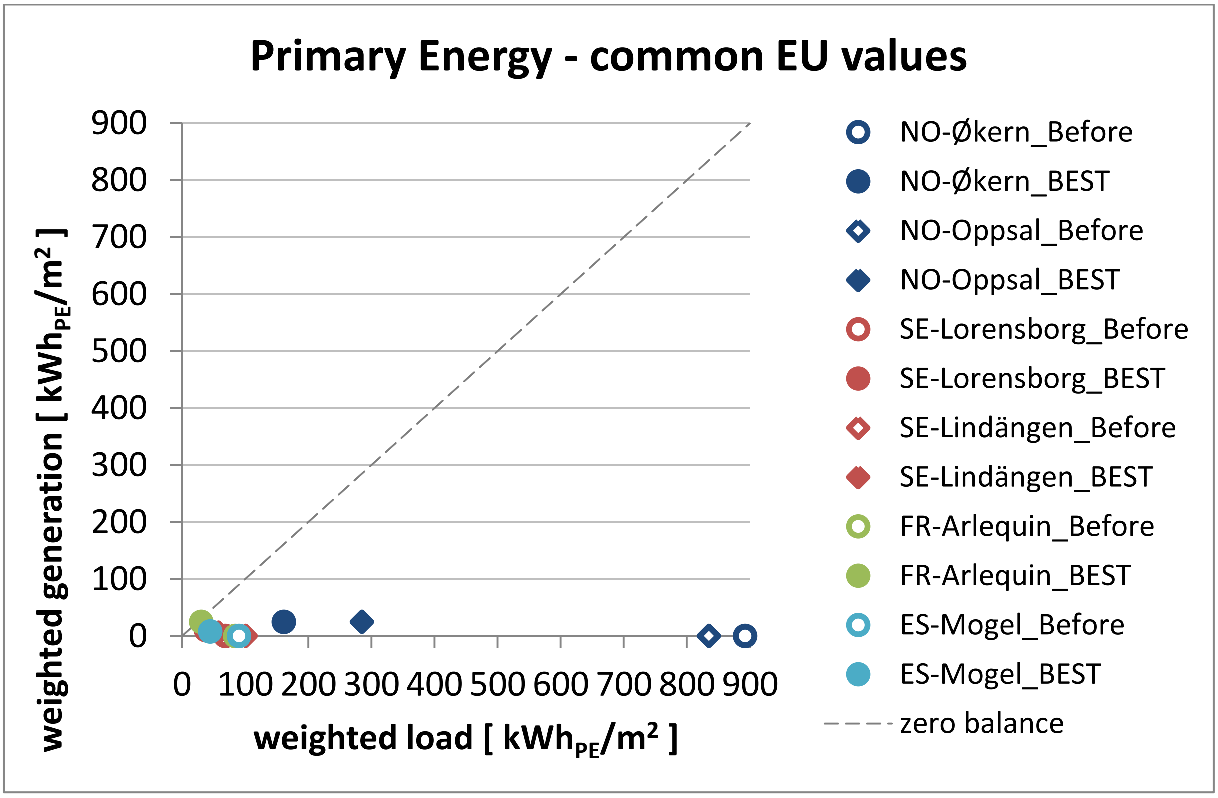


Figure 12.3 nZEB evaluation based on primary energy using common European values

