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Selected examples of Nearly Zero-Energy Buildings

Detailed Report

September 2014

CONCERTED ACTION
ENERGY PERFORMANCE
OF BUILDINGS

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Detailed report

Authors & Editors:

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1 Introduction

Pilot projects of energy-efficient buildings are important in order to accelerate the progress towards achieving nearly zero-energy buildings (NZEBs), as such projects provide relevant examples and practical experience. People want to learn that these types of buildings – or even buildings with higher levels of energy efficiency – are already possible, what the buildings look like, and what are the cost implications, the technologies used, user experiences, etc. In these pilot projects, innovative industry organisations can present their products, while advanced designers can showcase their capabilities.

This report contains a collection of examples of buildings that have an energy performance level in the range of NZEB (or approaching NZEB level) in the different EU Member States (MSs). Since several MSs have not yet set up their detailed national application of the NZEB definition, they were asked to provide selected examples that would most probably fulfil the envisaged NZEB requirements or surpass them. The examples have been selected and provided by the EPBD Concerted Action (EPBD CA) national delegates.

The cross analysis of the 32 selected examples of realised NZEBs in Europe can provide a first set of answers to the following questions:

- What kinds of NZEBs or NZEB-like buildings are already available in the different countries?
- Is there a focus on residential buildings, i.e., are non-residential buildings receiving adequate attention?
- How much more energy efficient are these buildings compared to the current national energy performance requirements?
- What kind of renewable energy sources (RES) are included in the concepts?
- Are there marketing concepts for the buildings, i.e., are these 'singular' case-studies or can they be replicated or somehow marketed?

2 Cross analysis of the selected examples

Until the beginning of June 2014 32 practical examples of NZEBs or buildings that will most probably represent at least the energy efficiency level of the future national application of the NZEB definition have been submitted by CA representatives of 20 countries. Figure 1 presents a map of all countries with selected examples included in this report.

Figure 1: European map showing the countries where examples of NZEBs have been provided.

Notes:
1) The template for describing the selected examples included sections for detailed characteristics (e.g. U-values for the building envelope components, energy data) and other parts that asked for descriptive information (e.g. building service systems or building component constructions). However, for some buildings, not all information is fully available. Therefore, not all stated numbers add up to the total number of buildings (33).
2) The 'lessons learned' are also provided by the authors of each case study. The numbers given in the cross evaluation are therefore minimum numbers of the same 'lessons learned'. It can be assumed, for example, that a high owner satisfaction has occurred in more than the cases that have explicitly mentioned it as one of the main lessons learned. Figures are meant only as trends and should thus be strictly interpreted in such restricted point of view.

2.1 Aim of the projects

The following goals have been stated as aims of the projects (only aims that were indicated at least twice are listed):

- Twelve projects wanted to perform an NZEB test in practice.
- Ten projects wanted to show significant reductions compared to current national requirements.
- Nine projects have been designed as plus-energy buildings.
- Six projects wanted to fulfil the 'Passive House' standard requirements.
- Three projects aimed to achieve maximum renewable energy integration.

Several projects indicated more than one of the above aims.

2.2 Building types

The construction phase of 28 of the 32 building concepts (88%) has already been completed. The other 4 concepts are expected to become a reality soon. The focus of this collection was clearly on already existing buildings, but it was decided to include the additional 4 cases as well. This was done in order to present information from countries which do not yet have completed examples, but have concrete concepts being implemented.

Two-thirds of the buildings (21) are residential buildings and 11 are non-residential buildings, of which 3 are public buildings. Twenty-five (78%) of the examples are new buildings, while 7 (22%) are buildings that have been renovated to the NZEB level.

Building sizes range from 98 m^2 up to 21,000 m^2, with an average of 2,359 m^2. The building areas have been calculated using different conventions, according to national practices: net floor area (20 buildings), gross floor area (5 buildings), living area (5 buildings) and useful area (2 buildings). The calculation of the reference areas is not consistent across MSs. The total of all 'floor area' types is 75,479 m^2.

2.3 Building envelope

The characterisation of the building envelopes includes a description of the construction and the achieved U-values per component.

In terms of wall construction technology, 10 buildings have a brick construction type, another 11 buildings have concrete walls and 7 buildings have a wooden construction type. A few buildings have more than one wall construction type.

The windows of 8 buildings have double glazing, with 6 of them being low-e-coated and the other 2 uncoated. 20 buildings have low-e-coated triple-glazed windows. The examples with double glazing are mostly located in Southern Europe. For 4 buildings, no window descriptions have been given and the U-values do not allow for a clear allocation.

Sixty-four per cent of the roofs are made of a concrete construction type and 36% use wood.

Ninety-three per cent of the cellar ceilings or ground slabs are insulated.

The U-values are very low in almost all buildings, as shown in Table 1. The lowest or the highest values do not all come from the same building.

Table 1: Range of U-values realised for the building components (wall, window, roof, ground and door) in the collected NZEB examples.

Building component	U-value [W/m².K]		
	Average	Lowest	Highest
Wall	0.29	0.065	1.97
Window	1.16	0.7	4.5
Roof	0.14	0.06	0.55
Ground	0.29	0.07	1.97
Door	0.98	0.68	2.19

In one building located in the Mediterranean region, it was emphasised that in such a climate only the roof has to be insulated. However, many examples from Southern Europe included considerable insulation in all building envelope components and use windows with high-performance glazing. The lowest U-values have naturally been used in buildings in Central or Northern Europe.

2.4 Building service systems

Thirteen of the 32 NZEB examples (41%) are heated by heat pumps, 7 buildings by gas boilers, 7 buildings by a district heating (one of them only as a back-up system) and 4 buildings by biomass boilers. One building is heated by a biomass combined heat and power (CHP) unit and the last case by a split air-conditioning unit.

Sixty-eight per cent of the buildings are not cooled. Thirty-two per cent that are mostly from Southern Europe and/or non-residential buildings include a cooling system. Many of these include activated building components in the cooling strategy. Activated building components are ceilings, floors or walls that include pipes filled with water or ducts with air for a thermal pre-conditioning of the rooms.

Hot water is generated in combination with the space heating system in 27 buildings. Four buildings use decentralised electrical hot water generation. Seventeen buildings (55%) include solar thermal panels for hot water generation.

About 77% of the buildings (24) use a mechanical ventilation system with heat recovery (MVHR), 3 use a mechanical ventilation system with heat recovery and heat pump, and an additional 2 buildings a mechanical ventilation system without heat recovery. Three buildings rely on natural ventilation (solely window opening) as the ventilation system.

In at least 4 of the 11 non-residential buildings, electrical lighting includes presence detectors and 3 buildings have daylight-dependent controls. Several buildings feature energy-efficient lamps, including LED.

2.5 Renewable energy systems

Photovoltaic (PV) panels are integrated in 69% of the NZEB examples (22 of 32 buildings). Solar thermal panels are part of the energy concept of more than half of the projects (53%, 17 buildings). Thirty-one per cent (10 buildings) are heated by ground source heat pumps. Another 6 buildings (18%) use an air-to-air heat pump, with 3 of the air-to-air pumps as part of the ventilation system feeding into the domestic hot water (DHW) storage.

District heating, including mostly high shares of renewable energy, is used in 7 buildings (22% of the projects). Direct biomass heating is used in 6 projects (19%). One building uses CHP that, in some countries, is considered (equivalent to) renewable energy because of the low primary energy factor of the heating system due to the benefit of producing electricity that is replacing grid electricity with a high primary energy factor.

2.6 Energy values

Measured energy values are available for 8 of the 32 buildings. For the other 25 projects, only calculated values are available, mostly with the national energy performance calculation method. Some of the given energy data were calculated with simulation tools that do not coincide with the national energy performance calculation method.

A positive primary energy balance was achieved by 9 buildings on an annual basis for the energy uses covered in the national EPC. Seven of these 9 buildings also have a positive primary energy balance for all energy uses (e.g., also covering equipment energy such as household energy, etc.).

The average renewable energy ratio related to the total final energy use of the 33 building examples is 70%. The renewable share ranges from 17% up to 216%.

The improvement compared to the current national requirements is between 21% and 202%, with an average of 74%.

2.7 Experiences

For 31% of the projects (10 buildings), the owner satisfaction was so high that it was explicitly mentioned as one of the main lessons learned. No projects were reported as having unsatisfied or disappointed users. In 8 buildings, it was reported explicitly that the monitored energy use met the predictions based on the calculations. Only 1 building was reported to have higher measured consumptions than predicted during the design phase. In some reports, the issue of consumption versus prediction was not covered, and not all buildings have measured results yet.

Feedback from the performance of the building service systems is available for 1/3 of the projects (10 buildings). The lessons learned from 6 buildings include advices on how to further increase the energy efficiency or comfort in the building by improving the building service systems or their management and control.

In 4 projects (13%), experiences with building material were reported. Most of them are positive. In 3 projects, experiences concerning shading material were reported. In 1 project, workforce problems were indicated, and with another project, the building service systems are too complicated for the users.

In one case, a limited financial project budget led to conceptual changes. On the other hand, in 2 projects it was reported as lessons learned that NZEBs can be built at an affordable price. In no project was it claimed that the additional costs were too high. Yet, some of the included buildings have aspired and realised energy levels that are more demanding than NZEBs. As all lessons learned are not based on predefined answers but on a free format, the experiences summarised here may have been shared by more than the number of projects given above. They may not have been considered as main lessons learned by the authors and have therefore not been reported.

2.8 Costs

Total project costs are available for 17 buildings (53% of the selected examples). Twelve project summaries include the additional costs of the project compared to a regular building fulfilling the current national energy performance requirements. The total costs are hard to compare and an average number of total costs per m² does not make much sense, as the cost data for each building is not consistent and includes different cost items. Construction costs also vary from country to country and thus cannot be directly compared.

Table 2: Additional costs for the NZEB standard compared to the current national minimum energy performance requirements.

	Additional costs of the selected examples of NZEBs compared to the energy level according to the current national requirements		
	Average	Lowest	Highest
% of total costs	11	0	25
€/m²	208	0	473

The additional construction and technology costs for NZEBs compared to buildings fulfilling the current energy performance requirements are between 0% (0 €/m²) and 25% (473 €/m²) with an average of 11% (210 €/m²). These values can only be used as a notional indication of additional costs for NZEBs. The ratios of additional costs are derived from 9 examples, and the €/m² additional costs are derived from 9 partly differing examples. Six buildings indicate both types of cost.

The examples are quite mixed and include residential as well as non-residential buildings, small and large buildings, etc. Moreover, differences between the national energy performance requirements compared to NZEB requirements also vary from country to country, thus making this comparison even more difficult. Some selected examples are much better in terms of energy performance than the foreseen national NZEB level.

In one of the selected examples, it was stated that the improved energy performance label was possible without additional costs. In a few other projects, it was indicated that reduced additional costs will be possible when multiplying the realisation of the concept. With 11% additional costs compared to the national minimum energy performance requirements, it can be said that NZEBs can be built at an affordable price (see also chapter 2.7).

2.9 Funding

Sixty-six per cent of the projects (21 of the 32 buildings) received special funding for part of the planning, construction or monitoring costs. The funding source was mostly national.

2.10 Marketing efforts and awards

In 18 of the 32 selected examples, the building projects included marketing or dissemination efforts, such as NZEBs or green certificates, posters, newspaper articles, press releases, internet or intranet communication, lectures, presentations at conferences, TV broadcasts, blogs, etc. Some of the buildings are part of a housing exhibition area or a network of similar buildings. Official opening events took place and guided tours are available in several cases.

In total, the 32 buildings received 34 architectural or energy efficiency awards, with some buildings earning more than one prize.

2.11 Links to further information

The data from the buildings was supplied by the national representatives in the EPBD CA and edited by the authors of this report for consistency of presentation. For 28 of the selected examples, links to further information are available (please see details in each building report).

For the calculation methods indicated in the building descriptions, please consult the national pages at the CA website or official documents setting national regulations.

3 Summary and conclusions

The catalogue of practical examples of NZEBs - or for countries without an officially available national application of the NZEB definition NZEB-like buildings – shows that there are pilot projects or demonstration projects of this future-oriented standard in most (at least 20) MSs. They cover very different building types, but with a clear focus on single-family houses. On the other hand, several multi-family houses, but also office buildings, a bank building, schools and a library, are included. It can be assumed that several countries started with NZEB applications in the residential sector and will continue with demonstration buildings in the non-residential sector in the next years. A few of the NZEB projects are even renovated buildings.

The buildings in the catalogue are in average 74% more energy efficient than buildings designed according to the national requirements. Some of the buildings are very advanced and result in an annually positive energy balance.

The included renewable energy sources are manifold. Photovoltaic systems and solar thermal panels are in more than half of the buildings in use. Many buildings use geothermal energy through ground coupled heat pumps. Other renewable energy sources used by the buildings are biomass and district heating with a high renewable energy ratio.

The high number of building awards received and the specified means to disseminate and in some cases even 'market' the projects show that the intention of the investors and planners is to demonstrate to the public and especially to other builders that the NZEB concept is already a reality and can be achieved with available technologies at acceptable additional costs.

Table 3. Summary table of the selected examples

Building number	Country	Type of Building				Final energy consumption								Improvement compared to national requirements [%]	RES contri-bution ratio [%]	Available energy data		Costs	
							including												
		Residential	Non-residential	New	Renovation	[kWh/ m^2. year]	Heating	Hot water	Cooling	Ventilation	Lighting	Electrical appliances	RES gen. electr.			Calculated	Measured	Total costs	Additional costs compared to conventional building
1.1	Austria	X		X		39.7	X	X		(X)[1]	(X)[1]	X		42	48	X		1,875 €/m^2	not available
1.2	Austria	X		X		45.8	X	X		(X)[2]				43	52	X		2,714 €/m^2	not available
2.1	Belgium-FL	X		X		15.5	X	X		X	(X)[1,3]	(X)[3]	X	78	59	X		not available	99 €/m^2 (8%)
2.2	Belgium-FL		X	X		116.4	X	(X)[1]	(X)[2]	(X)[2]	X	X[4]	(X)[3]	99	77	(X)	X	5,328 €/m^2	not available
3.1	Bulgaria		X		X	16.0	X	X	X	X	X	(X)[3]		78	63	X		130 €/m^2	130 €/m^2
4.1	Croatia	X		X		65.6	X	X	X	X	X	(X)[3]		78	22	X		912 €/m^2	0 €/m^2
5.1	Denmark	X			X	24.5	X	X		X			(X)[3]	70	16 (+ DH)	X		not available	not available
6.1	Estonia		X	X		86.3	X	X	X	X	X	X	(X)[3]	60	23	X		not available	5-10
7.1	Finland	X		X		44.0	X	X		X		[5]	[6]	50	100[6]	X		not available	400 €/m^2 (15%)
7.2	Finland	X		X		40.4	X	X	X	X	X	X[7]	[6]	66	100[6]	X		not available	not available
8.1	France	X		X		32.8	X	X		X	X			21	21	X		not available	not available
8.2	France	X		X		41.6	X	X		X	X		(X)[3]	202	100	X		not available	not available
9.1	Germany	X		X		-4.5	X	X		X[8]	X	X[9]	X	78	107	(X)	X	not available	362 €/m^2
9.2	Germany		X		X	68.5	X	X		X	X		[10]	44	43 (+ PV)	X	(X)	1,568 €/m^2	not available
10.1	Ireland	X			X	31.4	X	X		X	X			56	30	X		1,063 €/m^2	not available
10.2	Ireland		X	X		52.5	X	X		X	X		(X)[6]	50	40	X	(X)	1,132 €/m^2	54 €/m^2
11.1	Italy	X		X		42.7	X	X		[11]	X		(X)[3]	80	67	(X)	X	1,892 €/m^2	378 €/m^2 (25%)
11.2	Italy	X		X		35.3	X	X	X	[11]			[10]	unknown	unknown	X	(X)	1,465 €/m^2	not available

[1]: included in electrical appliances [2]: included in heating [3]: given, but not part of total final energy [4]: electricity for cash dispensers also given
[5]: auxiliary and outdoor electricity given [6]: RES not given but incl. in seasonal balance of RES contribution [7]: including outdoor lighting and car heating
[8]: including pumps and automation [9]: additionally given: electricity for e-mobility [10]: PV contribution unknown [11]: ventilation system in use but not measured
[12]: no final energy data available, but primary energy data given

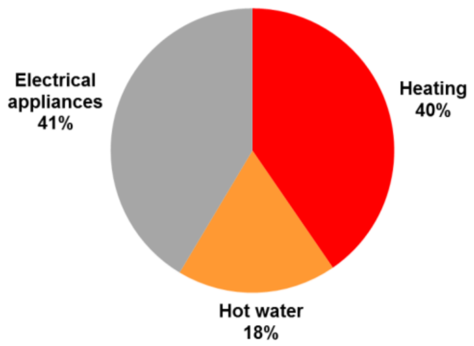
Building number	Country	Type of Building				Final energy consumption								Improvement compared to national requirements	RES contri-bution ratio	Available energy data		Costs	
							including												
		Residential	Non-residential	New	Renovation	[kWh/ m^2. year]	Heating	Hot water	Cooling	Ventilation	Lighting	Electrical appliances	RES gen. electr.	[%]	[%]	Calculated	Measured	Total costs	Additional costs compared to conventional building
12.1	Lithuania	X		X		n.a.[12]	X	X		X	X			82	60	X		not available	not available
12.2	Lithuania	X		X		n.a.[12]	X	X		X	X		X	81	51	X		not available	not available
13.1	Luxembourg	X		X		10.2	X	X		X			(X)[3]	80	140	X		not available	14%
13.2	Luxembourg		X	X		75.6	X	X	X	X	X		(X)[3]	62	84	X		2,813 €/m^2	not available
14.1	Malta	X			X	11.4	X	X	X		X			50	49	X		not available	not available
15.1	Netherlands	X		X		n.a.[12]	X	X		X	X		X	148	216	X		not available	not available
15.2	Netherlands	X		X		n.a.[12]	X	X	X	X	X		X	106	143	X		not available	not available
16.1	Norway		X		X	19.4	X	X	X	X	X		(X)[6]	80	100	X		2,665 €/m^2	not available
16.2	Norway		X	X		49.0	X	X	X	X	X	X		60	24	X		2,019 €/m^2	72 €/m^2 (4%)
17.1	Poland	X		X		90.9	X	X		(X)[2]				78	27	X		not available	not available
18.1	Portugal		X	X		5.0	X	(X)[2]		(X)[1]	(X)[1]	X	X	90	88	(X)	X	800 €/m^2	not available
19.1	Sweden		X	X		42.1	X	X	X	X	(X)[1]	X	X	80	90	(X)	X	2,450 €/m^2	300 €/m^2 (12%)
19.2	Sweden	X		X		55.7	X	X		X				51	100	(X)	X	not available	10%
20.1	UK		X		X	108.0	X	X	X	X[8]	X	X	(X)[3]	31	17	X		4,845 €/m^2	not available

