Net-ZEB

by
Kristof Lijnen

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Sustainable Architecture.

at

Norwegian University of Science and Technology Faculty of Architecture and Fine Art Department of Architectural Design, History and Technology

December 2011

Abstract

This paper is an overview meant to give a greater understanding of what Net ZEB is and how it can contribute in reaching the Kyoto goals. It will also give an insight on the methodology and calculation of Net ZEB. These issues will be linked to the study of seventeen case studies done in several different countries. The results from the case studies are summarized graphically and will be analyzed and discussed. This will provide a better understanding of how Net ZEB will reach an energy balance and thereby reduce the related CO2 emissions. In doing so the Net ZEB philosophy will prove to be a good way to help reach the Kyoto protocol goals by its deadline of 2015.

Table of Contents

Introduction

The issue of climate change and the growing energy resource shortage result in Net Zero Energy Buildings (Net ZEBs) being no longer perceived as buildings of a remote future, but as a realistic solution for the mitigation of the CO2 emissions and/or the reduction of energy use in the building sector (1). This brings us to enhance the Net ZEB philosophy for reaching the Kyoto goals from 1997. The deadline for achieving these goals has been extended, climate conference Durban, South Africa Dec. 2011, from 2012 to 2015 (2). The objective of this paper will focus on answering the following questions; what is Net ZEB? Is there a relation between Net ZEB and the Kyoto protocol? What is the methodology of Net ZEB? How is Net ZEB calculated? Are the Net ZEB results really in balance or is it not possible to reach that goal? The answers to these questions will give a better insight if Net ZEB can contribute to reach the Kyoto goals.

1. Net ZEB definition

A zero-energy building is an energy-efficient building which in combination with the public electricity grid meets its total annual primary energy demand, as determined by monthly balancing, by the primary energy credit for electricity surpluses fed into the grid. The electricity generated on-site is used primarily to meet the building's own energy demand (3).

The goal for *net* zero-energy buildings is simply a neutral result for an energy or emission balance over the period of one year. This implies that over the period of one year, the energy export of a net zero-energy building should be in a balance or greater than its energy import. The following balance inequality is then a minimum requirement for a Net ZEB:

Net ZEB: | *export* | – | *import* | ≥ 0 (4).

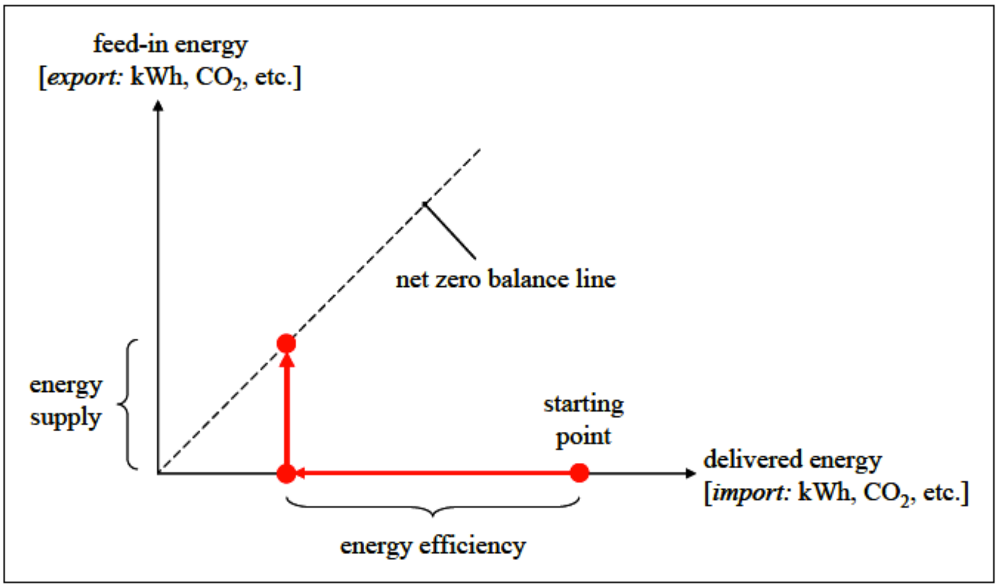

Fig 1. The graph representing a Net zero balance of a Net ZEB (4)

The graph in Fig. 1 represents the net zero balance of a Net ZEB. The starting point may represent the performance of a new building built according to the minimum requirements of the building code or the performance of an existing building prior to renovation work. The general pathway to achieve a Net ZEB consists of two steps. Firstly, reduce energy demand (*x*-axis) by means of energy efficiency measures. Secondly, generating electricity, or other energy carriers, by means of energy supply options to get sufficient credits (*y*-axis) to achieve the balance (4).

Electricity generated by photovoltaic

In order to achieve a net zero emission building that supplies his own energy by photovoltaic, the location of the building is an important issue. The following map gives a good overview of where in Europe the global horizontal irradiation from the sun is high or low. For example, it can been seen that the south of Spain has double the amount of irradiation (kWh/m^2) as compared to Norway or Northern countries in general.