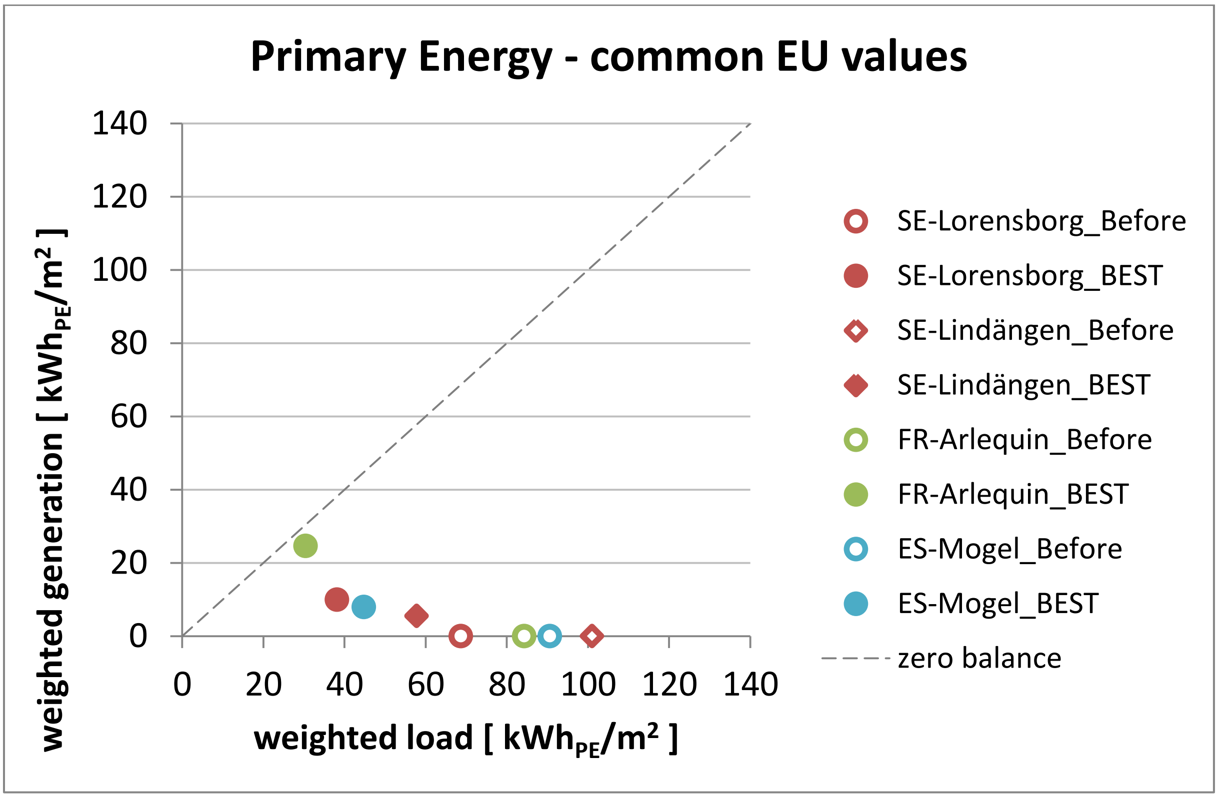
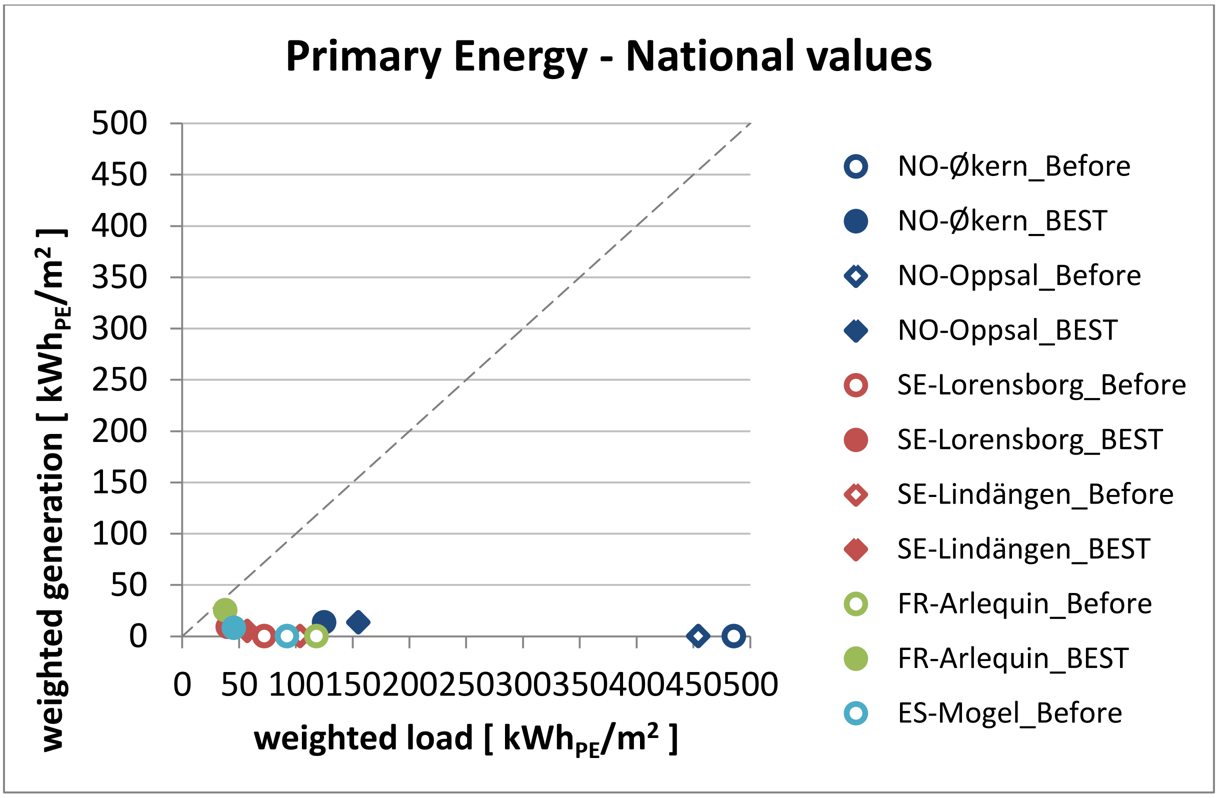
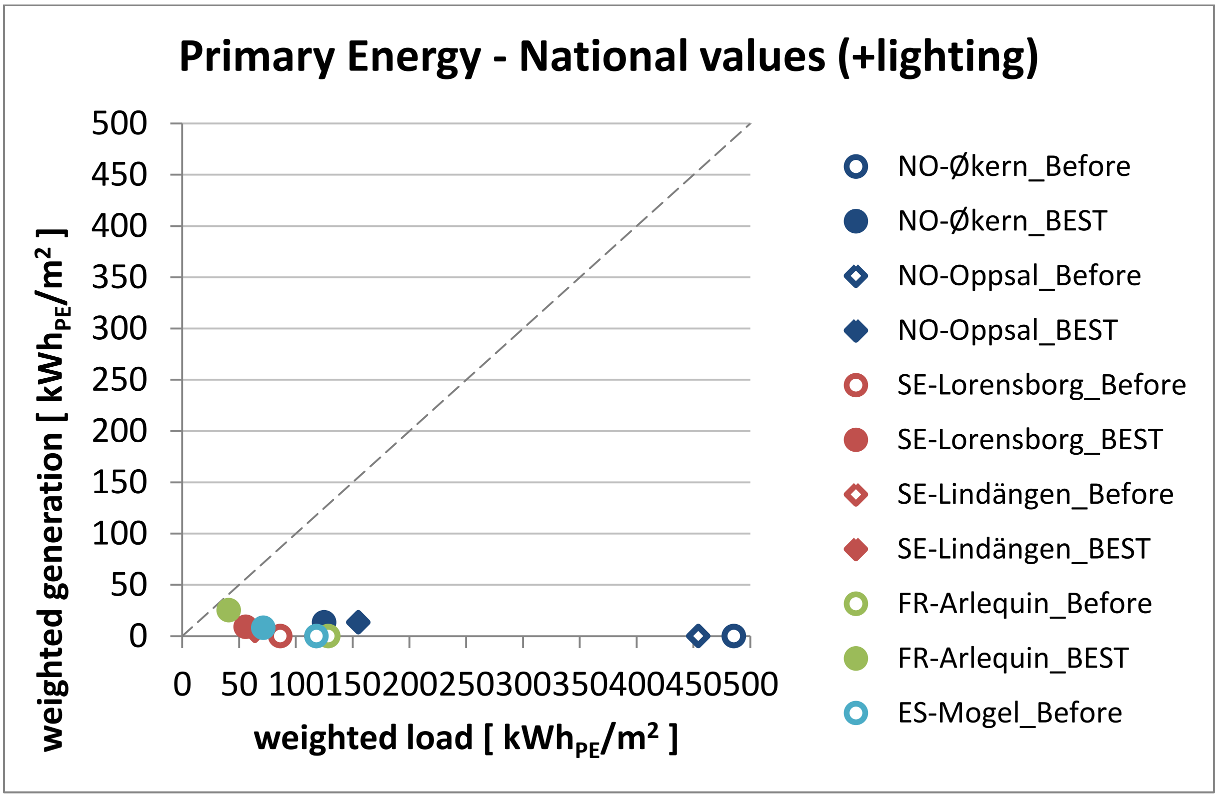