[1]: included in electrical appliances [2]: included in heating [3]: given, but not part of total final energy [4]: electricity for cash dispensers also given
[5]: auxiliary and outdoor electricity given [6]: RES not given but incl. in seasonal balance of RES contribution [7]: including outdoor lighting and car heating
[8]: including pumps and automation [9]: additionally given: electricity for e-mobility [10]: PV contribution unknown [11]: ventilation system in use but not measured
[12]: no final energy data available, but primary energy data given

4 National NZEB examples

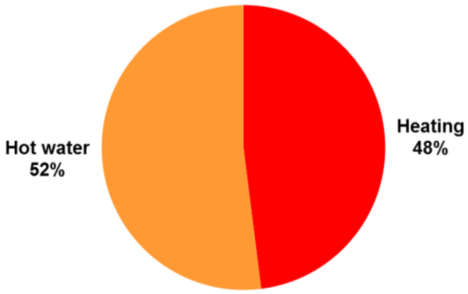
4.1 Austria

<table>
<tr><td colspan="6">4.1.1 Passive House Ebner</td><td colspan="2"></td></tr>
<tr><td>Author(s):</td><td colspan="7">Wolfgang Jilek, Energy Commissioner of Styria</td></tr>
<tr><td>Illustration:</td><td colspan="7"></td></tr>
<tr><td>Project aim:</td><td colspan="7">The house is built to meet the passive house standard, using solar thermal panels. The main focus was on the use of environmental building materials like straw, wood and loam rendering and a high contribution by the owner to the construction of the building.</td></tr>
<tr><td>Building address:</td><td colspan="7">Am Eichengrund 16, 8111 Judendorf-Straßengel</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td colspan="2">Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td colspan="2"></td></tr>
<tr><td colspan="7">Single-family house with a small integrated office</td></tr>
<tr><td>Building size:</td><td colspan="7">160 m² net floor area, 216 m² gross floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="7">The walls and the roof are made of 70 cm straw bales between wood frame construction, the windows have triple glazing and the floor consists of 50 cm foam-glass gravel fill under a concrete base plate.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="5">0.065 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="5">0.86 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="5">0.065 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="5">0.11 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="7">The house is heated by a wood-pellet stove. It has a mechanical ventilation system with 86% heat recovery. The demand of hot water is mostly covered by solar panels.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="7">Heating system with wood pellets and solar thermal panels (8 m²) for DHW production.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	OIB 2011
	Measured		Monitored in year:	Not yet monitored. Finished in 2014.
	Heating		16.0 kWh/m^2.year	
	Hot water		7.3 kWh/m^2.year	
	Cooling		0.0 kWh/m^2.year	
	Ventilation		incl. in electrical appliances	
	Lighting		incl. in electrical appliances	
	Electrical appli-ances (household electricity)		16.4 kWh/m^2.year	
	Total		39.7 kWh/m^2.year	
Primary energy use/CO_2 emissions:	Total primary energy		85.9 kWh/m^2.year	
	Total CO_2 emissions		10.4 kg/m^2.year	
Renewable energy contribution ratio:	About 48% of the total final energy			
Improvement compared to national requirements:	About 42%		Compared to:	Maximum final energy demand according to OIB 2011
Experiences/ lessons learned:	The challenge with this house was using straw in the building construction. The owner wanted to significantly contribute to the construction of the building. Thus, at the end, his degree of satisfaction and personal fulfilment satisfaction with the house is very high.			
Costs:	The building costs were about 300,000 € (1,875 €/m^2 net floor area) but this does not include the work of the house owner.			
Funding:	Subsidies of the Styrian government including a bonus for building a passive house and for the *klima:aktiv* declaration.			
Marketing efforts:	*klima:aktiv* declaration			
Links to further information:	http://strohundlehm.at			

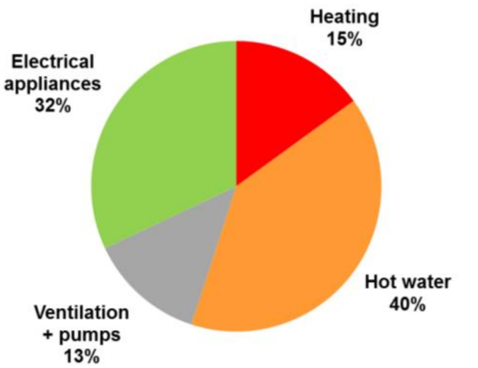
4.1.2 Messequartier

<table>
<tr><td>Author(s):</td><td colspan="6">Wolfgang Jilek, Energy Commissioner of Styria</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">The complex is built to meet the passive house standard. The main focus was to offer a mix of various common spaces (like service areas, a nursery, and student and senior dwellings) in a central location and a lot of open areas. This report only describes the multi-family section of the complex.</td></tr>
<tr><td>Building address:</td><td colspan="6">Klosterwiesgasse 101-103 and Münzgrabenstr. 84, 8010 Graz</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Multi-family apartment building</td></tr>
<tr><td>Building size:</td><td colspan="6">21,000 m² net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The house has a massive construction with insulated brick walls. The roof and the cellar ceiling consist of reinforced concrete, the windows have triple glazing.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.18 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.8 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.11 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.11 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">The house is heated by district heating. It has a mechanical ventilation system with 75% heat recovery. The demand of hot water is partially covered by 700 m² solar thermal panels on the roof.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Solar thermal panels (700 m²) are used for heating the hot water and as support for heating. A heat pump is used as preheating of the incoming air of the mechanical ventilation system.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	OIB 2007
	Measured		Monitored in year:	-
	Heating		14.4 kWh/m^2.year	
	Hot water		15.7 kWh/m^2.year	
	Cooling		0.0 kWh/m^2.year	
	Ventilation		incl. in heating	
	Lighting		Unknown	
	Electrical appli-ances (household electricity)			
	Total		30.1 kWh/m^2.year	
Primary energy use:	Total:		45.8 kWh/m^2.year	Primary energy factor of district heating: 1.52
Renewable energy contribution ratio:	About 52% of the total final energy			
Improvement compared to national requirements:	About 43%		Compared to:	Maximum final energy demand according to OIB 2007
Experiences/ lessons learned:	The satisfaction of the residents is very high. The infrastructure and the equipment are good and the mix of use is well accepted. The swimming pool with wellness area on the top floor, which is free to use for all residents, is a large plus.			
Costs:	The building costs were about 57 million € for the entire estate.			
Funding:	Subsidies of the Styrian government including a bonus for building a passive house and for the *klima:aktiv* declaration.			
Marketing efforts:	*klima:aktiv* declaration			
Awards:	Award for Architecture and Sustainability			
Links to further information:	http://www.klimaaktiv.at/bauen-sanieren/staatspreis/staatspreis2012 http://www.zement.at/Service/literatur/fileupl/05_12_wohnanlage_messequartier_graz.pdf			

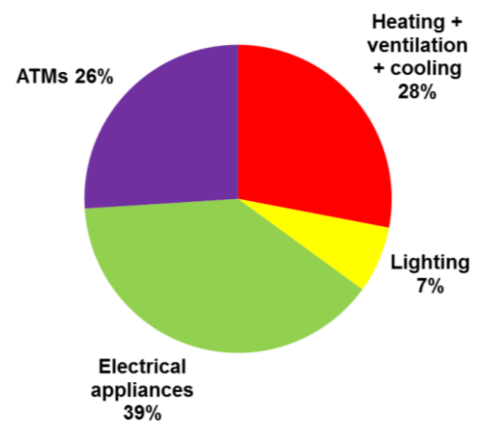
4.2 Belgium Flemish Region

<table>
<tr><td colspan="7">4.2.1 De Duurzame Wijk, Waregem</td></tr>
<tr><td>Author(s):</td><td colspan="6">Maarten de Groote, Flemish Energy Agency (VEA)
Involved organisations: Wienerberger, 3E nv</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">Research about the affordability of NZEB-dwellings: Passive building envelope, 100% renewable energy coverage of the primary energy use for heating, DHW and electrical auxiliary use.</td></tr>
<tr><td>Building address:</td><td colspan="6">Zultseweg 7, 8790 Waregem, Flanders, Belgium</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">7 individual dwellings with a small private garden and a large communal garden.</td></tr>
<tr><td>Building size:</td><td colspan="6">Total dwelling size (gross): 194 m² for the corner houses and 188 m² for the central houses.
Heated floor area: ca. 150 m²</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The building consists of brick walls and concrete floor slabs. All walls have a thickness of 14 cm, plus 24 cm of mineral wool for the outer walls. The roof is a wooden construction with 36 cm of mineral wool. The target for air tightness is 1.5 vol/h or 2.5 m³/hm² at 50 Pa pressure difference. The windows have a wooden frame and triple glazing.</td></tr>
<tr><td rowspan="6">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.12 – 0.13 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.78 W/m².K ($U_{glazing}$ = 0.6 W/m².K)</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.13 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.10 W/m².K</td></tr>
<tr><td colspan="2">Wall between 2 dwellings</td><td colspan="4">0.35 W/m².K</td></tr>
<tr><td colspan="2">Roof window</td><td colspan="4">1.01 W/m².K ($U_{glazing}$ = 0.5 W/m².K)</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating: gas boiler (12 kW) with floor heating in the kitchen and living area. The bedrooms are not equipped with a separate heating. In the bathroom, an electric towel dryer with thermostat will be installed.
DHW: gas boiler (same as above) with 200 liter buffer storage.
Ventilation: mechanical, supply of fresh air in dry rooms, exhaust in wet rooms, with heat recovery (min. 85%)
Cooling: a number of measures were part of the design to make active cooling unnecessary, including a big structural louvre on the south façade.
Lighting: up to buyers/tenants. All communal lighting will be according to BREEAM standards.</td></tr>
</table>

Included renewable energy technologies:	All possible renewable energy technologies where studied (heat pumps, biomass boilers, PV panels, solar thermal panels and collective installations of all these technologies for the 7 dwellings. A Life Cycle Cost Analysis study led to 3 possible and more or less equal choices in renewable energy systems: 1. a collective biomass boiler for the 7 dwellings 2. an optimally insulated dwelling with participation in renewable energy systems in the region (no production on site). 3. gas boiler + PV system (3.8 kW_p): for a number of practical reasons mainly linked to the preference of the real estate developer, this was the implemented solution.			
Final energy use:	Calculated	X	Calculation method:	VE (Virtual Environment)
	Measured		Monitored in year:	Monitoring over 3 years will start when construction is finished
	Heating		8.5 kWh/m^2.year	
	Hot water		22.0 kWh/m^2.year	
	Cooling		0.0 kWh/m^2.year	
	Ventilation + pumps		7.0 kWh/m^2.year	
	Lighting		incl. in electrical appliances	
	Electrical appliances (household electricity) incl. lighting		(18.0 kWh/m^2.year) -> not taken into account in calculation of NZEB energy	
	PV production		-22.0 kWh/m^2.year	
	Total gas		30.5 kWh/m^2.year	
	Total electricity		-15.0 kWh/m^2.year	
	Total final energy		15.5 kWh/m^2.year	
Primary energy use:	Gas		31 kWh/m^2.year	Primary energy factor: 1
	Grid electricity		18 kWh/m^2.year	Primary energy factor: 2.5
	PV production		-55 kWh/m^2.year	Primary energy factor: -2.5
	Total		-6 kWh/m^2.year	
Renewable energy contribution ratio:	59% of the total final energy (112% of primary energy)			
Improvement compared to national requirements:	78%		Compared to:	Current requirement is E60 + PV production of 7 kWh/m^2.year habitable space: this building is E13 + PV production of 22 kWh/m^2.year
Costs:	Difference in initial investment cost (CAPEX) compared to current legislation (E60 + RE): • Reference building = 242,000 € • NZEB (with collective biomass heating) = reference + 6% (14,500 €) • NZEB (with participation and condensing boiler) = reference + 6% (14,300 €) • NZEB (with PV and condensing boiler) = reference + 8% (18,900 €) Difference in net present value (NPV) over 30 years according to current legislation: • NZEB (with collective biomass heating) = reference - 7,100 € • NZEB (with participation and condensing boiler) = reference – 7,300 € • NZEB (with PV and condensing boiler) = reference – 11,000 €			
Marketing efforts:	• BREEAM Excellent certificate will be obtained for the design and the post construction phase • The project is widely known in the Belgian press • Series of lectures about the project and lessons learned for architects, developers, constructors, etc.			
Awards:	A BREEAM Excellent for both the design and post-construction phases.			
Links to further information:	www.deduurzamewijk.be (NL/FR)			

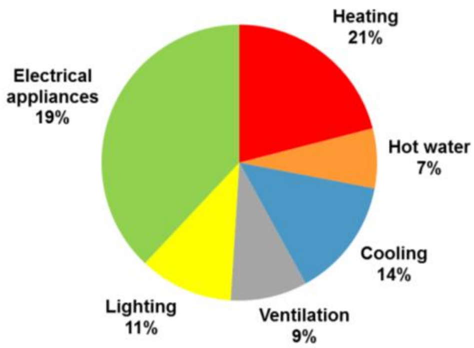
4.2.2 KBC Gooik Zero Energy Office

<table>
<tr><td>Author(s):</td><td colspan="6">Maarten de Groote, Flemish Energy Agency (VEA)
Involved organisations: Ingenium, KBC</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">The initial aim for the project was a low-energy bank office, whose concept could be used as an example for other KBC bank offices. During the building process, the aim became to build a (Nearly) Zero Energy bank office.</td></tr>
<tr><td>Building address:</td><td colspan="6">Edingsesteenweg, 1755 Gooik</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Office building</td></tr>
<tr><td>Building size:</td><td colspan="6">265 m² net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The building has high insulation and triple-glazed windows. The natural stone façade has 23 cm of extruded polystyrene (XPS), the green roof 20 cm of polyurethane (PUR) and the floor is on ground with 20 cm of XPS.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.20 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.87 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.13 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.18 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">The same philosophy of sustainable construction has been extended to the technical installations of the building. Therefore, concrete core activation, among others, is applied as the most important delivery system for heating and cooling. The lighting is completely operated by presence detection and daylight-based control.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">The necessary cold and heat is integrally generated by borehole thermal energy storage (BTES) in combination with a heat pump. A photovoltaic installation on the roof ensures the production of the necessary electricity.</td></tr>
</table>

Final energy use:	Calculated		Calculation method:	
	Measured	X	Monitored in year:	2013
	Heating		14.9 kWh/m².year	
	Hot water		incl. in electrical appliances	
	Cooling		incl. in heating	
	Ventilation		incl. in heating	
	Lighting		33.2 kWh/m².year	
	Electrical appliances		41.1 kWh/m².year	
	Cash dispensers		27.2 kWh/m².year	
	Total		116.4 kWh/m².year	
	PV generated electricity		-89.7 kWh/m².year	
Primary energy use:	Grid electricity		291.0 kWh/m².year	Primary energy factor: 2.5
	PV electricity		-224.3 kWh/m².year	Primary energy factor: -2.5
	Total		66.7 kWh/m².year	
Renewable energy contribution ratio:	77% of the total final energy			
Improvement compared to national requirements:	99%		Compared to:	Maximum primary energy use (maximum energy level 100). This building is energy level 1.
Experiences/ lessons learned:	This is clearly a success story. The overall consumption of the building is almost fully covered by photovoltaic panels and the users are very pleased with the indoor climate. The originally installed fixed sun blinds did not prevent reflections on the computer screens. New sun blinds have been installed, which together with the good orientation of the building solved the problem.			
Costs:	Total cost: 1,411,903 € (5,328 €/m²), which includes construction, technical installation, furniture, cleaning, etc.			
Marketing efforts:	Internal communication via Intranet (about 14,000 employees) Big posters on the windows of the new building Newspaper article "*Het Laatste Nieuws*" concerning the opening (published on 13 December 2012)			
Awards:	2020 Challenge 2013			
Links to further information:	http://ingenium.be/benl/site/references-detail.aspx?vPK=339&k=&page=33 http://www.2020challenge.be/project.asp?id=66 http://www.architectura.be/nl/newsdetail.asp?id_tekst=4337&content=Publiekswinnaar%202020%20Challenge%20-%20KBC%20Nulenergiekantoor			

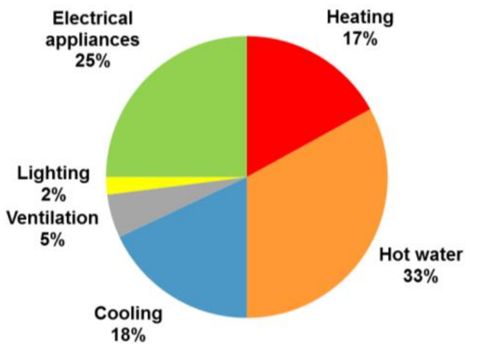
4.3 Bulgaria

<table>
<tr><td colspan="7">4.3.1 Technical University - Sofia, University Research Centre</td></tr>
<tr><td>Author(s):</td><td colspan="6">Prof. Nikola Kaloyanov, Technical University – Sofia
Prof. Merima Zlateva, Technical University - Sofia</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">Improving the university infrastructure, improving the building energy performance by no less than 45% when compared to the current norms.</td></tr>
<tr><td>Building address:</td><td colspan="6">8 Climent Ohridski blvd., blok 8, Sofia 1000</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">University research centre building</td></tr>
<tr><td>Building size:</td><td colspan="6">1,630 m² built-up area (total gross floor area)</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Walls: concrete and brick with thermal insulation
Roof: flat, unheated space, thermal insulation of 100 mm of mineral wool
Windows: PVC frames with double glazing</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.35 W/m².K (717 m²)</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">1.7 W/m².K (432 m²)</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.26 W/m².K (425 m²)</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.56 W/m².K (425 m²)</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating: ambient-based variable refrigerant flow (VRF) heat pump
Cooling: VRF based system
Ventilation: ambient air-based heat pump and heat recovery unit, including heating and cooling
Hot water: local electrical heaters
Low-energy lighting system</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Heating: ambient-based VRF heat pump with seasonal COP = 4
Ventilation: ambient-based heat pump with seasonal COP = 4 (in cooling mode 4.5) and heat recovery unit, with seasonal efficiency of 75% (heating mode)</td></tr>
</table>