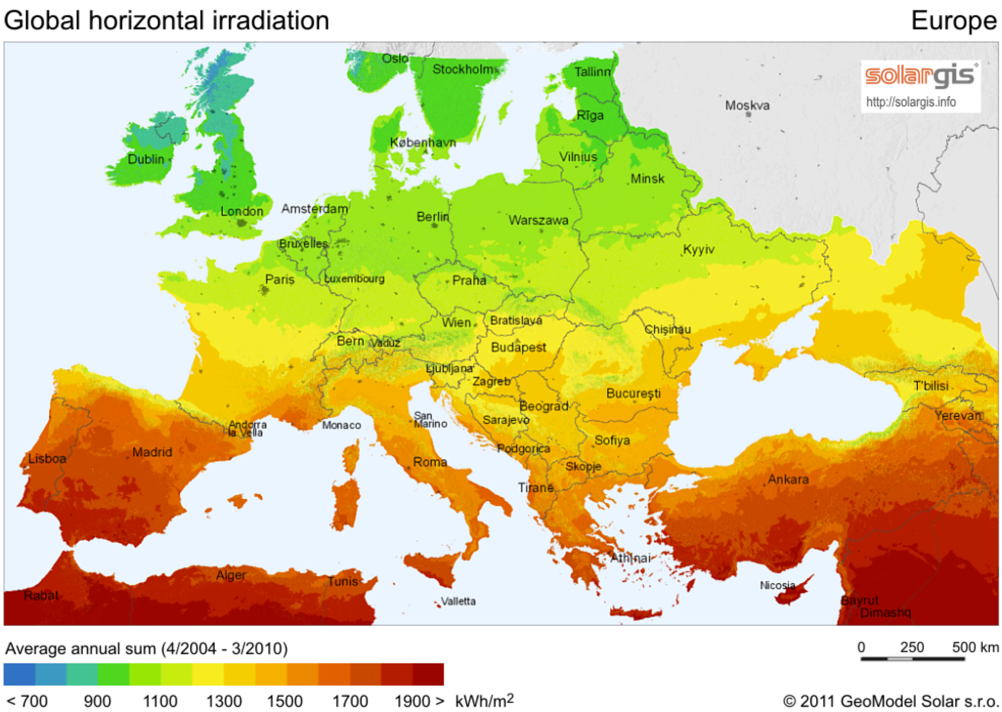

Fig. 2 Shows the global irradiation in Europe (5)

2. Kyoto goals

Under the Kyoto Protocol, accepted in 1997, industrialized countries agreed to reduce their collective green house gas emissions by 5.2% from the level in 1990. National limitations vary, with the EU set at 8% reductions over the five-year period 2008-2015(2). In the longer term, the global goal is to achieve 80% reductions by 2050 (6).

2.1. EU targets

In March 2007, the EU agreed to reduce emissions to at least 20% below 1990 levels by 2020, and for 20% of energy consumption across the EU to come from renewable sources. Renewable energy currently makes up some 8.5% of the EUs final energy consumption. In addition, the EU has offered to commit to a 30% reduction in greenhouse emissions if other developed countries agree to join in (6). The EU has to agree on how to "share the burden" of combating climate change, with countries such as the UK and Germany potentially making much bigger cuts (say 30%) and other high-growth but less developed countries being allowed more leeway. Already the EU's original 15 members are apparently currently well short of reaching their Kyoto target of an 8% cut by 2015. The European Union call upon member states to introduce the energy standard “Nearly Zero Energy Building” for all new buildings by no later than the end of 2020 (7). China, India and the other emerging economies are perhaps not unreasonably demanding that rich nations follow the implications of the latest climate science and agree to cut emissions by some 40% by 2020 compared to 1990 levels. If urban transportation is included this proportion may have to rise to 70%. In Europe emissions from the building sector vary from about 30% for countries in warmer climates to about 60% in the colder and more industrial countries. Figure 3 illustrates the final energy consumption form the building sector in 2007. Countries recognize that they are not going to meet carbon reduction obligations from renewable energy alone and therefore energy efficiency is crucial, with some countries setting ambitious targets—for example 70% reduction in residential buildings (6).

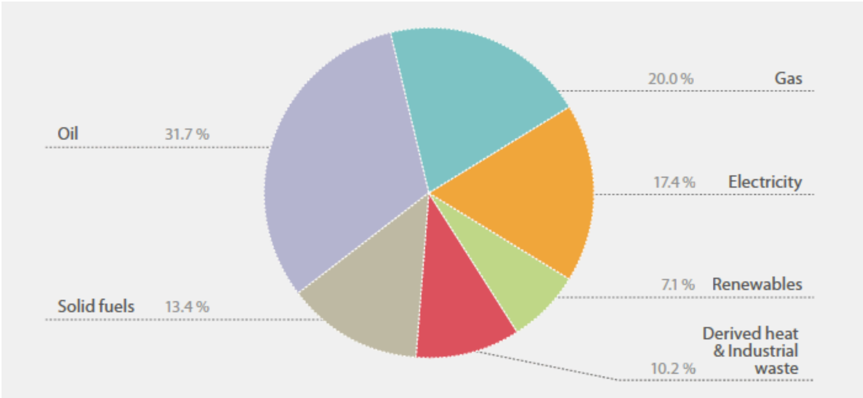

Fig. 3 Final energy consumption in European countries 2007(8).

It can be seen in fig.3 that *heating represents 70% of household energy consumption and about 14% of EU greenhouse gas emission. Reducing 1°C would cut down CO_2 emissions by 300kg a year for each household* (8).