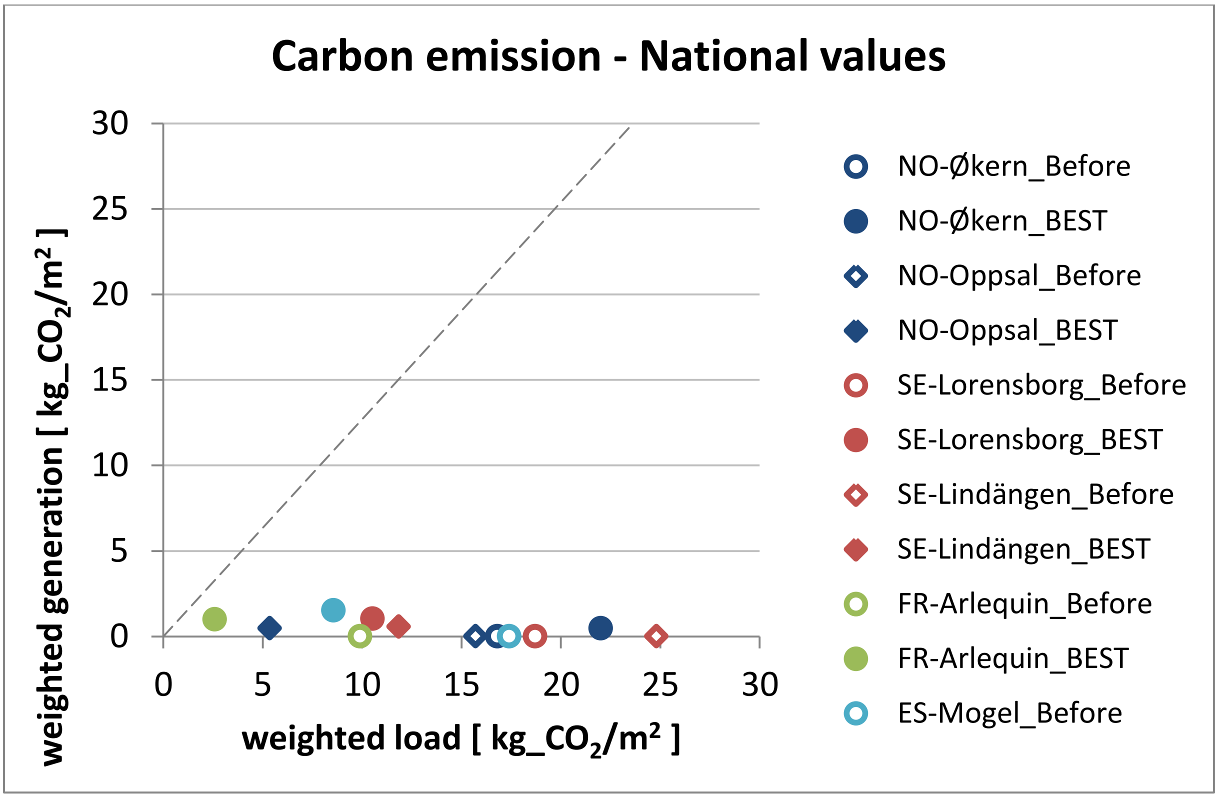
Figure 12.4 nZEB evaluation based on primary energy using common European weighting factors, excluding non-residential pilot buildings in Norway