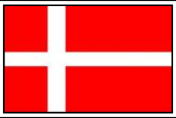
Final energy use:	Calculated	X	Calculation method:	National standard BDS EN ISO 13790 – national simulation tool
	Measured		Monitored in year:	-
	Heating		5.40 kWh/m^2.year (+RES 16.2 kWh/m^2.year = 21.60 kWh/m^2.year)	
	Hot water		1.90 kWh/m^2.year	
	Cooling		3.65 kWh/m^2.year	
	Ventilation		2.23 kWh/m^2.year (+RES 11.2 kWh/m^2.year = 13.43 kWh/m^2.year) including heating and cooling	
	Lighting		2.80 kWh/m^2.year	
	Electrical appliances		10.00 kWh/m^2.year	
	Total		15.98 kWh/m^2.year (+RES 27.40 kWh/m^2.year + appliances 10.00 kWh/m^2.year)	
Primary energy use:	Electricity		47.94 kWh/m^2.year	Primary energy factor: 3
	Total		47.94 kWh/m^2.year	
Renewable energy contribution ratio:	63.2% of the total final energy (51.3% of the total final energy including appliances)			
Improvement compared to national requirements:	77.6%		Compared to:	Annual final energy consumption (with district heating), according to the national requirements defined by the Ordinance for heat retention and energy efficiency in buildings (updated in 2009)
Costs:	Total costs for the building retrofit: 62,000 € for the building envelope + 150,000 € for the HVAC systems, lighting and DHW			
Funding:	Operative program "*Regional development*", National Research Found			
Links to further information:	Report for the Operative program "*Regional development*", 2012 Report for the National Research Found, 2013 (Contact: Prof. N. Kaloyanov, Technical University of Sofia)			

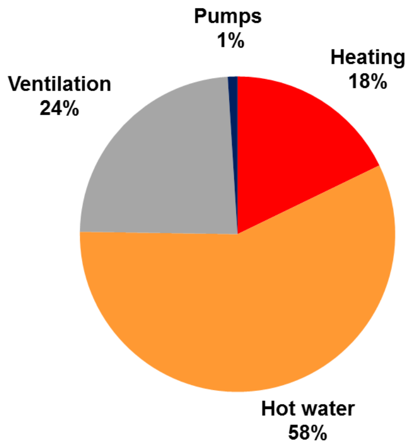
4.4 Croatia

<table>
<tr><td colspan="7">4.4.1 Multifamily building Lenišće East; “Šparna hiža”</td></tr>
<tr><td>Author(s):</td><td colspan="6">Nada Marđetko Škoro, Croatian Ministry of Construction and Physical Planning
Ivana Banjad Pečur, University of Zagreb, Faculty of Engineering
Investor: Agencija za društveno poticanu stanogradnju grada Koprivnice, Koprivnica
Designer: Tehnika projektiranje d.o.o.
Contractor: Tehnika d.d.</td></tr>
<tr><td>Illustration:</td><td colspan="6">
</td></tr>
<tr><td>Project aim:</td><td colspan="6">The building was planned and constructed to meet the requirements for energy performance class A with less than 15 kWh/m².year for heating.</td></tr>
<tr><td>Building address:</td><td colspan="6">Zvonimira Goloba 1,48 000 Koprivnica</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Multi-family house</td></tr>
<tr><td>Building size:</td><td colspan="6">1,539 m² net usable floor area (28 apartments, basement, ground floor and three floors with a ground area of 612 m²)</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The structural walls are reinforced concrete, 20 cm thick, or brick masonry block 25 cm thick. The building envelope is thermally insulated with stone wool of 20 cm thickness for concrete walls and 15 cm for brick walls. The roof is flat, made out of 20 cm concrete and thermally insulated with 30 cm of XPS. The PVC windows are made with triple low e-coated glazing filled with argon, mounted according to RAL installation. (RAL is a German quality assurance association of windows and front door producers, which publish guidelines for correct window installations.)</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.19 W/m².K (concrete wall) – 0.22 W/m².K (brick wall); allowed U_{max} = 0.45 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.99 W/m².K; allowed U_{max} = 1.80 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.10 W/m².K; allowed U_{max} = 0.30 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling</td><td colspan="4">0.21 W/m².K; allowed U_{max} = 0.50 W/m².K</td></tr>
<tr><td colspan="2">Ground slab</td><td colspan="4">0.13 W/m².K; allowed U_{max} = 0.50 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating and cooling are provided by an underfloor system using the same pipes for both heating and cooling. Heating is generated by a compact heat pump with COP = 2.8 (90%) or by boilers using natural gas (10%). Each apartment has its own energy meters. The ventilation system runs constantly to supply 0.5 air changes per hour of the entire volume of the apartment. The waste air heat is taken through a high performance energy recuperation system. Hot water is primarily generated by solar thermal collectors, and, if necessary, complemented by gas boilers.</td></tr>
</table>

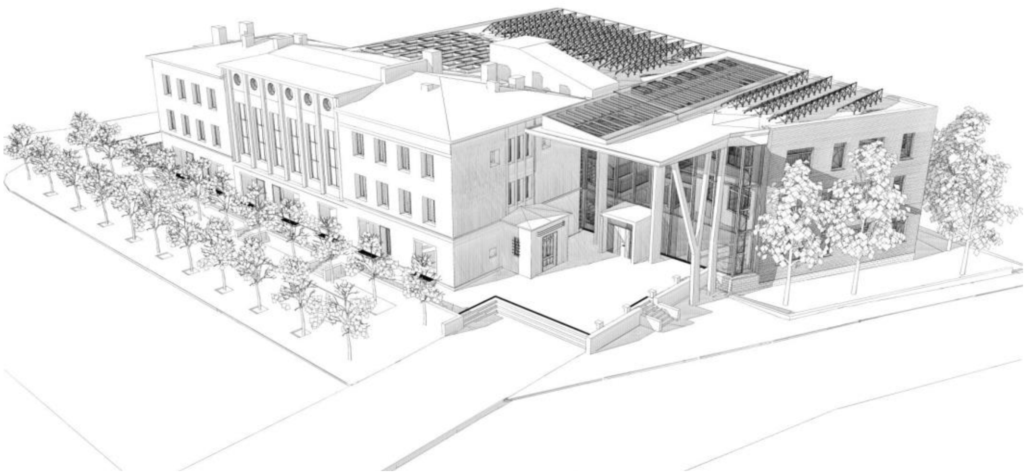
Included renewable energy technologies:	Solar energy for centralised DHW preparation: solar thermal collectors on the roof of the building, connected to the DHW storage tank with a volume of 4,000 liter. The system is designed to use primarily solar energy for hot water generation, with gas boilers as support.			
Final energy use:	Calculated	X	Calculation method:	HRN EN ISO 13790/PHPP 2009
	Measured		Monitored in year:	-
	Heating		14.95 kWh/m².year (~ 10% gas boiler, 90% el. heat pump)	
	Hot water		29.10 kWh/m².year (50% solar energy)	
	Cooling		15.65 kWh/m².year	
	Ventilation		4.17 kWh/m².year	
	Lighting		1.69 kWh/m².year	
	Total		65.56 kWh/m².year	
	Electrical appli-ances (household electricity)		21.54 kWh/m².year	
Primary energy use:	Electricity		78.95 kWh/m².year	Primary energy factor: 3
	Natural gas		17.65 kWh/m².year	Primary energy factor: 1.1
	Total		96.30 kWh/m².year	
Renewable energy contribution ratio:	22% (solar thermal energy) of the total final energy			
Improvement compared to national requirements:	78%		Compared to:	Maximum heating energy demand allowed for new buildings
Experiences/ lessons learned:	<u>Positive:</u> A higher quality than prescribed by the national legislation with the aim of improving quality of life, including renewable energy, and considering environmental protection is possible at an affordable price for the users. <u>Problematic:</u> The project showed insufficient experience of the workforce regarding the application of new technology (e.g. RAL installation of windows), quality of works (e.g., airtightness of the envelope) and a lack of information on how the building service system works under real conditions. The users showed insufficient awareness and a lack of knowledge of using such systems.			
Costs:	Costs of land, design, construction and supervision amount to 11,485,000.00 HRK (~ 1,500,000.00 €) for 1,644.00 m² (28 apartments). There were no additional costs for the A⁺ energy class type of building compared to a standard quality building.			
Funding:	The City of Koprivnica, the investor of the project, has also spent funds in a public awareness campaign, yet the money spent was relatively modest compared to the media attention that followed the construction and promotion.			
Marketing efforts:	The two multifamily buildings *'Šparne hiže'*, energy class A⁺, are unique in Croatia. Marketing efforts were aimed at informing the public of the advantages of low-energy buildings through public lectures, debates, articles in print media and broadcasts on TV.			
Awards:	• ManagEnergy award winner, ''The bold new face of Koprivnica' (European Commission, EACI, Sustainable energy week 24.-28. June 2013.); • Recognition for best practice in local government in the energy efficiency category (IN PLUS, Association of Croatian cities)			
Links to further information:	www.apos-koprivnica.hr			

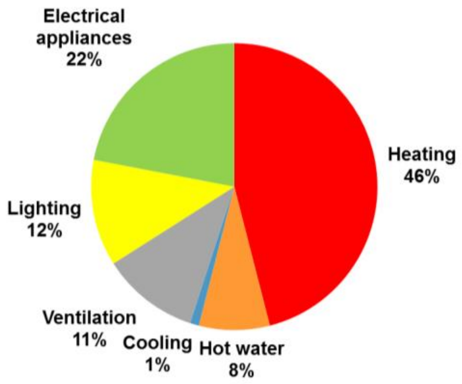
4.5 Denmark

<table>
<tr><td colspan="6"><h3>4.5.1 Sems Have, Roskilde, Denmark</h3></td><td></td></tr>
<tr><td>Author(s):</td><td colspan="6">Kirsten Engelund Thomsen, SBi, AAU Copenhagen</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">Renovation and transformation of a dormitory/day-care centre into 30 low-energy apartments: Improved thermal envelope, balanced mechanical ventilation system with heat recovery, improved architecture and PV. Danish Building class 2020 (NZEB)</td></tr>
<tr><td>Building address:</td><td colspan="6">Parkvej 3-5, 4000 Roskilde</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Renovation and transformation of a dormitory/day-care centre into 30 low-energy apartments. The renovation was completed in December 2013.</td></tr>
<tr><td>Building size:</td><td colspan="6">3,388 m^2 gross floor area after renovation</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Walls: pre-fabricated, light weight, with up to 480 mm insulation
Roof: 400 mm insulation
Windows: three-layer low-energy glazing
Basement floor: insulated with 100 mm expanded clay clinkers under the concrete</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.2 W/m^2.K (87% of the wall area) – 0.3 W/m^2.K (13%)</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">1.0 W/m^2.K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.09 W/m^2.K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">1.1 W/m^2.K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating: The building is connected to a district heating network
Ventilation: Balanced mechanical ventilation system with a Specific Fan Power (SFP) factor of 2 J/m^3 and a heat recovery efficiency of 84%.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Total photovoltaic (placed on both roofs): 115 m^2, 17.3 kW_p
• PV on building A: 55 m^2 with 8.16 kW_p/6,613 kWh per year.
• PV on building B: 60 m^2 with 9.12 kW_p/7,282 kWh per year.</td></tr>
</table>

Final energy use/production:	Calculated	X	Calculation method:	National tool Be10
	Measured		Monitored in year:	-
	Heating		4.30 kWh/m^2.year	
	Hot water		14.20 kWh/m^2.year	
	Cooling		0.00 kWh/m^2.year	
	Ventilation (electricity)		5.90 kWh/m^2.year	
	Lighting		unknown	
	Pumps (electricity)		0.14 kWh/m^2.year	
	Electrical appli-ances (household electricity)		unknown	
	Total		24.54 kWh/m^2.year	
	Electricity production by PV		3.85 kWh/m^2.year	The figures are the mean for the two buildings.
Primary energy use/production:	District heating		11.10 kWh/m^2.year	Primary energy factor: 0.6
	Electricity		11.00 kWh/m^2.year	Primary energy factor: 1.8
	Electricity production by PV		- 6.93 kWh/m^2.year	Primary energy factor: 1.8
	Overheating surcharge		1.00 kWh/m^2.year	
	Total		16.17 kWh/m^2.year	
Renewable energy contribution ratio:	16% of the total final energy (PV/total final energy). There is also renewable energy included in the district heating system.			
Improvement compared to national requirements:	70%		Compared to:	Renovated buildings in Denmark must fulfil component U-values, therefore it is not easy to derive one single value of improvement. As a new building, it would have to fulfil 53 kWh/m^2.year primary energy. This is used as basis for the comparison. Danish NZEB-class is 20 kWh/m^2.year primary energy. A similar non-renovated residential building would have a net space heating demand of around 150 kWh/m^2.year (gross area).
Experiences/ lessons learned:	The tenants like the buildings very much. It was challenging to change the building use. It was more cost-efficient to renovate the old building than to build a new one, and also more CO_2 efficient. It was challenging to fulfil the requirements for noise, PCB, lead and asbestos.			
Costs:	The rent is comparable to other apartments owned by the building association. It is not possible to compare rent before and after due to change in use.			
Funding:	The renovation was in the traditional way via loans and funding from the building association.			
Marketing efforts:	It is easy to rent out these flats: good design and size, and located near Roskilde centre.			
Awards:	Sems Have is nominated for the *RenoverPrisen* 2014			
Links to further information:	http://renover.dk/projekt/sems-have/ (in Danish) Sems Have will soon be one of the examples in the IEA Annex 56 project list: http://www.iea-annex56.org/index.aspx			

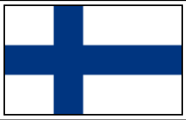
4.6 Estonia

<table>
<tr><td colspan="7">4.6.1 Rakvere Smart Building</td></tr>
<tr><td>Author(s):</td><td colspan="6">Mikk Maivel, KredEx
The building was designed by Oliver Alver.</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">The first Estonian NZEB, primary energy consumption is 60% better than the established current national requirement, and smart building automation systems are in use also.</td></tr>
<tr><td>Building address:</td><td colspan="6">Turu plats 2, Rakvere, Estonia</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Office building</td></tr>
<tr><td>Building size:</td><td colspan="6">2,170 m² gross floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Double façade, load-bearing structure of prefabricated concrete elements with polyurethane insulation. Typical roof construction with hollow-core slab and 500 mm insulation. Windows are made with wooden-aluminium frames and triple glazing.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.07 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.8 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.08 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.14 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating is generated by the local district heating system and delivered by low-temperature radiators. The building has mechanical supply-extract ventilation systems with heat recovery (Variable Air Volume (VAV) and Constant Air Volume (CAV) systems). Hot water is also generated by the district heating.
To prevent overheating, the building uses a high-temperature passive cooling system based on open energy piles connected to the ground water. The cooling delivery system consists of chilled beams in rooms.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Energy piles are connected to the ground water for passive cooling and a 33.8 kW photovoltaic system.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	National standard and dynamic simulation tool
	Measured		Monitored in year:	-
	Heating		39.4 kWh/m^2.year	
	Hot water		6.9 kWh/m^2.year	
	Cooling		0.6 kWh/m^2.year	
	Ventilation		9.8 kWh/m^2.year	
	Lighting		10.5 kWh/m^2.year	
	Electrical appliances		19.1 kWh/m^2.year	
	Total		86.3 kWh/m^2.year	
	PV generated electricity		-13.3 kWh/m^2.year	
Primary energy use:	District heating		41.7 kWh/m^2.year	Primary energy factor: 0.9
	Electricity		56.2 kWh/m^2.year	Primary energy factor: 2
	Total		97.9 kWh/m^2.year	
Renewable energy contribution ratio:	23% of the total final energy			
Improvement compared to national requirements:	60%		Compared to:	Minimum requirement for energy performance is 160 kWh/m^2.year (defined in the Estonian energy act "*Minimum requirements for energy performance of August 2012*")
Experiences/ lessons learned:	Due to the financial constraints, several conceptual changes were made during the planning process in order to remain within budget, and initial expectations had to be lowered. This meant that some of the technical solutions were replaced with cheaper and less effective ones.			
Costs:	Costs include planning and construction. Additional equipment and monitoring appliances are also included. The additional costs compared to a regular building are estimated to be around 5-10%.			
Funding:	The funding is provided by EU regional funds for the development of regional competence centres in Estonia. The main co-funder of the project is the Rakvere Municipality. Additional contributions are expected from private sector.			
Marketing efforts:	The building will be used as a test and demonstration building for intelligent and automated building systems and is expected to serve as a test base for regional and national research institutions.			
Links to further information:	http://www.rakveretarkmaja.ee/			

4.7 Finland

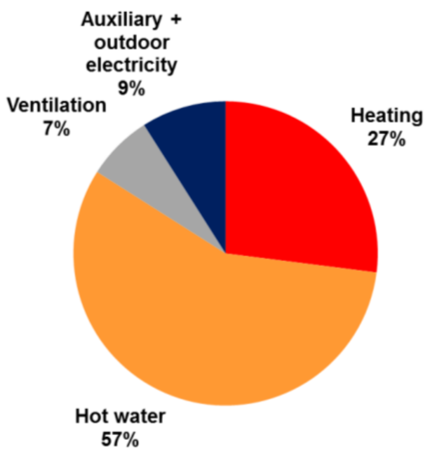
4.7.1 Järvenpää Zero Energy House



Author(s):	Riikka Holopainen, Miimu Airaksinen, VTT
Illustration:	
Project aim:	First nearly zero-energy house in Finland
Building address:	Jampankaari 4 ED, Järvenpää

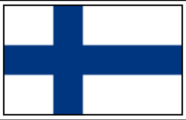
Building type:	Residential	Non-residential	Public		New	Renovated
	X				X	
	A home for elderly people					

Building size:	2,124 m² gross floor area	
Building envelope construction:	Sandwich structure concrete walls with 300 mm SPU (polyuerthane) insulation	
Building envelope U-values:	Wall	0.08 W/m²K
	Window	0.76 W/m²K
	Roof/ceiling to the attic	0.07 W/m²K
	Cellar ceiling/ground slab	0.10 W/m²K
Building service systems:	Water-based heating system, low-energy lighting, mechanical supply and exhaust ventilation system with heat recovery.	
Included renewable energy technologies:	Solar thermal collectors, solar electricity (PV) and geothermal heating.	