2.2. Norway towards the Kyoto goal

Since 1990 the CO2 emission in Norway have risen from 50 to 54 million tons in 2008. This is mainly explained by the growth in oil and gas activity and in the volume of transport. It is expected there will further rise in total emissions unless much more substantial measures are taken (9).

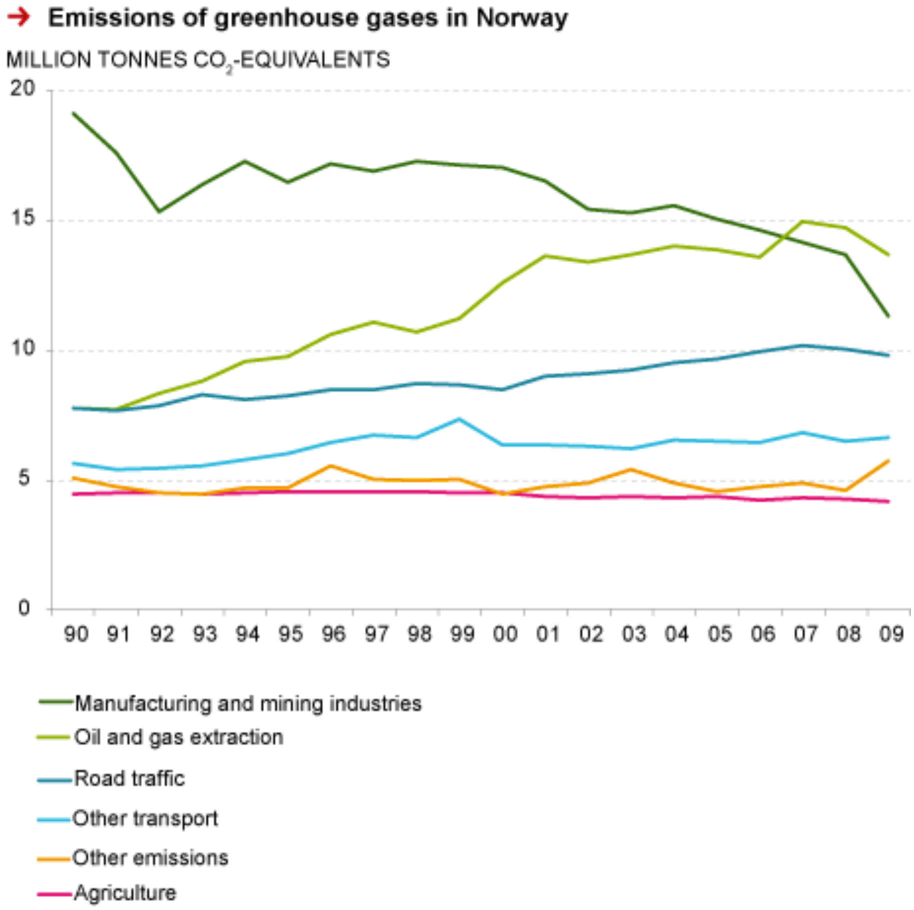

Fig. 4 Green house gas emissions in Norway (9).

Norway's emission target for 2008–2015

Norway's commitment under the Kyoto Protocol is to ensure that its greenhouse gas emissions in the period 2008–2015 are no more than one percent higher than in 1990. To do this, the average annual emissions in the period 2008–2015 must be reduced to 45.2 million tons, as compared with 49.7 million tons in 1990. The plan is to achieve this through a combination of measures in Norway, cooperation projects with other countries and the purchase of emission allowances abroad (9).

Norway's emission targets for 2020 and 2030

For 2020, Norway's target is to cut emissions by 30 percent. The plan is for approximately two-thirds of the cuts, or 15–17 million tons CO2 equivalents, to be made in Norway (9).

If an ambitious global climate agreement is achieved in which other developed countries also take on extensive obligations, Norway will undertake to achieve carbon neutrality by 2030 at the latest. This means that Norway would have to reduce emissions by the equivalent of 100% of its own emissions by 2030 (9).

2.3. Towards the Kyoto goal

The Net-ZEB definition, presented above, is a perfect philosophy for reaching this Kyoto goal. Net-ZEB and the Kyoto protocol are aiming towards the same goal of achieving a Carbon Neutral Environment.

A first approach in Norway has been the design of passive houses. These houses consume very little energy. The minimal energy consumption can be balanced by renewable energy like photovoltaic's and or wind turbine yields. This high energy-efficiency on site reduces the consumption of renewable energy and the requirements on transport and storage of energy in grids.

The most important factors allowing for this low energy consumption are high insulation standards as well as efficient ventilation heat recovery. Additional domestic factors are electricity-saving appliances; appropriate use behaviour and water saving tap fittings (10).

3. Net ZEB methodologies

A methodology has been developed for meeting the Net ZEB goals where carbon neutrality or zero emissions are the mean target of the result.

A study has been completed on Net ZEBs energy calculation methodologies proposed by organizations representing eight different countries: Austria, Canada, Denmark, Germany, Italy, Norway, Switzerland and the USA.

This study of the methodologies shows that the most accepted energy balance takes place between the energy use of a building and the renewable energy generation. In nine out of eleven proposals (American, 3 x Austrian, Canadian, Danish, 1x German, Norwegian and Switzerland) the energy balance includes both the energy related to the building (heating, cooling, ventilation, lighting, pumps and fans, other technical service systems) and the energy related to the users (DHW, cooking, appliances, lighting). The analysis of the methodologies indicates that primary energy is the most favoured metric for the balance, in ten out of eleven methodologies (11).