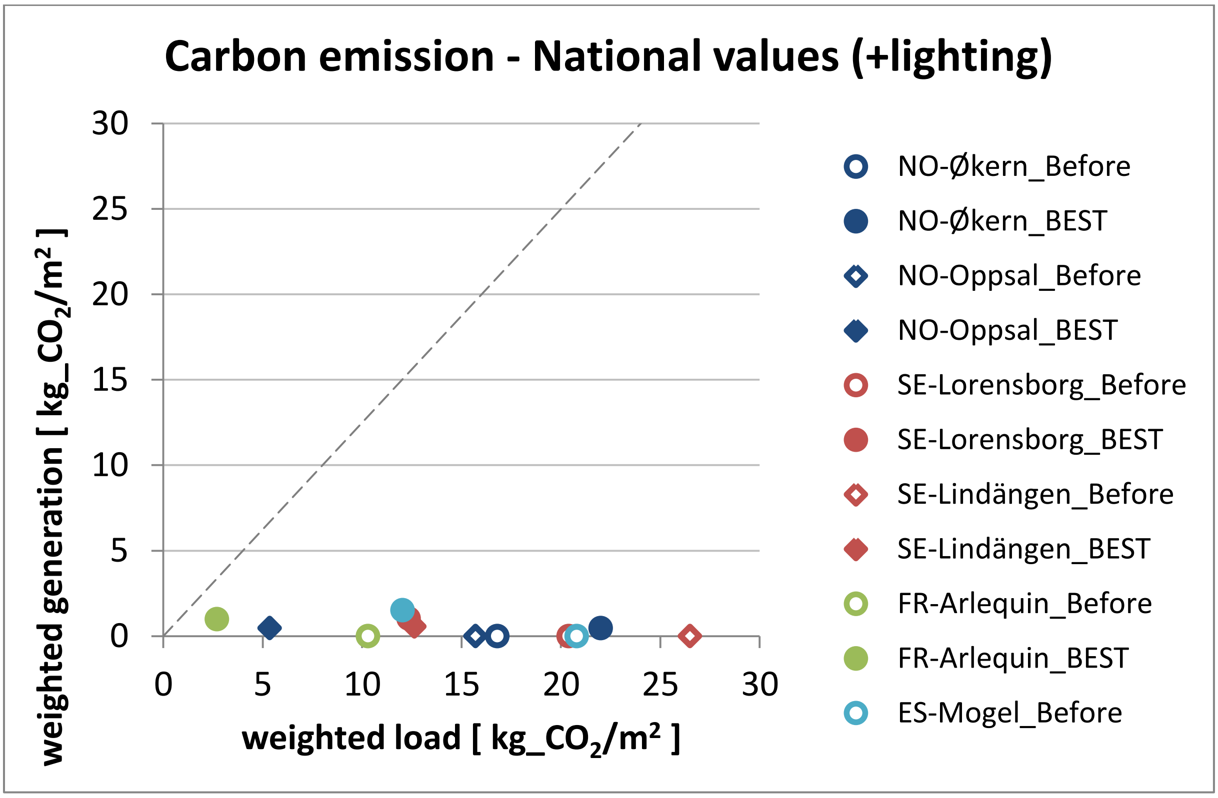
12.5 nZEB evaluation based on primary energy using national weighting fators