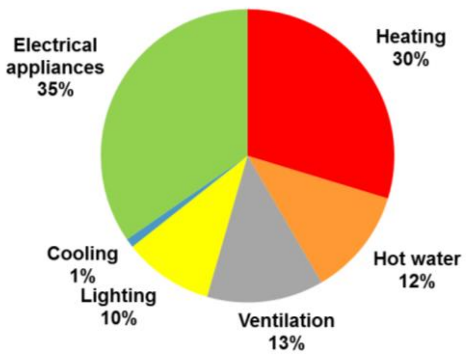
Final energy use:				
	Calculated	X	Calculation method:	VTT House simulation tool
	Measured		Monitored in year:	-
	Heating		12 kWh/m².year	
	Hot water		25 kWh/m².year	
	Cooling		0 kWh/m².year	
	Ventilation		3 kWh/m².year	
	Lighting		Unknown	
	Electrical appli-ances (household electricity)		Unknown	
	Auxiliary + outdoor electricity		4 kWh/m².year	
	Total		44 kWh/m².year	

Primary energy use:	Total	No data available	Primary energy requirements were introduced after the building permit was given.
Renewable energy contribution ratio:	100% of the total final energy (the excess energy during summer is sold to nearby house compensating the district heating consumption during winter)		
Improvement compared to national requirements:	~ 50%	Compared to:	Requirements in National Building Code of Finland, part D3
Experiences/ lessons learned:	Ground source heating was originally used without heat pump for pre-heating of the warm service water. A heat pump was later installed. It is important to sufficiently cool the inverter room of the solar system, as hot temperatures decrease the solar electricity supply rate.		
Costs:	Additional costs due to energy efficiency and renewable energy systems were roughly 400 €/m^2 or 15% higher than typical new elderly homes, according to the Finnish energy requirements for new buildings. Re-use of the concept is expected to reduce the extra costs down to 10% when compared to typical elderly homes with the same level of services.		
Funding:	A long-term interest-subsidised loan		
Awards:	Most environmentally conscious apartment house 2013 Climate award of Helsinki region 2013 *Järvenpää* award for sustainable building 2011 Constructor of the year 2011 Most influential residential actor 2010		
Links to further information:	http://www.nollaenergia.fi/jarvenpaantalo.php		

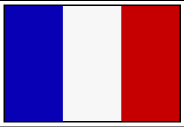
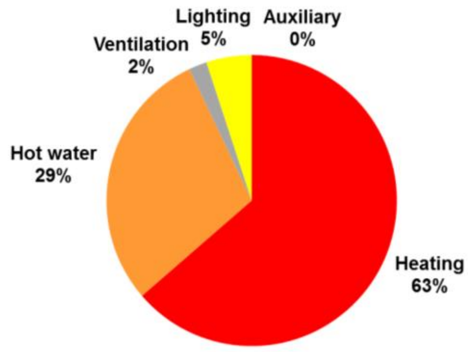
4.7.2 Villa ISOVER



<table>
<tr><td>Author(s):</td><td colspan="6">Teemu Vesanen, Miimu Airaksinen, Jari Shemeikka, VTT</td></tr>
<tr><td>Illustration:</td><td colspan="6">
© Architects Tiina Antinoja and Olli Metso, Muuan Studio http://www.muuan.fi/</td></tr>
<tr><td>Project aim:</td><td colspan="6">The building was designed based on an architectural competition for zero-energy buildings organised by Saint-Gobain ISOVER in co-operation with the architect association SAFA, Rakennuslehti magazine, VTT and WWF.</td></tr>
<tr><td>Building address:</td><td colspan="6">Housing fair (2013) area in Hyvinkää, Finland</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">A two-storey single-family house</td></tr>
<tr><td>Building size:</td><td colspan="6">Floor area: 195.5 m^2 + 21 m^2 storage space</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Wall insulation with Saint-Gobain Isover Vacupad vacuum insulation product (0.007 W/m.K). The roof includes 700 mm of mineral wool and the floor is insulated with 400 mm of Styrofoam XPS on a concrete slab based construction. The windows are triple glazed.</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.09 $W/m^2.K$</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.75 $W/m^2.K$</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.06 $W/m^2.K$</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.09 $W/m^2.K$</td></tr>
<tr><td colspan="2">Doors</td><td colspan="4">0.6 – 0.75 $W/m^2.K$</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Mechanical ventilation system with heat recovery unit with 80% efficiency. Since the set-point temperature against freezing of the heat exchanger was -10 $^\circ$C, the yearly heat recovery efficiency rate resulted in 76% for the ventilation system.
Heating energy is generated by a ground source heat pump and distributed by a low-exergy floor-heating system with clinker surfaces and a maximum surface temperature of 26 $^\circ$C.
Lighting is designed to be LED and all household equipment is designed to have the best energy label classification A^{++}.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">The main heating source is the ground source heat pump, but solar heat can also provide a share of the heating. In addition, the building has a fire place capable of storing heat in its thermal mass.
The ground source heat pump's Seasonal Performance Factor (SPF) is 3.5 for space heating and 2.5 for DHW generation. The solar thermal collector system (6 m^2) is faced southerly with an angle of 15-30 degrees.
The surface area of the photovoltaic system is 80 m^2 on the southern façade of the roof and at the same angle as the solar thermal collectors. The PV system consists of 72 Copper Indium Selenide (CIS)-type thin-film modules. The system has 3 inverters, each rated for 3 kW power.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	IDA. Indoor Climate and Energy according the Finnish Building Code
	Measured		Monitored in year:	-
	Heating		11.3 kWh/m^2.year	
	Hot water		4.6 kWh/m^2.year	
	Cooling		0.2 kWh/m^2.year	
	Ventilation		4.8 kWh/m^2.year	
	Lighting		4.0 kWh/m^2.year	
	Electrical appli-ances (incl. out-door lighting and car heating)		13.2 kWh/m^2.year	
	Total		40.4 kWh/m^2.year	
Primary energy use:	Electricity		68.7 kWh/m^2.year	
	Total		68.7 kWh/m^2.year	Primary energy factor: 1.7
Renewable energy contribution ratio:	100% of the total final energy (annual balance)			
Improvement compared to national requirements:	66%		Compared to:	Maximum primary energy value of the Finnish building regulation: 160 kWh/m^2.year. This does not include the 13.2*1.7 kWh/m^2.year primary energy for electrical appliances.
Experiences/ lessons learned:	The building performance is monitored in detail. The first preliminary results show promising results and further analysis shall be carried out to evaluate the holistic picture about the building performance in real use.			
Funding:	Saint Gobain Isover *Rakennustuotteet* funded the project.			
Marketing efforts:	The building is part of the *Hyvinkää* housing exhibition area.			
Awards:	The building won the architectural competition organised by Saint-Gobain ISOVER in co-operation with the architect association SAFA, *Rakennuslehti* magazine, VTT and WWF. There were 81 contestants in total.			
Links to further information:	http://www.isover.fi/passiivitalo/seurantakohteet/villa-isover-asuntomessut-2013-hyvinkaa/villa-isoverin-esittely (in Finnish)			

4.8 France

<table>
<tr><td colspan="7">4.8.1 Maison DOISY</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="7">Marie-Christine Roger, Loïc Chery, Fabien Auriat, Ministère de l'Ecologie, du Développement Durable et de l'Energie
Involved organisations: Villa Tradition, Promotelec</td></tr>
<tr><td>Illustration:</td><td colspan="7"> </td></tr>
<tr><td>Project aim:</td><td colspan="7">To produce a French NZEB.</td></tr>
<tr><td>Building address:</td><td colspan="7">143 avenue de la Rochelle - 79000 Niort</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td colspan="2">Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td colspan="2"></td></tr>
<tr><td colspan="7">Single-family house</td></tr>
<tr><td>Building size:</td><td colspan="7">158 m² net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="7">The building has brick walls insulated with mineral wool on the inside. The ceiling, made of reinforced concrete, has a mineral-wool insulation.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="3">Wall</td><td colspan="4">0.205 W/m².K</td></tr>
<tr><td colspan="3">Window</td><td colspan="4">1.45 W/m².K</td></tr>
<tr><td colspan="3">Roof/ceiling to the attic</td><td colspan="4">0.138 W/m².K</td></tr>
<tr><td colspan="3">Cellar ceiling/ground slab</td><td colspan="4">0.138 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="7">Heating is provided by a gas-condensing boiler and delivered by a floor-heating system. DHW is generated by solar thermal collectors and supported by the boiler. A single-flow ventilation system with humidity sensors was installed to maintain the quality of the indoor air.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="7">Nearly 4 m² of solar thermal collectors were installed on the roof to cover part of the DHW consumption.</td></tr>
<tr><td rowspan="11">Final energy use:</td><td>Calculated</td><td>X</td><td>Calculation method:</td><td colspan="4">National standard (méthode Th-BCE)</td></tr>
<tr><td>Measured</td><td></td><td>Monitored in year:</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Heating</td><td>20.80 kWh/m².year</td><td colspan="4" rowspan="9">
</td></tr>
<tr><td colspan="2">Hot water</td><td>9.50 kWh/m².year</td></tr>
<tr><td colspan="2">Cooling</td><td>0.00 kWh/m².year</td></tr>
<tr><td colspan="2">Ventilation</td><td>0.65 kWh/m².year</td></tr>
<tr><td colspan="2">Lighting</td><td>1.70 kWh/m².year</td></tr>
<tr><td colspan="2">Electrical appli-ances (household electricity)</td><td>unknown</td></tr>
<tr><td colspan="2">Auxiliary energy</td><td>0.15 kWh/m².year</td></tr>
<tr><td colspan="2">Total</td><td>32.80 kWh/m².year</td></tr>
<tr><td colspan="2">Solar thermal energy contribution</td><td>7.70 kWh/m².year</td></tr>
</table>

Primary energy use:	Electricity	6.50 kWh/m².year	Primary energy factor: 2.58
	Gas	30.30 kWh/m².year	Primary energy factor: 1
	Total	36.80 kWh/m².year	
Renewable energy contribution ratio:	21% of the total final energy		
Improvement compared to national requirements:	21%	Compared to:	Maximum primary energy use according to RT2012 (46.90 kWh/m².year).
Links to further information:	http://www.observatoirebbc.org/site/construction/fichepedagogique?building=BGJG3H#economiques		

4.8.2 Maison HANAU

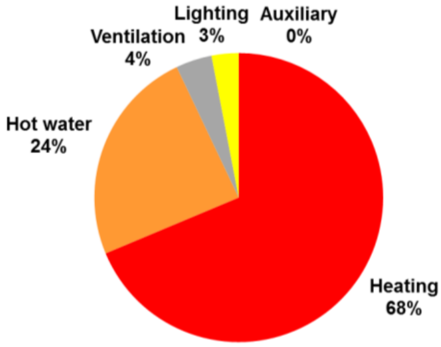
Author(s):	Marie-Christine Roger, Loïc Chery, Fabien Auriat, Ministère de l'Ecologie, du Développement Durable et de l'Energie Involved organisations: Villa Tradition, AET Loriot
Illustration:	
Project aim:	It is the second house in France to obtain *BEPOS Effinergie* certification. BEPOS is the certification for houses that generate more electricity than they use (plus-energy houses).
Building address:	67600 Selestat, France

Building type:	Residential	Non-residential	Public		New	Renovated
	X				X	
	Single-family house					

Building size:	178 m^2 net floor area
Building envelope construction:	This house has a structure of cellular concrete insulated with polystyrene, a high-performance insulation in the roofs and floors made of interjoist polystyrene and additional insulation of 8 cm of polyurethane. The windows are double glazed.

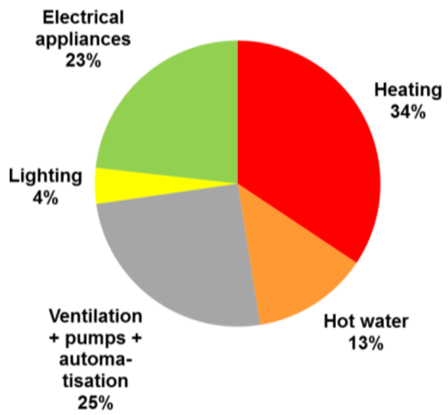
Building envelope U-values:		
	Wall	0.160 – 0.166 W/m².K
	Window	1.28 W/m².K
	Roof/ceiling to the attic	0.108 – 0.127 W/m².K
	Cellar ceiling/ground slab	0.112 W/m².K

Building service systems:	Heating is provided by a gas-condensing boiler and delivered by a floor-heating system. The boiler also provides support to the solar thermal collectors that are the main source of DHW. A single-flow ventilation system with humidity sensors was installed to maintain the quality of the indoor air
Included renewable energy technologies:	Nearly 4 m^2 of solar thermal collectors were installed on the roof to cover part of the DHW consumption. 51 m^2 photovoltaic panels have been installed on the roof, providing 8 kW_p.

Final energy use:	Calculated	X	Calculation method:	National standard (*méthode Th-BCE*)
	Measured		Monitored in year:	-
	Heating		28.40 kWh/m².year	
	Hot water		10.00 kWh/m².year	
	Cooling		0.00 kWh/m².year	
	Ventilation		1.55 kWh/m².year	
	Lighting		1.45 kWh/m².year	
	Auxiliary energy		0.15 kWh/m².year	
	Electrical appli-ances (household electricity)		unknown	
	Total		41.55 kWh/m².year	
	Solar thermal energy contribution		7.20 kWh/m².year	
	PV electricity		40.85 kWh/m².year	
Primary energy use:	Electricity		7.70 kWh/m².year	Primary energy factor: 2.58
	Gas		38.40 kWh/m².year	Primary energy factor: 1
	PV energy		-105.40 kWh/m².year	Primary energy factor: 2.58
	Total		-59.30 kWh/m².year	
Renewable energy contribution ratio:	100% of the total final energy			
Improvement compared to national requirements:	202%		Compared to:	Maximum primary energy use according to RT2012 (58.20 kWh/m².year)
Links to further information:	http://www.observatoirebbc.org/site/construction/fichepedagogique?building=B19KFE#descriptif			

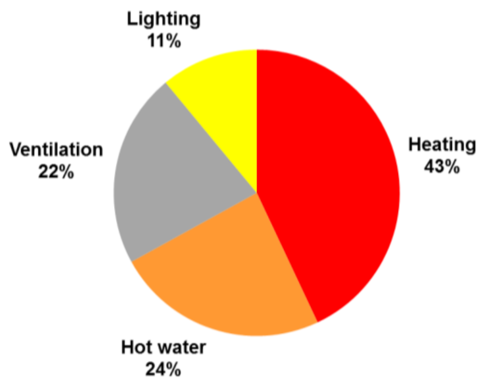
4.9 Germany

<table>
<tr><td colspan="2">4.9.1 Efficiency House Plus with E-mobility in Berlin</td></tr>
<tr><td>Author(s):</td><td>Heike Erhorn-Kluttig, Hans Erhorn, Antje Bergmann, Fraunhofer Institute for Building Physics</td></tr>
<tr><td>Illustration:</td><td>
© Schwarz (BMVBS)</td></tr>
<tr><td>Project aim:</td><td>This pilot building generates its own energy and makes it available to the users and the electric vehicles. Excess energy is fed back into the grid or stored in a battery. An annual positive energy balance is required for primary and final energy use.</td></tr>
<tr><td>Building address:</td><td>Fasanenstraße 87a, 10623 Berlin</td></tr>
<tr><td>Building type:</td><td><table><tr><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr><tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr><tr><td colspan="6">Single-family house with 2 floors</td></tr></table></td></tr>
<tr><td>Building size:</td><td>203 m² useful floor area ('A_N', with A_N=0.32*V_{gross}), 138 m² living area</td></tr>
<tr><td>Building envelope construction:</td><td>The floor, the walls and the roof are made of timber panels filled with up to 52 cm of cellulose insulation. The windows have triple glazing. Thermal bridges have been minimised. Photovoltaic modules cover the roof and the façade. All house elements can be separated and moved to another location or be disposed of once the lifetime of the building has expired.</td></tr>
<tr><td>Building envelope U-values:</td><td><table><tr><td>Wall</td><td>0.11 W/m².K</td></tr><tr><td>Window</td><td>0.70 W/m².K</td></tr><tr><td>Roof/ceiling to the attic</td><td>0.11 W/m².K</td></tr><tr><td>Cellar ceiling/ground slab</td><td>0.11 W/m².K</td></tr></table></td></tr>
<tr><td>Building service systems:</td><td>The house is heated by a central heating system with an air-to-water heat pump and floor heating. A balanced mechanical ventilation system with 80% heat recovery and a building energy management system with touch pads are installed. The PV systems on the roof and facades generate electricity that is used by the building, fed into the grid or stored in a battery. The battery, with a capacity of 40 kWh, is made of 7,250 single second-hand battery cells formerly used in electric cars.</td></tr>
<tr><td>Included renewable energy technologies:</td><td>The air-to-water heat pump uses ambient energy from the outside air. Two large photovoltaic fields are installed: 98 m² monochrystalline PV modules on the roof and 73 m² thin-film modules on the façade.</td></tr>
<tr><td>Final energy use:</td><td><table><tr><td>Calculated</td><td></td><td>Calculation method:</td><td>DIN V 18599, Effizienzhaus Plus-Rechner [Efficiency house plus calculator]</td></tr><tr><td>Measured</td><td>X</td><td>Monitored in year:</td><td>2012/2013</td></tr></table></td></tr>
</table>

Final energy use (cont.):	Heating	20.8 kWh/m².year	
	Hot water	8.1 kWh/m².year	
	Cooling	0.0 kWh/m².year	
	Ventilation incl. pumps and automatisation	15.3 kWh/m².year	
	Lighting	2.6 kWh/m².year	
	Electrical appli-ances (household electricity)	14.3 kWh/m².year	
	Total	61.1 kWh/m².year	
	E-mobility	19.6 kWh/m².year	
	PV energy gener.	- 65.6 kWh/m².year	
	thereof self-used	- 32.3 kWh/m².year	
	thereof fed-in	- 33.3 kWh/m².year	
	Electr. from grid	28.8 kWh/m².year	
	Electricity surplus	- 4.5 kWh/m².year	
Primary energy use:	Electr. from grid	69.1 kWh/m².year	Primary energy factor: 2.4 (PEF 2014)
	Electr. fed-in	-93.2 kWh/m².year	Primary energy factor: 2.8 (PEF 2014)
	Total	- 24.1 kWh/m².year	
Renewable energy contribution ratio:	107% of the total final energy		
Improvement compared to national requirements:	78%	Compared to:	Maximum primary energy use according to EnEV 2009. (Household equipment, e-mobility not taken into account. PV generated electri-city accounted up to monthly electricity use).
Experiences/ lessons learned:	The test family enjoyed living in the house without having a bad conscience because of using conventional energy. As the ventilation system was not manually controlled, it introduced warm external air into the rooms in summer, which became a problem. The measurements show that the goal of the efficiency house plus has been achieved, but only 25% of the electricity used for e-mobility could be covered.		
Costs:	The costs of the house are rather high, with 1,080,000 € for construction and 566,000 € for the building service systems. This is partly due to the high ambition (plus energy) and the ability to divide the house into different materials in the event of deconstruction. There is a network of efficiency houses plus with more than 20 buildings of the same energy performance level. These houses show that the additional costs compared to a regular new building can be decreased by about 50,000 €.		
Funding:	Research program "*Efficiency house plus*". The Federal Building Ministry (BMUB) supports the construction of buildings which produce significantly more energy than required for their operation. The pilot projects are assessed by a scientific support program. The goals are to improve energy management in modern structures and further develop necessary building envelope and renewable energy components.		
Marketing efforts:	- Network of more than 20 efficiency house plus pilot projects - The house can be visited and is used for events - BMUB website includes videos, a blog by the users, actual monitoring results, etc. - Official opening by Chancellor Angela Merkel		
Awards:	The design by architect Werner Sobek won the architectural competition for the BMUB pilot project. Case highlighted in February 2014 on EU's BUILD UP portal.		
Links to further information:	- website: http://www.bmvi.de/DE/EffizienzhausPlus/effizienzhaus-plus_node.html - case on BUILD UP: http://www.buildup.eu/cases/40001 - monitoring report of Fraunhofer Institute for Building Physics: link - videos: http://www.youtube.com/watch?v=mNCZxovLHRo; http://www.youtube.com/watch?v=LgLVuFWhIgM		