3.1. *Summary of energy supply options*

There are different boundary conditions for achieving Net-ZEB calculations. These are directly related to the location where the energy will be generated. They all have one common objective of providing a low energy building "Zero Emission Building".

Description of presented supply options (see Fig.5):

I. Generation on building footprint: The generation of usable forms of energy takes place within the building footprint by transforming renewable energy reaching the building without effort, i.e. no effort is needed to transport the renewable energy to the building footprint (sun, wind, etc.).

II. On-site generation from on-site renewable: Same as I. but with generation taking place on the building site (i.e. the ground owned by the building owner which is directly adjacent to the building footprint).

III. On-site generation from off-site renewable: Renewable are supplied from outside the building site but the generation of usable forms of energy takes place on the project site, i.e. energy carriers need to be transported

IV. Off-site generation: Investment from the building owner in renewable energy generation plants located outside the project site. The energy produced by the plant is included in the energy balance of the building.

V. Off-site supply: Purchase of green energy from the grid.

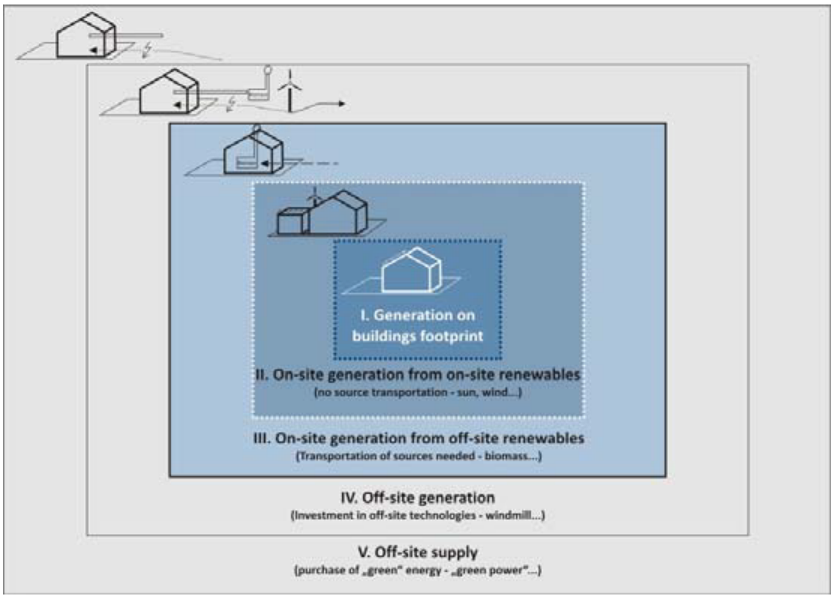

Fig. 5 Overview of current renewable energy supply options linked to common international practice for energy calculation methodologies for Net ZEBs (11).

Fig. 5. Presents the renewable supply options depicted by the different calculation proposals. The proposed opinions are divided, one claim that only the building footprint and site should be used, others accept the possibility of buying carbon credits in the carbon market in order to offset the energy use of a building. So far there is no clear statement on how the renewable energy supply should be implemented on the Net ZEB calculations (11).

4. Net ZEB calculation methodologies

4.1. Metric

In most countries, primary energy or the associated CO2 emissions are used as performance indicators. Emissions are calculated for energy. In Norway most building use electricity for heating and the electrical power generation is based on hydropower. Most people believe that it does not produce any green house gas emissions. However, this in not the case as a result of significant cross border trade of electricity between Norway and the Nordic countries, that produces CO2 emissions (13).

In practice, the tabulated factors according to the GEMIS, Global Emission Model for Integrated Systems, calculation models are generally used in the building sector to determine CO2 emissions and credits (14). A transition to building evaluation based on CO2 values would make climate change rather than limited resources the central topic.

4.2. Accounting

Conversion factors should be used when primary energy factors are used as indicators. Countries participating in the joint European grid are using averaged factors. These factors deviate from those for the national grid thereby lead to different balance results. For instance in Switzerland they not only use the calculated national energy factors but also politically determined weighting factors are used as a strategic steering instrument. Different factors for imported and exported energy are also possible. Temporally energy variable factors from "*smart grid*" are in development and could also be used. Temporally variable primary energy and emission factors are already applied in some American grids (3).

4.3. System boundaries for balancing

Most energy balancing methods only include service technologies and only occasional parts of the energy demand. The most appropriate systems for heating. Hot water and energy for pumps and fans are included.

For non-residential buildings ventilation, cooling and lighting are also included. The rest of the electrical appliances (house appliances, information technology, production machinery) and other installations (elevators, escalators, server rooms and cold storage houses) are almost always omitted. Photovoltaic systems on the generation site are generally omitted, as they are a part of electrical grid.

Use specific energy consumption

If the demands for use-specific electricity consumption, based on standards sets in SIA203 (Swiss Association of Engineers and Architects), are not represented in the balance, then two difficulties arise:

- Metered consumption is difficult to compare with buildings calculated consumption. The meters don't differentiate between types of energy consumption so normative balance is difficult to verify via measurements alone.
- In a complete balance, surplus via self-generated electricity would be smaller, because either demand or consumption would be higher (15).