12.6 nZEB evaluation based on primary energy using national weighting factors including lighting



12.7 nZEB evaluation based on carbon emissions using national weighting factors



12.8 nZEB evaluation based on carbon emissions using national weighting factors including lighting

13.1 Discussion

The improvements related to reduced energy demand for the different pilot buildings can be studied in the graphs, starting with delivered energy (figure 12.1 and 12.2). It should be reminded that the Norwegian pilot buildings are nursing homes (hence non-residential) with different requirements than residential buildings, especially about ventilation rates; therefore the larger energy demand. The energy savings related to reduced delivered energy is largest for the French pilot building, Arlequin, resulting in 76%. The two Norwegian pilot buildings are both accomplishing 66% energy savings, while the Spanish case Mogel accomplishes 55/51% (with and without lighting), the Swedish cases, Lindängen 55% and Lorensborg 41/44%. Table 12.1 and 12.2 presents these figures.

Figure 12.3 and 12.4 presents results using common European primary energy factors (see table 12.3). All cases, except the Norwegian ones, have now lower weighted load for both before and BEST scenarios, since the conveersion factor for thermal carriers (gas and district heating) is lower than one. The reason for the Norwegian exception is the large share of electricity, used also for heating purposes, which is multiplied by the the common European factor of 2.5. In Norway the national factor for electricity is significantly lower (1.36), due to the large extent of hydro power in the grid. Therefore, the difference between the Norwegian cases and the others are reduced when using National values (Figure 12.5 and 12.6).

The case which is closest to the zero balance line is the French case, Arlequin.