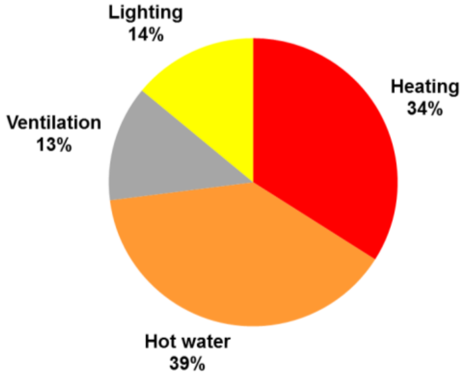
4.9.2 Hauptschule Schrobenhausen, pilot project of DENA Efficient Schools Project

<table>
<tr><td>Author(s):</td><td colspan="6">Heike Marcinek, Oliver Krieger, Deutsche Energie-Agentur (DENA)</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">The requirements of DENA’s efficient house pilot project (2009) intended to undershoot the national energy saving ordinance EnEV by at least 15% (primary energy use). The resulting quality shows an undercut of 44%, including a very efficient ventilation system. Generated electricity is not taken into account in the calculation, but it would enhance the result further.</td></tr>
<tr><td>Building address:</td><td colspan="6">Georg-Leinfelder-Straße 16, 86529 Schrobenhausen, Germany</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td>X</td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">School
Year of construction: 1975 / Renovation: 2010-2012</td></tr>
<tr><td>Building size:</td><td colspan="6">7,080 m² net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The existing façade of a 1970s concrete structure with internal brickwork was insulated with 24 cm expanded polystyrene. The roof received 40 cm cellulose insulation. The new windows have triple glazing (air-tight fitting).</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.17 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.96 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.11 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling</td><td colspan="4">0.16 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">The school is supplied by a district heating system, based on renewable energy.
The central ventilating system is equipped with a heat recovery system.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Electricity: The roof-installed photovoltaic modules supply part of the electricity use. The amount of electricity that is fed into the grid is unknown unfortunately.
Heating: The district heating system is based on renewable energy with a primary energy factor of zero.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	DIN V 18599
	Measured		Monitored in year:	2013: final heating energy: ~30 kWh/m^2.year 2009: final heating energy: ~80 kWh/m^2.year
	Heating		29.4 kWh/m^2.year	
	Hot water		16.3 kWh/m^2.year	
	Cooling		0.0 kWh/m^2.year	
	Ventilation		15.3 kWh/m^2.year	
	Lighting		7.5 kWh/m^2.year	
	Electrical appliances		unknown	
	Total		68.5 kWh/m^2.year	
Primary energy use:	District heating		0.0 kWh/m^2.year	Primary energy factor: 0
	Electricity (total)		104.5 kWh/m^2.year	Primary energy factor: 2.6 (PEF 2013)
	thereof heating auxiliary		3.0 kWh/m^2.year	
	thereof hot water		42.3 kWh/m^2.year	
	thereof ventilat.		39.7 kWh/m^2.year	
	thereof lighting		19.5 kWh/m^2.year	
	Total		104.5 kWh/m^2.year	
Renewable energy contribution ratio:	43% of the total final energy (heating energy based on the district heating). The renewable energy contribution of the PV system is not known.			
Improvement compared to national requirements:	44%		Compared to:	Maximum primary energy use according to EnEV 2009. PV-generated electricity is not taken into account in the calculation.
Experiences/ lessons learned:	Possibility to reach a very good energy reduction in schools. Widespread type of building of the 1970s in West Germany, so very good reproducibility for other schools. Low cost to enhance thermal comfort and air quality in the classrooms.			
Costs:	Based on cost groups, the cost estimate contains for construction: 5.1 million € building services: 2.9 million € additional expenses, incl. planning etc.: 3.1 million € Total: 11.1 million € (all costs incl. VAT)			
Funding:	The renovation was part of the *efficient house pilot projects* 2009. It was co-financed by the KfW Group and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMVBS)			
Marketing efforts:	Press releases about DENA's *efficient house pilot project*			
Links to further information:	www.zukunft-haus.info → *"Bauen & Sanieren"* www.zukunft-haus.info/effizienzhaus: Building-Database www.dena.de www.schrobenhausen.de → *"Bauen & Wirtschaft"*			

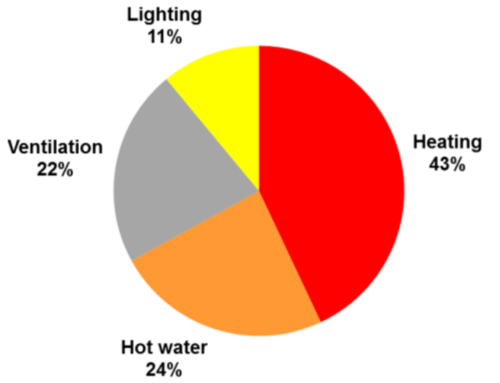
4.10 Ireland

<table>
<tr><td colspan="7">4.10.1Urban semi-detached house</td></tr>
<tr><td>Author(s):</td><td colspan="6">Chris Hughes, Sustainable Energy Authority of Ireland (SEAI)</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">Deep retrofit and extension of a 1950s 3 bedroom solid block house to provide a 160 m² two-storey, four-bedroom house. Calculated energy consumption reduced by over 90% to achieve an A2 energy rating.</td></tr>
<tr><td>Building address:</td><td colspan="6">58 Cedarmount Avenue, Mount Merrion, Co. Dublin</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Single-family house</td></tr>
<tr><td>Building size:</td><td colspan="6">160 m² living area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Walls: 150 mm Platinum EPS insulation and mineral render finish externally, on 1) solid original 230 mm concrete block or 2) solid 215 mm QUINN-lite aerated block (mortar joint), and gypsum hard-rock plaster.
Roof: attic floor for storage made airtight and insulated with 110 mm bio-based spray foam insulation, overlaid with 250 mm blown cellulose
Floor: concrete floor/Supergrund-insulated foundation system with 300 mm Aeroboard Platinum EPS insulation.
New tripled-glazed windows and doors
Airtightness: 1.23 air changes per hour at 50 Pa.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.145 - 0.19 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.9 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.13 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.11 - 0.14 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">25 KW modulating condensing, weather-compensated gas boiler with floor heating throughout ground floor at 150 mm centres with 2 towel radiators in bathrooms upstairs. Five-zone temperature control and timer. Ventilation system with 91% heat recovery.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Evacuated tubes solar thermal collector: 2 x 20 tubes (58 mm vacuum tube) with 300 liter dedicated solar storage volume.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	Dwelling Energy Assessment Procedure (DEAP)
	Measured		Monitored in year:	-
	Heating		10.7 kWh/m^2.year	
	Hot water		12.2 kWh/m^2.year	
	Cooling		0.0 kWh/m^2.year	
	Ventilation		4.0 kWh/m^2.year	
	Lighting		4.5 kWh/m^2.year	
	Electrical appliances (household electricity)		unknown	
	Total		31.4 kWh/m^2.year	
Primary energy use:	Natural gas		25.2 kWh/m^2.year	Primary energy factor: 1.1
	Electricity		21.9 kWh/m^2.year	Primary energy factor: 2.58
	Total		47.1 kWh/m^2.year	
Renewable energy contribution ratio:	30% of the total final energy Solar hot water heating system contribution is included in total final energy			
Improvement compared to national requirements:	56%		Compared to:	Overall primary energy calculation using the maximum permissible U-values
Experiences/ lessons learned:	Significant improvements in building fabric U-values and a mechanical ventilation heat recovery system were used to achieve the low space-heating goal. Old suspended timber floors on the ground floor were removed and replaced with concrete flooring and 200 mm EPS insulation for improved thermal performance and air tightness.			
Costs:	Budget: 170,000 € (1,063 €/m^2)			
Funding:	Client funds with support from SEAI			
Marketing efforts:	www.nzeb-opendoors.ie http://www.greenextension.eu/pdf/EnerPHit%20Project.pdf			
Awards:	Isover Energy Efficiency award winner in 2013			
Links to further information:	http://www.greenextension.eu/pdf/EnerPHit%20Project.pdf			

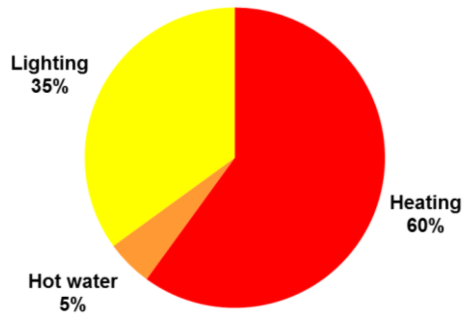
4.10.2 Post Primary School Research Project

<table>
<tr><td>Author(s):</td><td colspan="6">Chris Hughes, Sustainable Energy Authority of Ireland (SEAI)</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">First A2 rated post primary school</td></tr>
<tr><td>Building address:</td><td colspan="6">Colaiste Choilm, O’Moore Street, Tullamore, Co. Offaly</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Post primary school completed in 2011</td></tr>
<tr><td>Building size:</td><td colspan="6">4,681 m² useful floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Overall U-value is 0.36 W/m².K – 50% better than the current building regulations
Air tightness of 3 m³/h per m² at 50 Pa</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.09 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">1.5 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.18 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.19 W/m².K</td></tr>
<tr><td colspan="2">Doors</td><td colspan="4">2.19 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Biomass boiler and combined heat and power system based on natural gas with low-temperature hot water radiators for heating
Automatic ventilation openings fitted with airtight automatic shut-off and linked to CO_2 sensors
Building control strategies designed to minimise energy use
Improved energy monitoring and management awareness
Use of LED-based external lights with improved controls
Improved water conservation measures</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Biomass heating
Combined heat and power system based on natural gas
Photovoltaic electricity production.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	Non Domestic Energy Assessment Procedure (NEAP)
	Measured		Monitored in year:	2011
	Heating		32.89 kWh/m^2.year	
	Hot water		1.00 kWh/m^2.year	
	Cooling		0.00 kWh/m^2.year	
	Ventilation		3.10 kWh/m^2.year	
	Lighting		15.55 kWh/m^2.year	
	Electrical appliances		Unknown	
	Total		52.54 kWh/m^2.year	
Primary energy use:	Natural gas		31.36 kWh/m^2.year	Primary energy factor: 1.1
	Biomass		33.90 kWh/m^2.year	Primary energy factor: 1.1
	Electricity		18.65 kWh/m^2.year	Primary energy factor: 2.7
	Total		81.91 kWh/m^2.year	
Renewable energy contribution ratio:	~ 40% of the total final energy			
Improvement compared to national requirements:	50%		Compared to:	Improved insulation levels. U-value for the building is 0.36 W/m^2K which is 50% better than the current building regulations.
Experiences/ lessons learned:	The school is a research and demonstration project to improve the quality of teaching spaces and notably reduce the school's environmental impact. Over 21 sustainable design aspects were reviewed. Extensive automated monitoring systems establish energy consumption profiles and user patterns. The design incorporates passive, active, and renewable techniques.			
Costs:	Total project: 5.3 million € 255,000 € for additional energy efficiency measures			
Funding:	Department of Education and Skills			
Marketing efforts:	All new primary schools are built to Building Energy Rating (BER) A3 or better. Building is featured in SEAI Energy USE in Public Sector publication.			
Awards:	The Department of Education and Skills energy programme commenced in 1997 and is recognised at national and international levels for excellence in design and specifications. Top prize at 2012 Green Awards.			
Links to further information:	http://www.education.ie/en/Press-Events/Press-Releases/2012-Press-Releases/20%20April,%202012%20-%20Department%20of%20Education%20and%20Skills%20wins%20top%20prize%20at%202012%20Green%20Awards.html			

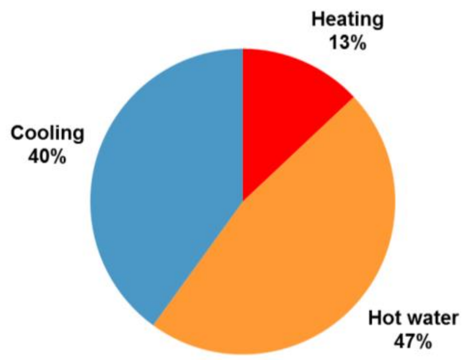
4.11 Italy

<table>
<tr><td colspan="7">4.11.1 ECOsil</td></tr>
<tr><td>Author(s):</td><td colspan="6">Gian Mario Varalda, Agenzia Provinciale per l’Energia del Vercellese e della Valsesia
Architect: Gianni Carlo La Loggia
Building contractor: Impresa La Loggia Giuseppe</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">The building minimises energy requirements and the remaining energy needs are covered by an innovative and efficient system, integrated with renewable sources.</td></tr>
<tr><td>Building address:</td><td colspan="6">P. Isacco 50, 13039 Trino (VC) Italy</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Single-family house with 2 storeys</td></tr>
<tr><td>Building size:</td><td colspan="6">185 m² heated floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">External walls are made of autoclaved aerated concrete blocks with external thermal insulation (EPS and cellulose fibre). The ground slab is created with disposable formwork for ventilated underfloor cavities; the roof has a wooden structure and is insulated with wood fibre.
The windows have triple glazing and wooden frames with aluminium-clad exterior. Thermal bridges have been minimised. Solar thermal collectors and photovoltaic panels cover the roof.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.18 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">1.00 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.18 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.21 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">The heating system is based on a condensing boiler (modulating between 5 and 25 kW) fuelled by natural gas, and it provides support to the DHW also. Radiant wall panels supply heat to the rooms. The heating system includes renewable energy, with 4 solar thermal collectors and a 500 liter storage. To provide good indoor air quality, a mechanical ventilation system with heat recovery was installed.</td></tr>
</table>

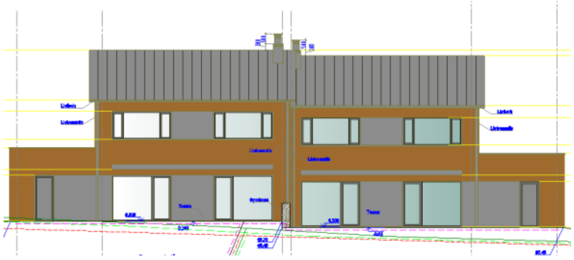
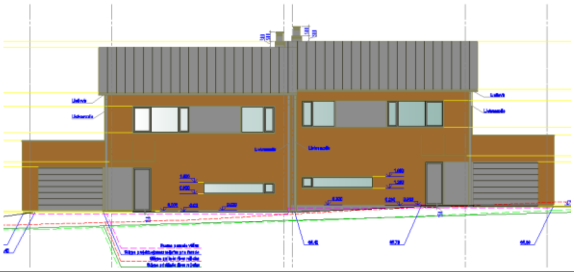
Included renewable energy technologies:	The solar thermal system (flat-plate solar collectors) has 9.32 m² and covers 96% of the needs for DHW. In addition, there are PV panels (monocrystalline) with a peak power of 2.94 kW_p.			
Final energy use:	Calculated		Calculation method:	According to EU Directive 2002/91/CE, 16/12/2002. According to the Decree n. 34, 29/09/2004 of the President of the Autonomous Province of Bolzano.
	Measured	X	Monitored in year:	2012/2013
	Heating		25.81 kWh/m².year	
	Hot water		2.05 kWh/m².year	
	Cooling		0.00 kWh/m².year	
	Ventilation		in use but not measured	
	Lighting		14.88 kWh/m².year	
	Electrical appli-ances (household electricity)		unknown	
	Total		42.74 kWh/m².year	
	PV generated electricity		~ 3,200 kWh/year 17.32 kWh/m².year	
Primary energy use:	Total		23 kWh/m².year	
Renewable energy contribution ratio:	67% of the total final energy			
Improvement compared to national requirements:	80%		Compared to:	Heating energy consumed by traditional building, according to the CASACLIMA certification.
Experiences/ lessons learned:	The family living in the house is very satisfied with the energy performance of their dwelling. The energy bill has been very low, so it demonstrates that the goal has been achieved.			
Costs:	The final cost of these buildings was 350,000 € each, which represents a 25% cost increase compared to a similar building using traditional solutions.			
Funding:	As this project was partially financed by the Piedmont Regional Administration with a 50% refund of the additional costs, the impact of such costs was significantly reduced.			
Marketing efforts:	These low-energy buildings were designed and built according to the Bolzano CASACLIMA protocol and they obtained the official CASACLIMA golden certification for the first time in the territory of the Province of Vercelli. Since 2010, the buildings have been visited by architecture students.			
Awards:	The house received CASACLIMA A classification, which refers to buildings with a heat consumption of less than 30 kWh/m².year. The project was illustrated in the KlimaHause n. 2 April 2011 magazine, and it has won first prize in the 2013 Best Practice S.A.E.E. contest organised by ValoreClima of the Province of Vercelli.			
Links to further information:	http://www.architettolaloggia.it/ http://europaconcorsi.com/projects/242014-Gianni-Carlo-La-Loggia-ECOsil http://www.agenziacasaclima.it/it/rete-casaclima/la-rete-casaclima/casa-eco-sil-2/111-11045.html http://www.consorziouniver.it/it-IT/news-eventi/i-vincitori-del-concorso-best-practice/			

4.11.2 ENERGY BOX

<table>
<tr><td>Author(s):</td><td colspan="6">Gian Mario Varalda, Agenzia Provinciale per l'Energia del Vercellese e della Valsesia
Architect: Ing. Pierluigi Bonomo</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">Best Current Practice according to ITACA protocol, certification in Italian national class A^+ (21.3 kWh/m².year); emissions reduced by 15 times compared to the required limits.</td></tr>
<tr><td>Building address:</td><td colspan="6">Via S. Demetrior ss 216, Località S. Gregorio – L'Aquila</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Single-family house with 3 storeys</td></tr>
<tr><td>Building size:</td><td colspan="6">173 m² net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Wood and wood-fibre walls with chalk lining, reinforced (1% steel) concrete lower walls, insulation of linen fibre. The windows have triple glazing.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">Upper: 0.120 W/m².K; lower: 0.126 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.89 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.09 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.12 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Systems include a 10 kW reversible geothermal heat pump for heating and cooling, solar thermal panels, a ventilation system with heat recovery and integrated electrical heaters, PV panels with 8.5 kW_p and fixed and adjustable shades.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Solar thermal panels, PV panels (thin-film), geothermal heat pump</td></tr>
</table>