Both aspects indicate that the balance boundary for Net Zero Energy Buildings should be expanded. The SIA standards in Switzerland and the Passive House

Planning Package (PHPP) have implemented this and orient planning on standard values (SIA) or project-specific planning data (PHPP) (16).

4.4. Balancing period

Net zero-energy buildings are defined in most cases by a balanced annual energy budget. The planning is based on meteorological data for a typical year at the location, often in the form of a Test Reference Year (TRY), not an extreme year. In practice, both types of year can occur, so that the energy budget may be balanced in one year but not in another.

The embodied energy should also be brought into account. This includes energy for the replacement and renovation measures that are required during the service lifetime, typically accounts for 20 to 30% of the total primary energy expenditure for an energy-efficient building with a lifetime of 80 years; this represents about 30 kWh/m2 a (17). The values vary significantly depending on the type of building construction (wooden or masonry construction) and further features (with/without an underground garage). First calculations indicate that these differences are greater than those caused by constructing a net zero-energy building. Due to their relatively high-energy demand for production, the dimensions of the photovoltaic systems on the building represent a critical factor. This is a further argument for ensuring that the energy demand is low, so that the energy budget can be balanced with the smallest possible photovoltaic system (7).

4.5. Load Match

If the local generator is grid-connected, decentrally generated electricity is used both a) to reduce the amount of external energy required, and b) to feed into the public grid. A load match index serves to describe the relative proportions and can be formulated as follows:

$$f_{load,i} = \min . \left[1, \frac{on - side\ electricity\ generation}{electricity\ consumption} \right] . 100\ (\%)$$

i = time interval (hour, day, moth)

The load match index calculated in this way is influenced by the consumption profile and thus by the building usage, the generation profile and the time interval for evaluation. Introduction of a load match index leads to classification of the electricity generated on site. This approach allows distinction between those net zero-energy buildings that largely achieve the zero balance by internally consuming the electricity generated on-site and those that essentially use the seasonal storage function of the grids. The calculated load match index raises problems due to the user-specific electricity consumption that is not taken into account. It should also be noted that also monthly values are only virtual load match indices, as a balance based on instantaneous values results in significantly lower values (19).

5. Net ZEB case studies

5.1. Selection of case studies

The projects were chosen by "Net Zero Energy Buildings, 2011" by Karsten Voss and Eike Musall(7). The projects were presented with a lot of energy data. This data will be presented in a spreadsheet that gives a good overview of the energy results according to the Net ZEB methodology. The projects are divided into;

- Small residential buildings
- Large residential buildings
- House developments
- Office buildings
- Production and administration

Case studies were chosen as a method because they show realistic values according to Net ZEB. The projects are chosen for their low energy purpose and their goal of reaching an energy balance according to the Net ZEB methodology. These are also the most common buildings on the construction market so they will represent an accurate view of the existing Net ZEB projects in several countries. These case studies will give a good understanding of the Net ZEB philosophy and address the question if buildings can reach an energy balance.

Analyzing these results will prove if Net ZEB is a feasible way of reaching the Kyoto goals in the future.

5.2. Overview of case studies

	Project name	Country	Location	Date completed	Energy supply features	Energy surplus kWh/m^2a
SMALL RESIDENTIAL BUILDINGS	Residential House	Switzerland	Riehen	2007	vent. with HR solar thermal collectors, HP, PV	28
	Eco Terra Home	Canada	Eastman	2007	Solar elec. With combined air coll., vent.with HR, gr.HP, TMA	-52
	Light House	Great Britain	Watford	2008	PH comp, vent.with HR, PV, solar thermal, biomass boiler	26
	Home for Life	Denmark	Lystrup	2009	PH comp. vent.with HR, contr. Window vent. PV, solar thermal	-9
LARGE RESIDENTIAL BUILDINGS	Kraftwerk	Switzerland	Bennau	2009	PH, vent.with HR, exp. HP, PV, HR from WW, wood burn. Stove	24
	Renovation Blaue Heimat	Germany	Heidelberg	2005	electricity grid, gas grid electricity local heat.grid	-98
	Kleehäuser	Germany	Freiburg	2006	electricity grid gas grid,nat. gas electricity	-4
	Multi dwelling	Switzerland	Dübendorf	2008	MINI-P-ECO concept, vent.HR, A-W HP, solar thermal coll.	-30
HOUSE DEVELOPMENTS	Solar community	Germany	Freiburg	2006	PH, vent.HR, daylight optimization, distr.heat.(wood chip fuel), PV	72
	Energy plus community	Austria	Weiz	2008	PH, PV, AAHE vent.HR, fresh air intake via earth HE,	3
	BEDZED Community	Great Britain	London	2002	PH concept, wind press.vent.with HR, GHP, PV, small district grid	12
OFFICE BUILDINGS	Corporated Heat Quarters	Austria	Kempttal	2008	vent.with HR, Geothermal HP, PV,	-16
	WWF Headquarters	Netherlands	Zeist	2008	vent.with use of wate water, CHP with Biomass, PV, Solar Thermal energy	79
	Office building with appartment	Austria	Villach	2002	PH concept, fac.coll., vent.with HR and earth HE, loc.heat.network, PV	619
	Pixel Building	Australia	Melbourn	2010	vent.with HR, CHP powered Biomass, loc. Heat.network, biogas plant, PV,	101
PROD. AND ADM.	Company Headquarters	Germany	Berlin	2008	vent.HR,TMA, gas abs.HP, PV, micro windturbine,	2
	Zero emission factory	Germany	Braunsweig	2002	PH comp., vent.with HR, vac.insul., CHP with biomass, loc.heat., PV, sol.thermal, pass. Cooling	-51

Fig. 6 Shows a summary from the spreadsheet that is attached to this file.