Looking at the carbon balance (figure 12.7 and 12.8), the results for the Norwegian case Økern present yet another peculiarity. It appears that the balance before retrofitting is better than after retrofitting. Here, the energy carrier for heating is actually shofted from electricity (before) to district heating (after). The carbon factor on electricity is very low in Norway due to large extent of hydro power in the grid and, contrary to what happens with primary energy, the carbon factor for electricity is lower that the carbon factor fordistrict heating (see Table 12.3). Therefore, given the special conditions of the electricity generation mix in Norway, a balance based on carbon emission factors would favour the use of electricity for heating (including with heat pump) over other thermal carriers.

14 Conclusion

The report on a common nZEB definition for ZenN is devided into two parts; Part A (*Literature review)* and Part B (*Common definition of nZEB renovation).* The last part presents the definition agreed upon by the ZenN partners. Five main criterias have been considered: Building system boundary, Weighting system, Net ZEB balance, Temporal energy match characteristics and Measurement and verification.

In part B, a last chapter called "Net ZEB evaluation" is included, describing the pilot cases before and after renovation using the common nZEBr definition and IEA net ZEB evaluation tool. Althogh the theorethical figures of most of the pilot cases do not touch the zero balance line, the comprehensive renovations shows a great improvement on weighted load, described by delivered energy and related primary energy and emissons.

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16 Appendix

16.1 Primary energy and emission metrics, Norway

Table 16.1. The used conversion factors in the calculation of the PEF and GHG emission factor for the district heating in Oslo, Norway

Fuel	**Total primary energy factors (kWh_p/kWh_{de})**		**Non-renewable primary energy factors for fuels**		**Choice for rating**	**CO_{2e} [kg/MWh_{LHV}] (upstream and incineration)**	
	Norway	Source	Norway	Source		Norway	Source
Lignite							
Hard Coal							
Heavy fuel oil (not used in residential sector)							
...							
Secondary energy carrier						**CO_{2e} [kg/MWh_{LHV}]**	
Electricity – grid	1,36	[*ENTSO-E*, 2007-2011] Background data: Ecoinvent	0,24	[*ENTSO-E*, 2007-2011] Background data: Ecoinvent		0,047	[*ENTSO-E*, 2007-2011] Background data: Ecoinvent
Wind power electricity (large scale) + PV electricty							
Hydro power							
Nuclear power							
District heating	0,78	[*Berget*, 2013] Background data: Ecoinvent	0,68	[*Berget*, 2013] Background data: Ecoinvent		0,295	[*Berget*, 2013] Background data: Ecoinvent

16.2 Primary energy and emission metrics, Sweden

Table 16.2. The used conversion factors in the calculation of the PEF and GHG emission factor for the district heating in Malmö, Sweden

Fuel	**Total primary energy factors for fuels [kWh_p/kWh_{de}**		**Non-renewable primary energy factors for fuels**		**Choice for rating**	**CO_{2e} [kg/MWh_{LHV}] (upstream and incineration)**	
	Sweden	**Source**	**Sweden**	**Source**	**Total**	**Sweden**	**Source**
Hard Coal	1.15	IVL 2011[5]	1.15	IVL 2011[4]		419	IVL 2011[4] + SEPA
Heavy fuel oil	1.11	IVL 2011[4]	1.11	IVL 2011[4]		301	IVL 2011[4] + SEPA
Light fuel oil	1.11	IVL 2011[4]	1.11	IVL 2011[4]		291	IVL 2011[4] + SEPA
Natural Gas	1.09	IVL 2011[4]	1.09	IVL 2011[4]		249	IVL 2011[4] + SEPA
Peat	1.02	IVL 2011[4]	1.02	IVL 2011[4]		433	IVL 2011[4] + SEPA
Bioenergy (solid primary)[6]	1.03	IVL 2011[4]	0.03	IVL 2011[4]		7.8	IVL 2011[4] + SEPA
Bioenergy (solid refined)[7]	1.18	IVL 2011[4]	0.18	IVL 2011[4]		18.6	IVL 2011[4] + SEPA
Bioenergy (solid secondary)[8]	1.01	IVL 2011[4]	0.01	IVL 2011[4]		5.9	IVL 2011[4]
Residual fuel[9]	0.65	IVL 2011[10]	0.05	IVL 2011[4]		89.5	IVL 2011[4] + SEPA
Waste as fuel[11]	0.61	IVL 2011[8]	0.33	IVL 2011[4]		100.6	IVL 2011[4] + SEPA
Secondary energy carrier						**CO_2 [kg/MWh_{LHV}]**	
Electricity (Nordic residual mix 2012)	2.26	Swedish Energy, 2011	0.97	Swedish Energy, 2011, 42.9 % fossil		260	Energimarknadinspektionen 2012
Industrial waste heat	0.03	(1.5 % auxiliary el)	0.01	(1.5 % auxiliary el)		4	(1.5 % auxiliary el)
Deep geothermal heat	0		0			0	
wind power electricity (large scale)	0.05	IVL 2011[4]				3.7	IVL 2011[4]
PV electricity	0.17	Ecoinvent data v2.0 (2008). Example data				37	Ecoinvent data v2.0 (2008). Example data
Hydro power	1.10	IVL 2011				1.3	IVL 2011
Nuclear power	2.92	IVL 2011				1.0	IVL 2011