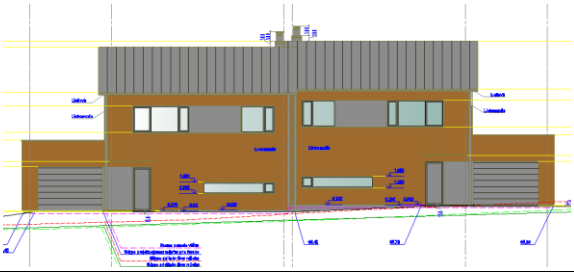
<table>
<tr><td rowspan="10">Final energy use:</td><td>Calculated</td><td>X</td><td>Calculation method:</td><td>According to EU Directive 2002/91/CE, 16/12/2002, UNI/TS 11300:2008 and CASACLIMA protocol</td></tr>
<tr><td>Measured</td><td></td><td>Monitored in year:</td><td>2013 (data not yet available)</td></tr>
<tr><td colspan="2">Heating</td><td>4.60 kWh/m^2.year</td><td rowspan="8">
</td></tr>
<tr><td colspan="2">Hot water</td><td>16.68 kWh/m^2.year</td></tr>
<tr><td colspan="2">Cooling</td><td>14.00 kWh/m^2.year</td></tr>
<tr><td colspan="2">Ventilation</td><td>in use but not measured</td></tr>
<tr><td colspan="2">Lighting</td><td>Unknown</td></tr>
<tr><td colspan="2">Electrical appli-ances (household electricity)</td><td>Unknown</td></tr>
<tr><td colspan="2">Total</td><td>35.28 kWh/m^2year</td></tr>
<tr><td colspan="2">PV generated electricity</td><td>Unknown</td></tr>
<tr><td>Costs:</td><td colspan="4">Total costs were 1,465 €/m^2 gross floor area including demolitions.</td></tr>
<tr><td>Marketing efforts:</td><td colspan="4">This very low-energy building was designed and built according to the Bolzano CASACLIMA protocol and the official CASACLIMA golden certification was obtained for the first time in the territory of Region Abruzzo.</td></tr>
<tr><td>Awards:</td><td colspan="4">Golden CASACLIMA certificate
Special mention of "Premio SOSTENIBILITA' 2013" of Modena Sustainable Energy Agency AESS</td></tr>
</table>

4.12 Lithuania

<table>
<tr><td colspan="6">4.12.1 Single-family houses in Moletai with district heating</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="6">Tomas Baranauskas, Ministry of the Environment of the Republic of Lithuania</td></tr>
<tr><td>Illustration:</td><td colspan="6">
</td></tr>
<tr><td>Project aim:</td><td colspan="6">Presenting a simple way to achieve NZEB</td></tr>
<tr><td>Building address:</td><td colspan="6">Not yet available (building project for a private builder)</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Double house</td></tr>
<tr><td>Building size:</td><td colspan="6">394.42 m² heated net floor area for both building halves, 197.21 m² for one residential unit.</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Not defined at this stage. The calculation is based on the required U-values.</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.1 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.7 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.08 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.1 W/m².K</td></tr>
<tr><td colspan="2">Doors, gates</td><td colspan="4">0.7 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating and hot water: District heating system ('Moletu siluma')
Ventilation: Mechanical ventilation system with 85% heat recovery and electricity consumption for the ventilation of 0.4 Wh/m³
Lighting: 50 lm/W
No cooling equipment</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Parameters of district heating system given by the thermal energy supplier 'Moletu siluma': non-renewable primary energy factor f_{PRn} = 0.22, renewable primary energy factor f_{PRr} = 1.42. This means a renewable energy ratio of the district heating system of 87%.</td></tr>
</table>

Primary energy use: -> Non-renewable primary energy use	District heating (heating + DHW)	8.12 kWh/m^2.year	(Non-renewable) primary energy factor: 0.22
	Electricity (ventilation + lighting + household electricity + outdoor lighting)	34.65 kWh/m^2.year	(Non-renewable) primary energy factor: not available
	Total	42.77 kWh/m^2.year	
Renewable energy contribution ratio:	60% of the total primary energy In Lithuania, the renewable energy contribution ratio is calculated by renewable primary energy divided by non-renewable energy and has to be > 1 for NZEBs. The value for this house is 1.53.		
Improvement compared to national requirements:	82%	Compared to:	Normal non-renewable primary energy use for heating, cooling, hot water and electricity: 236.02 kWh/m^2.year

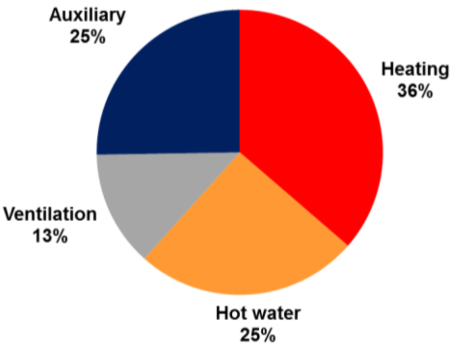
4.12.2 Single-family houses in Moletai with wood boiler

<table>
<tr><td>Author(s):</td><td colspan="6">Tomas Baranauskas, Ministry of the Environment of the Republic of Lithuania</td></tr>
<tr><td>Illustration:</td><td colspan="6">
</td></tr>
<tr><td>Project aim:</td><td colspan="6">Presenting a simple way to achieve NZEB</td></tr>
<tr><td>Building address:</td><td colspan="6">Not yet available (building project for a private builder)</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Double house</td></tr>
<tr><td>Building size:</td><td colspan="6">394.42 m² heated net floor area for both building halves, 197.21 m² for one residential unit.</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Not defined at this stage. The calculation is based on the required U-values.</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.1 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.7 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.08 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.1 W/m².K</td></tr>
<tr><td colspan="2">Doors, gates</td><td colspan="4">0.7 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Space heating: stand-alone wood boiler with an efficiency of 85%
Hot water: wood boiler + solar thermal collectors + 1,500 m³ storage including a composite electrical heater
Ventilation: Mechanical ventilation system with 85% heat recovery and electricity consumption for the ventilation of 0.4 Wh/m³
Lighting: 15 lm/W
No cooling equipment</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Solar thermal collectors for hot water of 24 m²
Photovoltaic panels of 10 m²
Wind power station for electricity: wing diameter 4 m, axle height over ground level 10 m, location: Vilnius region.</td></tr>
</table>

Primary energy use: -> Non-renewable primary energy use	Wood	not available	Non-renewable primary energy factor: not available
	Electricity (ventilation + lighting + household electricity + outdoor lighting)	not available	Non-renewable primary energy factor: not available
	Total	44.25 kWh/m^2.year	
Renewable energy contribution ratio:	51% of the total primary energy In Lithuania, the renewable energy contribution ratio is calculated by renewable primary energy divided by non-renewable energy and has to be > 1 for NZEBs. The value for this house is 1.03.		
Improvement compared to national requirements:	81%	Compared to:	Normal non-renewable primary energy use for heating, cooling, hot water and electricity: 236.02 kWh/m^2.year

4.13 Luxembourg

4.13.1 EcoHouse in Ayl

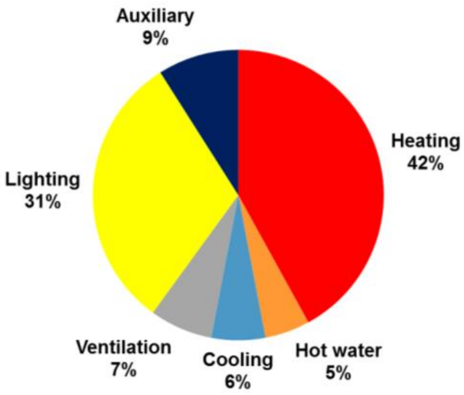
Author(s):	Markus Lichtmeß, Goblet Lavandier & Associés S.A.				
Illustration:					
Project aim:	NZEB and Class A-certification according to the energy ordinance of Luxembourg				
Building address:	Markus Lichtmeß, 54441 Ayl, Germany. (Situated in Germany on the border to Luxembourg, built according to Luxembourgs NZEB-Standard)				
Building type:	Residential	Non-residential	Public	New	Renovated
	X			X	
	Single-family house				
Building size:	212 m² net floor area				
Building envelope construction:	Massive wood structure; ~40 cm sustainable external building insulation (cellulose, wood fibre and foam-glass gravel) with opaque building components. Windows have triple glazing.				
Building envelope U-values:	Wall	0.11 W/m².K			
	Window	0.64 W/m².K			
	Roof/ceiling to the attic	0.10 W/m².K			
	Cellar ceiling/ground slab	0.12 W/m².K			
	Others	Doors: 0.78 W/m².K, optimised thermal bridges ± 0 W/m².K			
Building service systems:	Air-to-air heat pump with additional use of exhaust air (custom built), ventilation system with heat recovery, ground heat exchanger for ventilation.				
Included renewable energy technologies:	6 m² solar thermal plant (vacuum collector) for heating and DHW PV on roof 5.28 kW_p to cover the bulk of the building energy consumption.				
Final energy use:	Calculated	X	Calculation method:	*Règlement grand-ducal du 5 mai 2012 modifiant.*	
	Measured		Monitored in year:	2013-2014	
	Heating	3.7 kWh/m².year			
	Hot water	2.6 kWh/m².year			
	Cooling	0.0 kWh/m².year			
	Ventilation	1.3 kWh/m².year			
	Lighting	unknown			
	Electrical appli-ances (household electricity)	unknown			
	Auxiliary	2.6 kWh/m².year			
	Total (building services)	10.2 kWh/m².year			

<table>
<tr><td rowspan="4">Primary energy use:</td><td>Electricity (building services)</td><td>27.1 kWh/m².year</td><td colspan="2">Primary energy factor: 2.66</td></tr>
<tr><td>Electricity (lighting + household)</td><td>20.1 kWh/m².year</td><td colspan="2">Primary energy factor: 2.66</td></tr>
<tr><td>PV accountable (~30% directly used by building)
PV total incl. feed-in</td><td>19.9 kWh/m².year

66.2 kWh/m².year</td><td colspan="2">Primary energy factor: 2.66</td></tr>
<tr><td>Total (PV accountable)
Total (PV total)</td><td>27.3 kWh/m².year

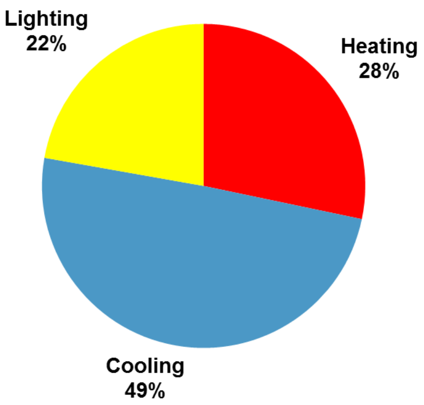
-19.0 kWh/m².year</td><td colspan="2"></td></tr>
<tr><td>Renewable energy contribution ratio:</td><td colspan="4">~ 30% of the final energy for heating and DHW (thermal solar plant)
~ 30% of the total electric energy use (services and household) (PV 5.28 kW_p)
If total PV is accounted: 140% renewable energy contribution ratio</td></tr>
<tr><td>Improvement compared to national requirements:</td><td>80%</td><td>Compared to:</td><td colspan="2">Règlement grand-ducal du 5 mai 2012 modifiant (version of 2010, Class D)
Primary energy compared to reference building of national calculation method (at present without PV).</td></tr>
<tr><td>Experiences/ lessons learned:</td><td colspan="4">The measured final energy consumption for heating and hot water in 2013 was 6.2 kWh_{el}/m².year; the total electric energy consumption 17.8 kWh_{el}/m².year (services + household). The PV delivers 24.9 kWh_{el}/m².year and the yearly load-match of the PV is approximately 30%.
It is fundamental that all buildings and systems are correctly designed and installed on the construction site:
take special care on the hydraulics of the heat storage tank (connections of pipes and tank, thermosiphon);
avoid low frequency noise < 150 Hz, especially for compressors in heat pumps;
the delivered temperature of the heat pump must be as low as possible;
careful sizing of the heat delivery systems to work at these temperatures;
execution of building construction details according to drawings (insulation of window frames, thermal bridges, etc.);
keep the ventilation duct system as short as possible and reduce the air flow speed to a minimum (energy consumption + noise);
choose ventilation systems with low-energy consumption (also in standby mode);
Venetians blinds should be automatically controlled to prevent overheating (at least according to the radiation and external temperature);
prevent condensation problems (e.g., pipes with cold air through insulated walls).
Main conclusion: in high efficient buildings, the design and execution of technical details (building and systems) carry a high proportion of the energy losses of the building, which underlines the importance of careful planning of these details.</td></tr>
<tr><td>Costs:</td><td colspan="4">Additional costs for the energy standard were ca. +14.4% (based on total costs for a ready to use house):
thermal solar plant +1.4%;
rain water collection system +0.5%;
PV-System (dated 2010) +3.7%;
insulation of walls, roof and ground +5.1%;
high energy efficient windows +1.2%;
energy efficient lighting (LED) +0.1%;
ventilation system with heat recovery +1.7% (integrated in heat pump);
ground heat exchanger +0.6%.</td></tr>
<tr><td>Funding:</td><td colspan="4">No request of external funding</td></tr>
<tr><td>Links to further information:</td><td colspan="4">Presentation about monitoring (period 2011 - 03/2013):
https://dl.dropboxusercontent.com/u/16134639/Vortrag%20Evaluierung%20PH%2007.03.2013.pdf</td></tr>
</table>

<table>
<tr><td colspan="6">4.13.2 Horizont-Building Strassen</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="6">Markus Lichtmeß, Goblet Lavandier & Associés S.A.
Project developer: Groupe Schuler</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">NZEB and HQE (“Haute Qualité Environnementale - Certivéa”) certification.</td></tr>
<tr><td>Building address:</td><td colspan="6">163 rue de Kiem – L-8030 Strassen Luxembourg</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Office building</td></tr>
<tr><td>Building size:</td><td colspan="6">3,200 m² net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">Concrete structure. External insulation of the building with a minimum 24 cm mineral wool for external walls. The windows have triple glazing.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.13 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">0.82 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.11 W/m².K to the outside
0.18 W/m².K to unheated zone</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.19 W/m².K to unheated zone</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating is based on a biomass (pellet) boiler. Heating and cooling distribution through concrete core activation. Cooling is generated by a scroll compressor with a hybrid water chiller combined with free chilling during the night. All zones are equipped with CO_2-sensors to regulate the hygienic air stream.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Pellet boiler included.
The roof is fully covered with PV (938 m² and 138 kW_p).</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	*Règlement grand-ducal du 5 mai 2012 modifiant*
	Measured		Monitored in year:	-
	Heating		31.8 kWh/m^2.year	
	Hot water		3.9 kWh/m^2.year	
	Cooling		4.5 kWh/m^2.year	
	Ventilation		5.3 kWh/m^2.year	
	Lighting		23.4 kWh/m^2.year	
	Electrical appliances		unknown	
	Auxiliary		6.7 kWh/m^2.year	
	Total		75.6 kWh/m^2.year	
	PV production		37.6 kWh/m^2.year	
Primary energy use:	Pellets (wood)		1.8 kWh/m^2.year	Primary energy factor: 0.07
	Gas		10.7 kWh/m^2.year	Primary energy factor: 1.12
	Electricity		105.9 kWh/m^2.year	Primary energy factor: 2.66
	Total		118.5 kWh/m^2.year	(PV production not deducted)
Renewable energy contribution ratio:	84% of the total final energy (94% of the total electricity)			
Improvement compared to national requirements:	62%		Compared to:	*Règlement grand-ducal du 5 mai 2012 modifiant* (version of 2010, Class D) Primary energy compared to reference building national calculation method (without PV).
Costs:	9 million € (2,813 €/m^2) incl. VAT for construction, without costs for consultancies, land and auxiliaries.			
Funding:	Equity and bank loans.			
Marketing efforts:	Awards and participations (Fiabci International Award, Green Awards, *Bauhärepräis OAI*), press articles as NZEB, visited by the Minister of Economy, Luxembourg, for the inauguration of the building.			
Awards:	*“Prix d’excellence Fédération internationale des professions immobilières FIABCI Luxembourg”* in Sustainable Building category			
Links to further information:	http://www.groupe-schuler.lu			

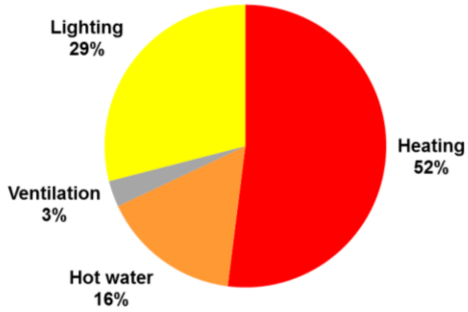
4.14 Malta

<table>
<tr><td colspan="7">4.14.1 Mosta House of Character</td></tr>
<tr><td>Author(s):</td><td colspan="6">Matthew Degiorgio, Building Regulation Office</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">The project was undertaken as a private initiative by the building owners to reduce the energy use of the building.</td></tr>
<tr><td>Building address:</td><td colspan="6">9, Triq Salvu Dimech, Mosta, Malta</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Single-family house</td></tr>
<tr><td>Building size:</td><td colspan="6">209 m² total floor area (all internal areas which might be heated or cooled)</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The walls are made of stone masonry with a total thickness of 0.5 m (2 limestone walls of 0.225 m and a 0.05 m air cavity in between). The roof is constructed with reinforced concrete slabs with an average of thickness 125 mm expanded polystyrene insulation under 100 mm stone chippings laid to slope and a 100 mm concrete screed above. The windows are double glazed (not low emissivity) with an argon-filled gap.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">1.57 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">3.00 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.25 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">1.97 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Heating and cooling are provided through inverter split-type air-conditioning systems. Due to the high thermal mass of the building, the heating and cooling loads are limited. Hot water is provided through a flat-plate solar water collector with an aperture area of 4 m² and a storage capacity of 250 liters.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">The house was fitted with a south-facing flat-plate solar water heater. The collector is capable of providing all hot water requirements throughout the whole year.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	EPRDM (Standard energy performance certification software)
	Measured		Monitored in year:	-
	Heating		3.25 kWh/m².year	
	Hot water		0.00 kWh/m².year (100% renewable)	
	Cooling		5.62 kWh/m².year	
	Ventilation		0.00 kWh/m².year	
	Lighting		2.57 kWh/m².year	
	Electrical appli-ances (household electricity)		unknown	
	Total		11.44 kWh/m².year	
Primary energy use:	Electricity		39.47 kWh/m².year	Primary energy factor: 3.45
	Total		39.47 kWh/m².year	
Renewable energy contribution ratio:	49% of the total final energy			
Improvement compared to national requirements:	50%		Compared to:	Current minimum requirements stipulate maximum conductivity of elements and do not require minimum contributions from renewable sources. A building with similar geometry built to minimum requirements and with no renewable energy sources installed would have a primary energy rating of 110 kWh/m².year (as per the national EPC rating system).
Experiences/ lessons learned:	Given the mild climate and good solar potential of most buildings in Malta, NZEB levels may be achieved through minimisation of heat transfer through the roof, high thermal mass and some use of renewable sources (in this case solar water heating). Conservation of energy through the building envelope is particularly critical for the roof, but NZEB levels may still be achieved with only low insulation levels in the walls.			
Costs:	Cost data was not provided (private project).			
Funding:	Funding for the project was private. The renovation was eligible to benefit from schemes available such as those for double glazing, roof insulation and solar water heaters. These are available to the public in general and not dependent on the building achieving the overall NZEB levels.			
Marketing efforts:	The building is owned and occupied by the owner; therefore, no marketing efforts took place.			
Awards:	The building is classified as NZEB.			