5.3. Graphical simulation from the results

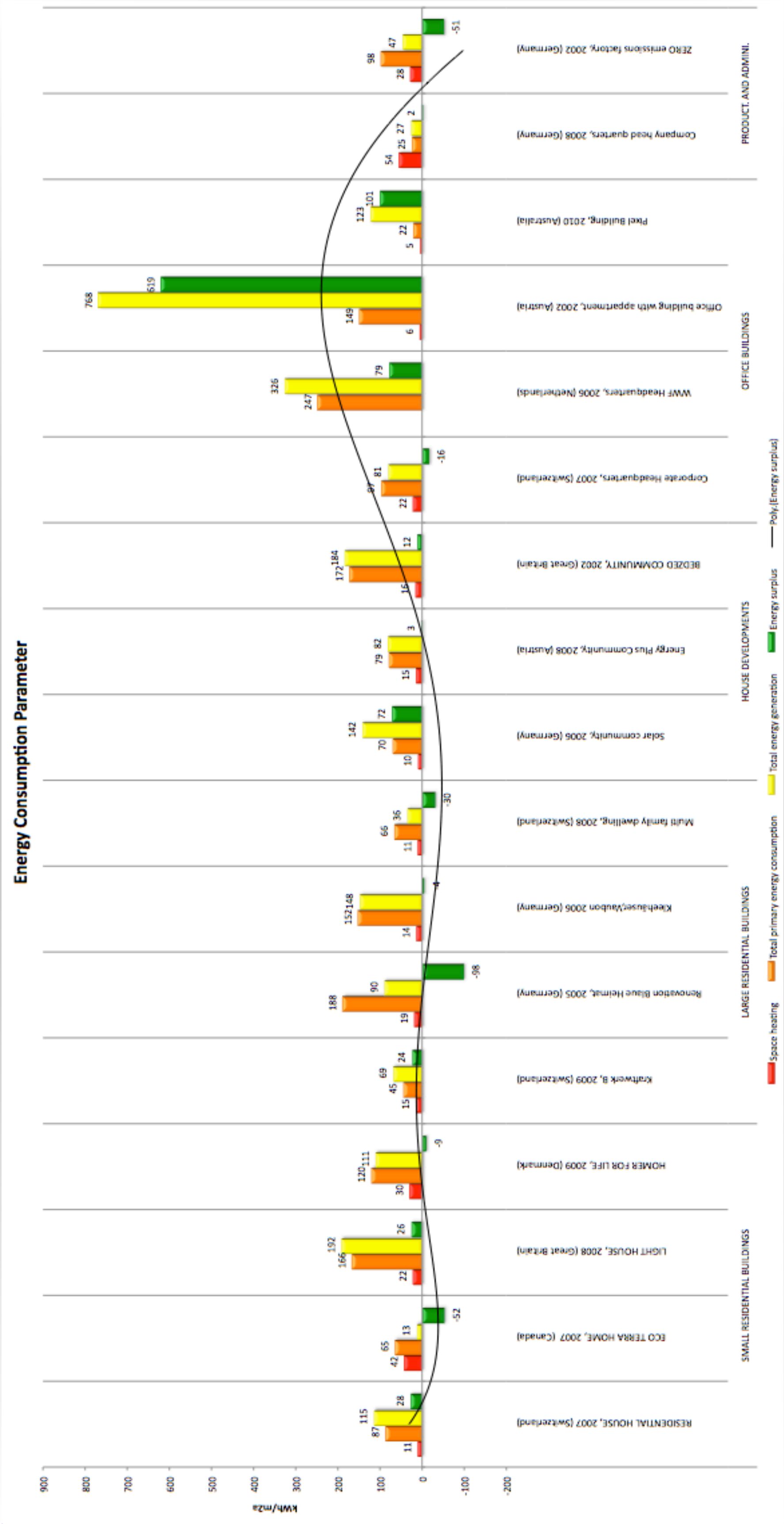

Fig.7 Shows a graph of the energy consumption parameters. It also presents a good insight on which projects reach a plus or minus balance.

5.4. Summary of case studies

See attachment: Net ZEB spreadsheet

After analyzing the results we can assume that the following average results are good performance values to use for reaching a Net ZEB balance. By considering the results below, the chance for achieving a good balance is higher.