[5] Gode et al 2011
[6] e.g. wood chips from short rotation tree, agricultural crops
[7] e.g. briquettes or wood pellets from round wood
[8] e.g. wood from industry residues, agricultural residues
[9] e.g. refused derived fuels (paper, wood, plastic)
[10] Gode et al 2012
[11] municipal solid waste

16.3 Primary energy and emission metrics, Spain

Table 16.3. The used conversion factors in the calculation of the PEF and GHG emission factor for the district heating in Eibar, Spain

Fuel	**Total primary energy factors (kWh_p/kWh_{de})**		**Non-renewable primary energy factors for fuels**		**Choice for rating**	**CO_{2e} [kg/MWh_{LHV}] (upstream and incineration)**	
	Spain	**Source**	**Spain**	**Source**		**Spain**	**Source**
Lignite	1,14	IDAE 2011	1,14	IDAE 2011		416	IDAE 2011
Hard Coal	1,14	IDAE 2011	1,14	IDAE 2011		423	IDAE 2011
Heavy fuel oil (not used in residential sector)							
Light fuel oil	1,12	IDAE 2011	1,12	IDAE 2011		306	IDAE 2011
Natural Gas	1,07	IDAE 2011	1,07	IDAE 2011		201	IDAE 2011
Bioenergy –solid_primary)[1]	1.25	IDAE 2011	0.25	IDAE 2011		0[2]	IDAE 2011
Bioenergy (industry/agricultural residues)[3]	1.25	IDAE 2011	0.25	IDAE 2011		0[4]	IDAE 2011
GLPs	1,05	IDAE 2011	1,05	IDAE 2011		272	IDAE 2011
Secondary energy carrier						**CO_{2e} [kg/MWh_{LHV}]**	
Electricity –grid	2,464	IDAE 2011	1,60	IDAE 2011, REE 2011 (67,5% fossil)		330	IDAE 2011
Wind power electricity (large scale) + PV electricty	1,09	IDAE 2011 (combined PV/WP)	0	IDAE 2011 (combined PV/WP)		0	IDAE 2011 (combined PV/WP)
Hydro power	1,09	IDAE 2011	0	IDAE 2011		0	IDAE 2011
Nuclear power	3,31	IDAE 2011				0	IDAE 2011

16.4 Primary energy and emission metrics, France

Table 16.4. The used conversion factors in the calculation of the PEF and GHG emission factor for the district heating in Grenoble, France

Fuel	**Total primary energy factors (kWh_p/kWh_{de})**		**Non-renewable primary energy factors for fuels**		**Choice for rating**	**CO_{2e} [kg/MWh_{LHV}] (upstream and incineration)**	
	France	**Source**	**France**	**Source**		**France**	**Source**
Lignite							
…							
Secondary energy carrier						**CO_{2e} [kg/MWh_{LHV}]**	
Electricity – grid	2,58	Decree of 13 June 2008				From 40 to 180 according to the uses	2001-2010 © ADEME – Emission factors guide - Version 6.1
PV electricty	2,58	Because of the feed-in tariffs in France, all PV electricity is sent to the grid and thus is taken into account in the global conversion factors calculation for electricity				15 with a level of uncertainty of 30%.	2001-2010 © ADEME – Emission factors guide - Version 6.1
District heating[1]	0,6	Decree of 13 June 2008 (This district heating increased in 50 years from 0% to 54% renewable energy or fatal (RE & R))				55	2001-2010 © ADEME – Emission factors guide - Version 6.1
…							

[1] Default value if not calculated according to common methodolgy