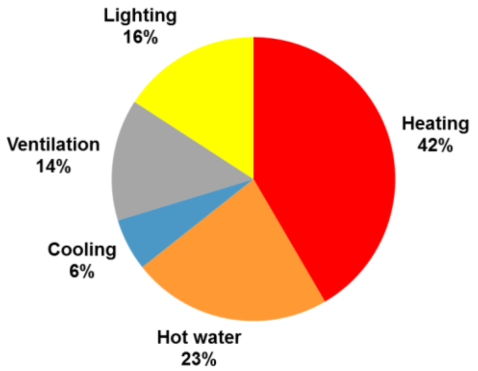
4.15 The Netherlands

<table>
<tr><td colspan="7">4.15.1Brabantwoningen</td></tr>
<tr><td>Author(s):</td><td colspan="6">Daniël van Rijn, Jacqueline Hooijschuur, RVO.nl</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">Focusing on ecological and biological building techniques, these single-family houses are positive energy buildings (thus have a negative Energy Performance Coefficient) and have low investment costs.</td></tr>
<tr><td>Building address:</td><td colspan="6">Kruizemuntstraat, St.Oedenrode, Netherlands (province: Brabant)</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">27 single-family houses</td></tr>
<tr><td>Building size:</td><td colspan="6">98.35 m² living area each ('gebruiksoppervlak' according to NEN 2025)</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The 'Brabantwoning' development has a high-level insulated building envelope and triple glazing. The separation wall between the dwellings is insulated also. To avoid high indoor temperatures in the summer, the roof is partly covered with sedum plants and the construction has a high thermal mass. Burglar-proof features have been added (with a rain sensor in the roof) to make high ventilation rates possible during the night and during periods of the absence of inhabitants.</td></tr>
<tr><td rowspan="4">Building envelope U-values/R-values:</td><td colspan="2">Wall</td><td colspan="4">Rc = 8 m².K/W</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">U = 0.8 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">Rc = 8 m².K/W</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">Rc = 5 m².K/W</td></tr>
<tr><td>Building service systems:</td><td colspan="6">Exhaust air from the ventilation system is used by a heat pump for heating the house and providing hot water in combination with solar thermal panels.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">A large number of photovoltaic panels are placed on the roof to compensate the electricity required for the building service systems and other equipment in the house. This way a NZEB is realised. The building service systems include a heat pump and solar thermal panels.</td></tr>
</table>

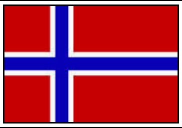
Primary energy use:	Calculated	X	Calculation method:	Energy performance of buildings - determination method NEN 7120
	Measured		Monitored in year:	-
	Heating		22.8 kWh/m^2.year	
	Hot water		7.1 kWh/m^2.year	
	Cooling		0.0 kWh/m^2.year	
	Ventilation		1.5 kWh/m^2.year	
	Lighting		12.8 kWh/m^2.year	
	Electrical appli-ances (household electricity)		unknown	
	PV panels		-95.3 kWh/m^2.year	
	Total		-51.1 kWh/m^2.year	
Primary energy factors:	Electricity building related			Primary energy factor: 2.54
	Electricity household equipment			Primary energy factor: 2.00
	Natural gas			Primary energy factor: 1.00
Renewable energy contribution ratio:	216% PV contribution of the total primary energy			
Improvement compared to national requirements:	148%		Compared to:	Dutch Energy Performance Coefficient (*Energieprestatiecoefficient*) requirement. Required Energy Performance Coefficient is 0.6. Calculated Energy Performance Coefficient is -0.29
Links to further information:	http://www.kennishuisgo.nl/voorbeeldprojecten/ProjectPage.aspx?id=955 http://www.archiservice.nl/?cat=7 http://www.brabant.nl/dossiers/dossiers-op-thema/bouwen-en-wonen/duurzaam-bouwen/de-brabantwoning.aspx			

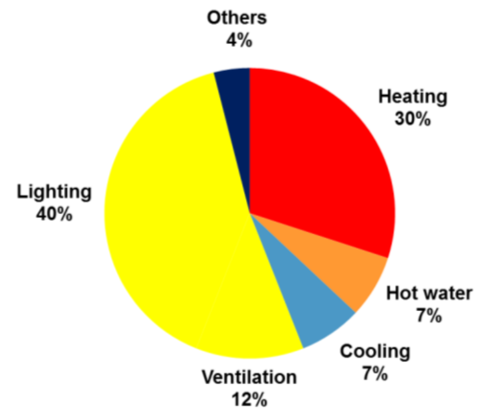
4.15.2 Down 2-000

<table>
<tr><td>Author(s):</td><td colspan="6">Daniël van Rijn, Jacqueline Hooijschuur, RVO.nl</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">These 21 low-energy houses on the Rijsdijk in Etten-Leur are built with a Dutch Energy Performance Coefficient below zero. The project is a part of a larger group of 43 houses. They are a part of the newly developed district 'de Keen' where more zero-energy houses are built. The intention of this district is to help reducing CO_2 emissions.</td></tr>
<tr><td>Building address:</td><td colspan="6">Rijsdijk, Etten-Leur</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">21 single-family houses</td></tr>
<tr><td>Building size:</td><td colspan="6">160 m² living area each ('gebruiksoppervlak' according to NEN 2025)</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The construction of the roof of these houses, with approximately 50 m² photovoltaic solar panels, is special. The separate construction is mounted on the flat roof. This makes the construction easy to reach for maintenance and, if necessary, for expansion. The structure also provides shade to prevent overheating in the summer. The separate structure makes it possible to optimise the ventilation of the solar panels to improve their performance. It also makes the solar panel system independent from the orientation of the houses and gives possibilities for further optimisation in the future.</td></tr>
<tr><td rowspan="4">Building envelope U-values/R-values:</td><td colspan="2">Wall</td><td colspan="4">Rc = 5 m².K/W (ground floor), 8.1 m².K/W (1st + 2nd floor)</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">U = 1.65 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">Rc = 5 m².K/W</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">Rc = 4 m².K/W</td></tr>
<tr><td>Building service systems:</td><td colspan="6">The Energy Performance Coefficient below zero is realised by the use of a ground source heat pump, heat recovery from the exhaust air, solar thermal collectors, PV panels and an optimised orientation of the houses. The summer heat is stored in the ground and used in winter time.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">Photovoltaic panels, solar thermal collectors for DHW, ground source heat pump</td></tr>
</table>

Primary energy use:	Calculated	X	Calculation method:	Energy performance of buildings - determination method NEN 7120
	Measured		Monitored in year:	-
	Heating		32.4 kWh/m^2.year	
	Hot water		17.7 kWh/m^2.year	
	Cooling		4.3 kWh/m^2.year	
	Ventilation		10.8 kWh/m^2.year	
	Lighting		12.8 kWh/m^2.year	
	Electrical appli-ances (household electricity)		unknown	
	PV panels		-111.4 kWh/m^2.year	
	Total		-33.4 kWh/m^2.year	
Primary energy factors:	Electricity building related			Primary energy factor: 2.54
	Electricity household equipment			Primary energy factor: 2.00
	Natural gas			Primary energy factor: 1.00
Renewable energy contribution ratio:	143% PV contribution of the total primary energy			
Improvement compared to national requirements:	106%		Compared to:	Dutch energy performance coefficient ("*Energieprestatiecoefficient*") requirement. Required Energy Performance Coefficient is 0.6. Calculated Energy Performance Coefficient is -0.04
Experiences/ lessons learned:	Ventilation and solar blinds are positively valued by the inhabitants, but the production of electricity by the PV panels is below expectation. There have been problems with the heat pump system due to bad maintenance. The collective heat source (ground) for the heat pump is relatively expensive for a small project like this. Individual heat pumps might have been more cost effective. In the design stage, sufficient attention should be paid to the position and the space needed for technical equipment and maintenance of these, to avoid inconvenience for the inhabitants.			
Links to further information:	http://www.kennishuisgo.nl/voorbeeldprojecten/ProjectPage.aspx?id=959			

4.16 Norway

<table>
<tr><td colspan="7">4.16.1 Powerhouse Kjørbo</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="7">Martin Strand, Norwegian Building Authority</td></tr>
<tr><td>Illustration:</td><td colspan="7"></td></tr>
<tr><td>Project aim:</td><td colspan="7">Demonstrate the possibility of transforming a typical 1980s office building into a plus-energy office building, generating more energy during its lifetime than what was used during the production of materials, construction, operation and demolition. The project is aiming for a BREEAM-NOR 'Outstanding' classification, the highest classification in BREEAM-NOR. It will also fulfil all requirements in the Norwegian passive house standard for non-residential buildings, NS 3701.</td></tr>
<tr><td>Building address:</td><td colspan="7">Kjørboveien 18 - 20, 1337 Sandvika, Norway</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td colspan="2">Public</td><td rowspan="2"></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td>X</td><td colspan="2"></td><td></td><td>X</td></tr>
<tr><td colspan="7">Office building</td></tr>
<tr><td>Building size:</td><td colspan="7">5,200 m^2 net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="7">Old structural elements in concrete were kept, highly insulated timber frame walls and charred wood cladding added to maintain the aesthetics of the old black glass façade. Use of tailor-made aluminium-framed openable windows with triple glazing. The design airtightness of the building envelope is 0.50 air changes per hour at 50 Pa (tests have shown actual results of 0.3 air changes per hour).
Exposed concrete for high internal inertia is used. Low emitting materials reduce ventilation demand for indoor air quality control.</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="5">0.13 $W/m^2.K$</td></tr>
<tr><td colspan="2">Window</td><td colspan="5">0.80 $W/m^2.K$</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="5">0.08 $W/m^2.K$</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="5">0.14 $W/m^2.K$</td></tr>
<tr><td colspan="2">Thermal bridge value ('normalised')</td><td colspan="5">0.02 $W/m^2.K$</td></tr>
<tr><td>Building service systems:</td><td colspan="7">Electricity is covered by solar panels on roof. Geothermal heat pumps, for heating, cooling and hot water. Own heat pump to re-use heat from the cooling of server parks as heating. Exterior sunscreen automated system. Innovative ventilation system with extremely low pressure drop over the components and in the ventilation ducts. Components with high pressure drop, such as the heat recovery unit, are bypassed when not in use. The system utilises displacement ventilation, demand-controlled lighting and better use of daylight.</td></tr>
</table>

Included renewable energy technologies:	Solar cell park (1,400 m^2) on flat roof, delivering more than 200,000 kWh/m^2.year, or 41 kWh/m^2.year. Geothermal heat pump with 10 wells. Connected to district heating as a back-up solution.			
Final energy use:	Calculated	X	Calculation method:	NS 3031
	Measured		Monitored in year:	-
	Heating	5.9 kWh/m^2.year		
	Hot water	1.4 kWh/m^2.year		
	Cooling	1.3 kWh/m^2.year		
	Ventilation	2.3 kWh/m^2.year		
	Lighting	7.7 kWh/m^2.year		
	Electrical appliances	unknown		
	Others	0.8 kWh/m^2.year		
	Total	19.4 kWh/m^2.year		
Primary energy use:	Electricity	28.3 kWh/m^2.year		There are no official national primary energy factors available yet. However, the project has calculated a life-cycle-based primary energy factor for the electricity by balancing the grid electricity and the PV produced electricity as an average over 60 years at 1.46.
	Total	28.3 kWh/m^2.year		
Renewable energy contribution ratio:	100% of the total final energy. The building has been designed to generate a surplus of 18.4 kWh/m^2.year, with operational energy (excluding equipment computers, servers, etc.) and embodied energy in materials being taken into account.			
Improvement compared to national requirements:	80%		Compared to:	National minimum requirements for net energy use defined in TEK10: "*Regulations on technical requirements for building works*". http://www.dibk.no/globalassets/byggeregler/regulations_on_technical_requirements_for_building_works.pdf
Experiences/ lessons learned:	High focus on integrating architecture and technical systems, embodied energy, options for the re-use of materials and construction elements, high level of energy efficiency (building envelope and innovative ventilation solutions). Effort was put into designing an optimised energy supply system for on-site production of thermal energy and electricity. The project is expected to be an important demonstration project for plus-energy buildings worldwide. The building has been occupied since 2014; therefore, measured values are not yet available.			
Costs:	Construction costs were 114 million NOK (13.86 million €, or 2,665 €/m^2). The project was developed in cooperation between the Powerhouse-Alliance and the Research Centre on Zero Emission Buildings (ZEB).			
Funding:	14.9 million NOK (1.81 million €) in funding from the national support program for upgrade of existing buildings (ENOVA).			
Marketing efforts:	New tenant was part of the design team.			
Awards:	BREEAM-NOR 'Outstanding'			
Links to further information:	www.powerhouse.no www.zeb.no			

4.16.2 Miljøhuset GK

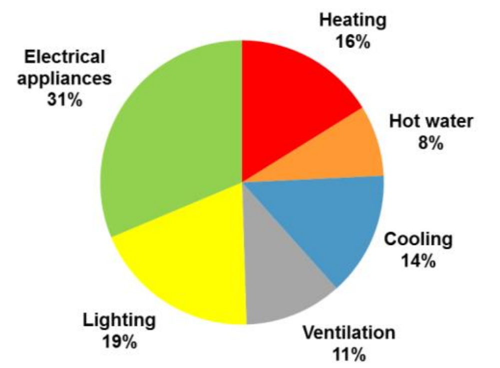
Author(s):	Martin Strand, Norwegian Building Authority
Illustration:	
Project aim:	Passive house office building according to the Norwegian passive house standard NS 3701, EPC Classification A, good architectural qualities, low total environmental impact, space efficient, economical in construction and operational phase. The extra cost of constructing at passive house level should be profitable.
Building address:	Ryenstubben 12, 0679 Oslo, Norway

Building type:	Residential	Non-residential	Public		New	Renovated
		X			X	
	Office Building					

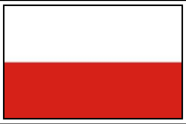
Building size:	13,619 m² heated (net) floor area
Building envelope construction:	Use of insulated timber studs and sills for wall construction, reducing the wall thickness from 35 cm to 29 cm. Thirty-five cm EPS insulation for slab on ground. Thirty cm standard mineral wool in walls and 40 cm standard mineral wool in roof. Triple-paned windows. Achieved airtightness is 0.23 air changes per hour at 50 Pa.

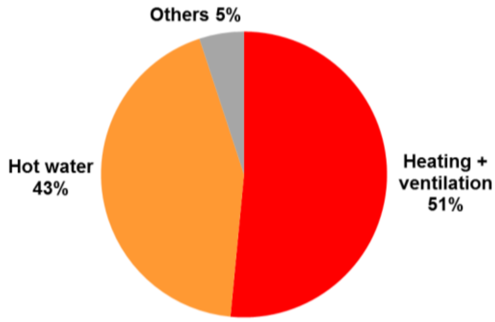
Building envelope U-values:	Wall	0.14 W/m².K
	Window	0.78 W/m².K
	Roof/ceiling to the attic	0.10 W/m².K
	Cellar ceiling/ground slab	0.07 W/m².K
	Thermal bridge value (‘normalised’)	0.03 W/m².K

Building service systems:	Air-to-water reversible heat pumps with the same distribution system for heating and cooling. The building uses heat recovery from cooling, especially from server rooms. Well-insulated pipes, valves and flanges. Automatic solar shading system on the eastern, southern and western façades. Electric heat system integrated in office power poles, estimated to be used less than 2% of the year (when outside temperature is below -15°C). Detector-controlled (presence, CO_2, and temperature) ventilation and lighting systems. Eighty-eight per cent heat recovery in the ventilation system. Six oversized ventilation generators ensure low pressure fall and SFP < 1.2 kW/(m³/s).

Included renewable energy technologies:	Air-to-water heat/cooling pump (glycol).			
Net energy use:	Calculated	X	Calculation method:	NS 3031
	Measured		Monitored in year:	-
	Heating		10.5 kWh/m^2.year	
	Hot water		5.0 kWh/m^2.year	
	Cooling		9.2 kWh/m^2.year	
	Ventilation		7.2 kWh/m^2.year	
	Lighting		12.5 kWh/m^2.year	
	Electrical appliances		19.8 kWh/m^2.year	
	Total		64.2 kWh/m^2.year	
Final energy use:	Total		49 kWh/m^2.year	Calculated based on the efficiency of the heat pumps.
Primary energy use:	Electricity		Not available	There are no official national primary energy factors available yet.
	Total		Not available	
Renewable energy contribution ratio:	24% of the total final energy (76% of the total net energy need of building covered by electricity)			
Improvement compared to national requirements:	60%		Compared to:	National minimum requirements for net energy use defined in TEK10: "*Regulations on technical requirements for building works*". http://www.dibk.no/globalassets/byggeregler/regulations_on_technical_requirements_for_building_works.pdf
Experiences/ lessons learned:	Design phase showed that few measures with very little extra cost would make the building go from the minimum requirements for new buildings (EPC rating C) to a B rating. The developer and future tenant is an important provider of technical building systems, especially ventilation, and thus wanted the building to be an example of their best solutions. Decision was then made to build according to the Norwegian passive house standard or even better. After one year in use it is clear that optimising pumps and having a more efficient and better controlled lighting system would improve the measured energy use, which is somewhat above the calculated amount. The roof is prepared for installation of solar collectors and/or PV and these might be installed in the future. A contractor responsible for all maintenance and optimisation of the technical system gives good results.			
Costs:	Construction cost: 225 million NOK (27.5 million €). Calculated to be 8 million NOK (977,000 €, 72 €/m^2) more expensive than the minimum requirements. The extra investment will be paid back within 5 years of operation.			
Funding:	4 million NOK (489,000 €) in support from the national support scheme for very energy efficient new buildings (ENOVA).			
Marketing efforts:	Developer is now tenant.			
Awards:	BREEAM-NOR 'Very good'			
Links to further information:	http://miljohuset-gk.no			

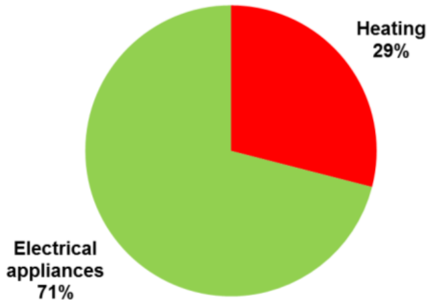
4.17 Poland

<table>
<tr><td colspan="7">4.17.1 House in Oraczewice</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="7">Krzysztof Kasperkiewicz, Building Research Institute (ITB)
Design Office - ap15 architektura pasywna
Architects: Aleksandra Poźniak-Wołodźko, Marcin Sienkowski</td></tr>
<tr><td>Illustration:</td><td colspan="7"></td></tr>
<tr><td>Project aim:</td><td colspan="7">Cheap for investments, environmentally friendly and energy-efficient single-family building.</td></tr>
<tr><td>Building address:</td><td colspan="7">Oraczewice 73-200, community Choszczno, West Pomerania Voivodship</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td rowspan="2"></td><td>New</td><td colspan="2">Renovated</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td colspan="2"></td></tr>
<tr><td colspan="7">Single-family house</td></tr>
<tr><td>Building size:</td><td colspan="7">84 m² net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="7">Wooden roof with 30 cm of rock wool, lime sandstone wall with 15 cm of graphite embedded Styrofoam, typical windows with double glazing, ground slab with 15 cm of XPS</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="5">0.205 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="5">1.3 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="5">0.151 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="5">0.213 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="7">Wood fireplace with closed combustion chamber.
DHW: Large, highly insulated hot water tank heated in winter by a water jacket in the fireplace, in the summer by solar collectors.
Ventilation system with highly efficient heat recovery 95% - Individual design.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="7">Solar thermal collectors and wood fireplace.</td></tr>
</table>