Summary results	Small Residentials	Large Residentials	Role Model Kraftwerk B, 2009 (Switzerland)	House Develop.	Office buildings
BUILDING ENVELOPE PARAMETERS (W/m^2K)					
U- value, exterior walls	0.12	0.14	0.11	0.11	0.27
U- value, windows (incl. frame)	0.95	0.96	57-0.79	0.93	1.19
U- value, roof area	0.11	0.11	0.11	0.11	0.15
U- value, basement floor	0.39	0.16	0.18	0.49	0.14
Mean U- value envelope	0.27	0.23	0.20	0.19	0.44
BUILDING EQUIPEMENT PARAMETERS					
Solar collector area per m^2 (m^2/m^2)	0.09	0.15	0.11	2.00	0.13
Storage per m^2	2.67	25.00	19.6	0.31	3.66
PV area per m^2 (m^2/m^2)	0.36	0.11	0.2	0.31	0.16
PV Capacity per m^2 (W_p/m^2)	36.53	13.76	23	70.07	16.80
CHP Capacity per (W_{th}/m^2)		17.80			13.40
(W_{el}/m^2)		10.18			7.50
CONSUMPTION PARAMETER 2009 (kWh/m^2a)					
Space heating	18.92	14.75	15	13.67	11.00
Water heating	18.50	14.00	14	19.67	3.67
Site energy, heating (incl. hot water)	21.33	43.25	11	32.67	8.00
Electricity	43.25	25.75	18	38.67	48.00
Total primary energy consumption	109.50	112.75	45	107.00	128.75
Total energy generation	107.75	85.75	69	136.00	324.50
Energy surplus	-1.75	-27.00	24	29.00	195.75

DESIGN STRATEGIES, CONCEPTUAL FOCUS
Passive house concept, MINERGIE-P-ECO, mechanical ventilation with heat recovery, expelled air heat pump, PV system, heat recorery from waste water, energy display for tenants, wood-burning small storage stoves, feed-in of heat

Fig.8 Shows the average results from 17 case studies in several countries. It also shows how Kraftwerk B in Bennau, Switzerland, 2009 can be used as a role model building. It has already received the Swiss and European Solar Prize, and in 2010 it won the first Norman Foster Award.

5.5. Analysis of the energy and concepts of the case studies

This is an evaluation of 17 case studies covering many different building types in several countries which all aim to achieve a net-zero energy balance. Most of the projects achieve the targets set. A comparison of the use of primary energy for energy consumption and the primary energy credit for locally generated energy clearly shows that efficiency is a basic prerequisite for reaching this goal. Usually the lower the consumption of these projects the more likely that these projects achieve a zero or plus energy balance. This is also highly dependent on the amount of solar collector, storage, wind power and PV capacity per square meter (20).

ENERGY BALANCE

Regarding the housing sector, the following statement can be made for achieving an energy balance. The target for residential buildings in central Europe is set by an average primary energy consumption of 73kWh/m^{2}a (21). A number of case studies that planned to achieve the goal of net zero energy buildings did not achieve their goal. This was mainly due to the small increases of energy consumption. These increases were related to the number of staff, the volume of production or the size of a family. Colder winters or lower amounts of solar radiation and technical problems with systems were also responsible for the small increases of energy consumption. The users remain the decisive dimension. Their behaviour cannot be determined in simulations or calculations (21).

MONTHLY COVERAGE RATE

Large proportions of the monthly energy consumption are covered by renewable energy yields on site. Therefore the electricity grid is not completely utilised as seasonal storage. In residential buildings this proportion amounts to between 82%(housing development buildings) and 60% (small residential houses). With non-residential buildings the monthly chargeable yields are also above 60% of the consumption parameters (22).

The buildings that use biomass are particularly high as, due to the low primary energy factors, the amount used for the provision of space heating is reduced and even lower solar electricity yields can offset a greater proportion of consumption. Buildings with a high amount of solar electricity plants or combined heat and power plants also achieve high coverage rates (22). The result in the spreadsheet (see attachment) underlines this statement.

PATHS TO AN EQUALISED ENERGY BALANCE

MINERGIE or passive house concepts are regarded as the basic means for reducing heating demands. Solar thermal energy plants are covering the heating of hot water in residential and support heating systems. An efficient sun shade system reduces the danger of overheating on the south facing windows that are used for the exploitation of passive solar heat. They also provide the supply of daylight and thereby reduce the energy for lighting. Passive cooling, like natural cross ventilation, removes the need for air-conditioning or other cooling systems. Utilisation of energy-saving equipment and appliances also reduces the use-specific consumption energy.

Photovoltaic plants are required to cover energy consumption. This of course is related to the location. In Norway for example photovoltaic plants are not covering the whole electricity supply that is needed. Here an alternative energy supply system, a combined heat and power plant powered by biomass or wind turbine, is required for covering the electricity demand. This is due to lack of solar radiation during the winter (see Fig.2). Wind turbines are also a good alternative and they are not dependent on the time of the day. The first wind power turbines integrated in buildings reveal that they cannot completely offset the energy demands of buildings. Due to the increased use of heat pumps, electricity is the main energy source for net zero energy buildings.
Biomass, e.g. wood pellets, wood chips or rapeseed oil are replacing the fossil fuels. District or local heating grids are being used increasingly in housing projects(23).

5.6. Discussion

Analysing the Net ZEB graph and spreadsheet gives a significant insight on the case studies done in several countries. These results show that it is not so obvious to achieve a Net ZEB balance however it definitely is possible. The results show also that it is easier for a community to reach the Net ZEB balance. The *Solar Community in Freiburg* is a good example and can serve as a role model Net ZEB community.
It can be stated that the achievement of a Net ZEB balance is highly dependent on the amount of renewable energy input and not only from an energy efficient building, like a passive house or MINERGIE-P* standards. The combination of these two factors will have a high influence on achieving this balance. The latitude of the project location is also a factor that cannot be neglected as it highly influences the solar irradiation and thereby has a high influence on the capacity of the photovoltaic cells (see Fig2). By achieving the goal of a Net ZEB balance we also assume that this is the correct approach for buildings in the future and for reaching the Kyoto protocol goals.

*MINERGIE-P; This is a standard used in Switzerland similar to the Passive House standard.

6. Conclusion

This paper answers on the fundamental questions of Net ZEB presented in the introduction. What is Net ZEB? Is there a relation between Net ZEB and the Kyoto protocol? What is the methodology of Net ZEB? How is Net ZEB calculated? Are the Net ZEB results really in balance or is it not possible to reach that goal?

This review of several case studies concludes that achieving a Net-ZEB project is not so obvious however it is possible. Having a surplus result is highly recommended, this for taking into account changes in the future such as future climate changes (less solar gains, colder climate, less/more wind…) expansion of population (expanding the number of employees in an office or the expansion of a family…) and thereby an increase in the consumption of electricity for IT (Information Technology) and lighting. An increase in user awareness and the appropriate management of the IT equipment together with a surplus energy can help to counteract this phenomenon. The amount of surplus is highly dependent on the amount of renewable energy sources.

As a final statement we can conclude that buildings making use of energy supply systems such as; solar thermal systems, photovoltaic's, wind turbines and a heat pump systems that use biomass as an energy source, have a higher potential for reaching a Net ZEB balance. For PV, this depends on the capacity per square meter. Also Net ZEB buildings must be built according to the passive house or MINERGIE-P standards. *Net Zero Energy Buildings are primarily energy efficient buildings with a consistent energy efficient strategy.*

The Net ZEB philosophy together with other measures must be implemented in order to avoid the effects of global warming where the entire planet can heat up with 3°C. There is a general consensus among many scientists that such a degree of global warming would have detrimental effects on our environment. *Norway together with the Maldives and Costa Rica are aiming to become carbon neutral before 2030.* This was stated at the Convention on Climate Change in Durban, South Africa in 2011 (2). This means there is a future for Net ZEB in Norway for reaching this goal!!!

Future research will concentrate on the details regarding CO_2 as its reduction is the aim of Net ZEB, to achieve a global Carbon Neutral environment.

References

(1) International Energy Agency (IEA), Energy Technologies Perspectives: Scenarios and Strategies to 2050, OECD/IEA, 2008, Paris.
(2) Climate convention, Durban, South-Afrika Dec.2011, http://unfccc.int/meetings/durban_nov_2011
(3) From low-energy to Net ZEBs; Status and perspective, Karsten Voss, Eike Musall and Markus Lichtmeb, (2010)
(4) Goal: Zero Nenergy Building Exemplary Exp
(5) Criteria for Definition of Net Zero Energy Buildings Igor Sartori, Assunta Napolitano, Anna J. Marszal, Shanti Pless, Paul Torcellini and Karsten Voss
(6) Global horizontal solar irradiation, www.solargis.info
(7) European Carbon atlas (2007)
(8) Detail Green Books, Ambitious policy goals, p12 Net Zero Emissions Buildings by Karsten Voss and Eike Musall (2011)
(9) Europe's energy position markets and supply,p.11 (2007)
(10) Norway environment emission data, http://www.environment.no/Maps-and-data/Norway/
(11) erience Based on the Solar Estate Solarsiedlung Freiburg am Schlierberg, Germany (2009) Mira Heinze and Prof. Karsten Voss
(12) Net Zero Energy Buildings - Calculation Methodologies versus National Building CodesAnna Joanna Marszal, Julien S. Bourrelle, Eike Musall, Per Heiselberg, Arild Gustavsen and Karsten Voss (2010)
(13) The Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, Official Journal of the European Union, 53 (2010)
(14) Sintef, Dokka et al, (2011)
(15) Institut Wohnen und Umwelt, download unter: http://www.iwu.de/fileadmin/user_upload/dateien/energie/werkzeuge/kea.pdf.
(16) Detail Green Books, Net Zero Emissions Buildings, p.37 by Karsten Voss and Eike Musall (2011)Load-Match as Criterion of differentiation
(17) Detail Green Books, Net Zero Emissions Buildings, p.33-34 by Karsten Voss and Eike Musall (2011)
(18) Kugel, D.: Lebenszyklusbetrachtungen als ökonomisches und ökologisches Einsparpotential in der Gebäudeplanung und Bewirtschaftung, Master Thesis, Universität Wuppertal, Bauphysik und technische Gebäudeausrüstung, (2007).
(19) Voss, K. et. al.: Load Matching and Grid Interaction of Net Zero Energy Buildings, Proceedings of EuroSun 2010, Graz, Austria.
(20) Load Matching and Grid Interaction of Net Zero Energy Buildings Karsten Voss, Igor Sartori, Assunta Napolitano, Sonja Geier, Helder Gonzalves, Monika Hall, Per Heiselberg, Joakim Widén,, Eike Musall, Björn Karlsson, Paul Torcellini (2009)
(21) Detail Green Books, Net Zero Emissions Buildings, comparison of energy evaluations and concepts p.118 by Karsten Voss and Eike Musall (2011)
(22) Detail Green Books, Net Zero Emissions Buildings, energy balance, p.118 by Karsten Voss and Eike Musall (2011)
(23) Detail Green Books, Net Zero Emissions Buildings, monthly coverage rate, p.118 by Karsten Voss and Eike Musall (2011)
(24) Detail Green Books, Net Zero Emissions Buildings, paths to an equalized energy balance, p.118 by Karsten Voss and Eike Musall (2011)