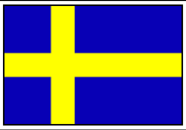
Final energy use:	Calculated	X	Calculation method:	National monthly method
	Measured		Monitored in year:	-
	Heating		46.60 kWh/m^2.year	
	Hot water		39.49 kWh/m^2.year	
	Cooling		0.00 kWh/m^2.year	
	Ventilation		incl. in heating	
	Electrical appli-ances (household electricity)		unknown	
	Others		4.77 kWh/m^2.year	
	Total		90.86 kWh/m^2.year	
Primary energy use:	Biomass		17.22 kWh/m^2.year	Primary energy factor: 0.2
	Electricity		14.32 kWh/m^2.year	Primary energy factor: 3
	Total		31.54 kWh/m^2.year	
Renewable energy contribution ratio:	27% (solar thermal collectors as part of the total final energy)			
Improvement compared to national requirements:	78%		Compared to:	Polish Building Regulations WT 2008 (Maximum primary energy use: 146.13 kWh/m^2.year).
Experiences/ lessons learned:	The building has not yet been finished.			
Awards:	The winning project in a competition for Model Polish Ecological House organised by Polish Technical Publishing MURATOR SA in 2011.			
Links to further information:	www.ap15.pl			

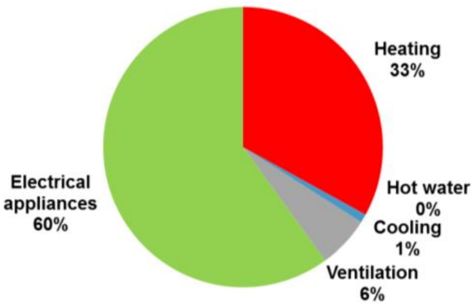
4.18 Portugal

<table>
<tr><td colspan="7">4.18.1 SOLAR XXI</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="7">Helder Gonçalves, Laura Aelenei, Susana Camelo, LNEG (UEE-Energy Efficiency Unit)</td></tr>
<tr><td>Illustration:</td><td colspan="7"></td></tr>
<tr><td>Project aim:</td><td colspan="7">Solar XXI building aimed at an energy performance that is 10 times better than a standard Portuguese office building. From the NZEB goal perspective, the building may be currently considered a 'plus (electric) energy building' and a NZEB in terms of the overall building energy consumption.</td></tr>
<tr><td>Building address:</td><td colspan="7">Paço do Lumiar 22, 1648-038, Lisbon, Portugal</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td colspan="2">Renovated</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td>X</td><td colspan="2"></td></tr>
<tr><td colspan="7">Office building</td></tr>
<tr><td>Building size:</td><td colspan="7">1,200 m², heated area/net floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="7">The whole building has external insulation, so that the influence of the thermal bridges was reduced significantly while the building thermal inertia was preserved. The building has external walls made of 22 cm brick and an external thermal insulation composite system (ETICS) of 6 cm, a concrete roof with 10 cm insulation on top, a ground slab with 10 cm expanded polystyrene insulation and transparent double glazing.</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="5">0.54 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="5">4.5 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="5">0.26 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="5">0.80 W/m².K</td></tr>
<tr><td colspan="2">Thermal bridges</td><td colspan="5">0.55 W/m².K (related to area of columns and beams)</td></tr>
<tr><td>Building service systems:</td><td colspan="7">Solar XXI building's main façade (south oriented) is covered by windows and PV modules in equivalent proportions. The glazed area (~ 46% of the south façade and 12% of the conditioned floor area) interacts directly with the permanently occupied office rooms by collecting direct solar energy and providing heat and natural light. The building has no active cooling system. A set of efficient measures and strategies contributes to diminishing the building cooling loads. Adjustable Venetian blinds have been placed outside the glazing to limit direct solar gains, a ground cooling system provides incoming pre-cooled air into the building using the earth as a cooling source. Natural ventilation is provided due to cross winds and stack effect via openings in the façade and roof level. A solar thermal collector system on the roof of the building is used for space heating with a storage system in the basement. This system is assisted by a natural gas boiler in periods without sun.</td></tr>
</table>

Included renewable energy technologies:	The building integrated combined PV and solar thermal (PV-T) system on the south façade contributes to the improvement of the indoor climate during the heating season during daytime hours, when the heat released in the process of converting solar radiation into power is successfully recovered. Two other PV systems are installed in the car park near the building. A solar thermal collector system is installed on the roof of the building for space heating purposes. The supply air is pre-cooled by the use of buried pipes.			
Final energy use:	Calculated		Calculation method:	Dynamic simulation: EnergyPlus
	Measured	X	Monitored in year:	2011
	Heating (gas)		12 kWh/m^2.year (calc.)	
	Hot water		incl. in heating	
	Solar thermal system		-5 kWh/m^2.year (calc.)	
	Cooling		0 kWh/m^2.year	
	Ventilation		included in electrical appliances	
	Lighting			
	Electrical appliances (total grid electricity)		30 kWh/m^2.year	
	PV generation (fed-in)		-32 kWh/m^2.year	
	Total		5 kWh/m^2.year	
	Electricity surplus		-2 kWh/m^2.year	
Primary energy use:	Gas		12 kWh/m^2.year (calc.)	Primary energy factor: 1
	Solar thermal system		-5 kWh/m^2.year (calc.)	Primary energy factor: 1
	Total electricity (from the grid)		75 kWh/m^2.year	Primary energy factor: 2.5
	PV generation (fed-in)		-80 kWh/m^2.year	Primary energy factor: 2.5
	Total		2 kWh/m^2.year	
	Electricity surplus		-5 kWh/m^2.year	
Renewable energy contribution ratio:	88% of the total final energy (106% of the electricity use)			
Improvement compared to national requirements:	90%		Compared to:	Primary energy coefficient of the reference office building: 30 kg$_{oe}$/m^2.year This building has 2.8 kg$_{oe}$/m^2.year (kg$_{oe}$: kg oil equivalent)
Experiences/ lessons learned:	Solar Building XXI has been fulfilling its mission through pedagogy, demonstration and dissemination, focused on the performance of thermal and energy efficiency using passive systems and renewable energy systems integration, its operation and results. There was always the underlying intention of constructing an office building for the laboratory with demonstration activities related to energy efficiency and renewable energy integration, and research in these areas.			
Costs:	Total cost (including taxes) 800 €/m^2			
Funding:	Design and construction of the building with the support of: EU/FEDER, PRIME programme.			
Awards:	EDP Award: Electricity and Environment. The Solar XXI building is the absolute winner in the category of service buildings. European Award: Building-Integrated Solar Technology 2008. Solar XXI is within the first 5, among 40 projects in 8 countries, having been awarded third place.			
Links to further information:	http://www.lneg.pt/download/4079/BrochuraSolarXXI_Maio2010.pdf http://www.rehva.eu/publications-and-resources/hvac-journal/2012/032012/solar-xxi-a-portuguese-office-building-towards-net-zero-energy-building/?L=0			

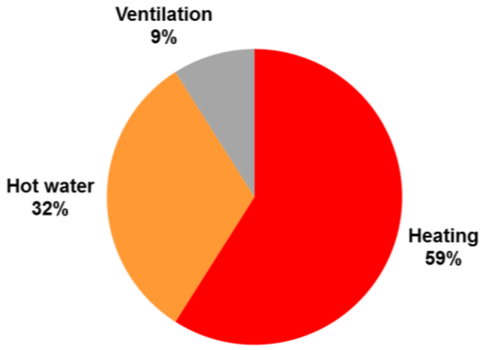
4.19 Sweden

<table>
<tr><td colspan="7">4.19.1 Väla Gård</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="7">Åse Togerö, Skanska Sverige AB, ase.togero@skanska.se
Per Kempe, Projektengagemang AB / Skanska Installation AB</td></tr>
<tr><td>Illustration:</td><td colspan="7"></td></tr>
<tr><td>Project aim:</td><td colspan="7">Net Zero Energy balance excluding tenant load (operational electricity).
No hazardous substances in building materials. No construction waste to landfill.
LEED: Platina (highest level)</td></tr>
<tr><td>Building address:</td><td colspan="7">Kanongatan 100A, 254 67 Helsingborg</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td colspan="2">Renovated</td></tr>
<tr><td></td><td>X</td><td></td><td></td><td>X</td><td colspan="2"></td></tr>
<tr><td colspan="7">Office building</td></tr>
<tr><td>Building size:</td><td colspan="7">1,750 m² heated indoor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="7">Walls: 120 mm concrete, 200 mm Graphite EPS + 95 mm mineral wool and wooden panels as cladding. Roof: double pitched with glued laminated timber beam constructions, 520 mm mineral wool. Ground slab: concrete with 350 mm EPS. Windows: triple glazed lowE with argon filling. The gables have solar shading made of perforated weathering steel with a pattern of trees.</td></tr>
<tr><td rowspan="5">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="5">0.11 W/m².K</td></tr>
<tr><td colspan="2">Window</td><td colspan="5">0.90 W/m².K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="5">0.08 - 0.10 W/m².K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="5">0.08 W/m².K</td></tr>
<tr><td colspan="2">Glazed entrance</td><td colspan="5">1.00 W/m².K</td></tr>
<tr><td>Building service systems:</td><td colspan="7">The office building has a Demand-Controlled Ventilation (DCV) system, which is controlled by the presence, temperature and CO_2 in the conference rooms. The building has a radiator system with a ground source heat pump and free cooling from the ground source system to the cooling coils in the air handling units. The lighting system consists of energy-efficient light fixtures, which can be dimmed and controlled by presence and daylight. To minimise operational electricity, the main part of the electrical outlets are turned off when the alarm is switched on.</td></tr>
</table>

<table>
<tr><td>Included renewable energy technologies:</td><td colspan="4">450 m² of PV panels mounted on the southwest slope of the pitched roofs. Peak power of the PV panels is 71 kW_p and the power generation is 66,678 kWh/year. Heating and DHW are produced by an oversized ground source heat pump system with 22 bore holes that are 180 m deep that also provide cooling.</td></tr>
<tr><td rowspan="14">Final energy use:</td><td>Calculated</td><td></td><td>Calculation method:</td><td>IDA ICE 4</td></tr>
<tr><td>Measured</td><td>X</td><td>Monitored in year:</td><td>2013/2014</td></tr>
<tr><td colspan="2">Heating</td><td>13.7 kWh/m².year</td><td rowspan="12">
</td></tr>
<tr><td colspan="2">Hot water</td><td>0.2 kWh/m².year</td></tr>
<tr><td colspan="2">Cooling</td><td>0.4 kWh/m².year</td></tr>
<tr><td colspan="2">Ventilation (fans)</td><td>2.4 kWh/m².year</td></tr>
<tr><td colspan="2">Lighting</td><td>incl. in electrical appliances</td></tr>
<tr><td colspan="2">Electrical appliances</td><td>25.4 kWh/m².year</td></tr>
<tr><td colspan="2">Total</td><td>42.1 kWh/m².year</td></tr>
<tr><td colspan="2">PV power gener.</td><td>38.1 kWh/m².year</td></tr>
<tr><td colspan="2">thereof self-used</td><td>15.6 kWh/m².year</td></tr>
<tr><td colspan="2">thereof fed-in</td><td>22.5 kWh/m².year</td></tr>
<tr><td colspan="2">Electricity from grid</td><td>26.5 kWh/m².year</td></tr>
<tr><td rowspan="3">Primary energy use:</td><td colspan="2">Electricity from grid</td><td>66.3 kWh/m².year</td><td>Primary energy factor: 2.5</td></tr>
<tr><td colspan="2">Electricity fed-in</td><td>56.3 kWh/m².year</td><td>Primary energy factor: 2.5</td></tr>
<tr><td colspan="2">Total</td><td>10.0 kWh/m².year</td><td></td></tr>
<tr><td>Renewable energy contribution ratio:</td><td colspan="4">90% of total final energy</td></tr>
<tr><td>Improvement compared to national requirements:</td><td colspan="2">80%</td><td>Compared to:</td><td>55 kWh/m².year (Swedish national building code for electrically heated buildings)
Specific energy use = Building energy (electr.) – PV power generation that can be used the same hour:
16.7 – 5.7 = 11.0 kWh/m².year</td></tr>
<tr><td>Experiences/ lessons learned:</td><td colspan="4">Lessons learned are the importance of early involvement from energy experts and an overall energy plan for implementation, control, follow-up and optimisation. Meetings with the facility manager to check the energy status are essential for finding faulty components, etc. From an economic point of view, Väla Gård is good business for Skanska, resulting in lower rental cost compared to the previous older office in Helsingborg. It has raised people's awareness of NZEBs, providing experiences and inspiration to develop and construct other Deep Green buildings.</td></tr>
<tr><td>Costs:</td><td colspan="4">Total cost excluding land: 4,360,000 €, or 2,450 €/m².
Extra cost for materials, installations, working hours (consultants, advisors and builders) and PV-panels: 245 €/m² (10%). Grants are included for PV-panels and follow-up measurements. Extra costs without grants: 300 €/m² (12%)</td></tr>
<tr><td>Funding:</td><td colspan="4">State financed grant for PV panels: 79,000 €, funding from Lågan (state-financed support for very low energy buildings) for follow-up of energy system.</td></tr>
<tr><td>Marketing efforts:</td><td colspan="4">Approximately 150 site visits, and 80 external presentations during 2 years. Marketed as a 'Sustainability Case Study' at Skanska AB that provides many facts for web visitors. Two papers published in scientific magazines, 78 media articles written about Väla Gård.</td></tr>
<tr><td>Awards:</td><td colspan="4">Skåne Solar Award 2013, The great Solar Energy Award 2013, by the Swedish Association for Solar Energy, Sweden Green Building Award 2013 in the category 'Best Green Building' (in total) and 'Best building according to LEED'.</td></tr>
<tr><td>Links to further information:</td><td colspan="4">http://www.skanska-sustainability-case-studies.com/Vala-Gard-Sweden</td></tr>
</table>

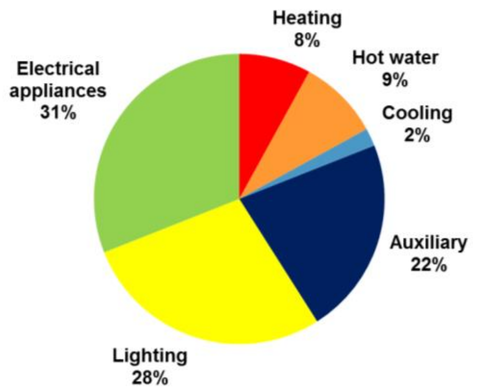
4.19.2 Single-family house in Vallda Heberg passive house residential area

Author(s):	Elsa Fahlén, NCC Construction Julia Östberg, Håkan Jimmefors	
Illustration:	 © Elin Bennewitz/Byggindustrin	
Project aim:	To build a residential area with different types of premises with focus on energy efficiency from planning to operation. All buildings will be certified as passive houses according to the Swedish standard. The goal is that 40% of the energy for heating and hot water will be supplied by solar energy from a local district-heating system.	
Building address:	Guldvingevägen, 434 90 Vallda, Sweden	
Building type:	Residential: X; Non-residential: ; Public:	New: X; Renovated:
	Single-family house	
Building size:	140 m² living area	
Building envelope construction:	The external walls are load-bearing timber stud walls with 195 + 95 mm mineral wool insulation, façade board, 80 mm glass wool insulation, air gap and timber façade clothing. The roof structure is a cold attic with timber roof trusses and 600 mm blowing wool. There are triple glass windows filled with argon.	
Building envelope U-values:	Wall	0.106 W/m².K
	Window	0.70 W/m².K
	Roof/ceiling to the attic	0.066 W/m².K
	Cellar ceiling/ground slab	0.08 W/m².K
	Doors	0.80 W/m².K
Building service systems:	All the dwellings in Vallda Heberg are equipped with a supply and exhaust air ventilation system with a rotating heat exchanger and a heating element. There is a circulating hot water system inside the building which is used for both hot tap water and space heating. There is additional comfort heating in the bathroom floor, which is also connected to the hot water circulation system.	
Included renewable energy technologies:	The energy for heating and hot water in all the premises in the area consists of 100% renewable energy from a local district heating system. 40% of the energy of this system comes from solar thermal collectors located at substations in the area and the remaining 60% comes from a central pellet boiler. According to the residents' contract, the residents were offered to buy electricity from wind power according to their use of electricity.	

<table>
<tr><td rowspan="9">Final energy use:</td><td>Calculated</td><td></td><td>Calculation method:</td><td colspan="2"></td></tr>
<tr><td>Measured</td><td>X</td><td>Monitored in year:</td><td colspan="2">2013</td></tr>
<tr><td colspan="2">Heating</td><td>33.0 kWh/m².year</td><td colspan="2" rowspan="7">
</td></tr>
<tr><td colspan="2">Hot water</td><td>17.6 kWh/m².year</td></tr>
<tr><td colspan="2">Cooling</td><td>0.0 kWh/m².year</td></tr>
<tr><td colspan="2">Ventilation</td><td>5.1 kWh/m².year</td></tr>
<tr><td colspan="2">Lighting</td><td>unknown</td></tr>
<tr><td colspan="2">Electrical appliances (household electricity)</td><td>unknown</td></tr>
<tr><td colspan="2">Total</td><td>55.7 kWh/m².year</td></tr>
<tr><td rowspan="4">Primary energy use:</td><td colspan="2">Solar energy</td><td>0.0 kWh/m².year</td><td colspan="2">Primary energy factor: 0</td></tr>
<tr><td colspan="2">Biofuel</td><td>30.4 kWh/m².year</td><td colspan="2">Primary energy factor: 1</td></tr>
<tr><td colspan="2">Wind energy</td><td>0.0 kWh/m².year</td><td colspan="2">Primary energy factor: 0</td></tr>
<tr><td colspan="2">Total</td><td>30.4 kWh/m².year</td><td colspan="2"></td></tr>
<tr><td>Renewable energy contribution ratio:</td><td colspan="5">100% of the total final energy</td></tr>
<tr><td>Improvement compared to national requirements:</td><td colspan="2">51%</td><td>Compared to:</td><td colspan="2">The National Board of Housing (BBR) Maximum specific energy use is 110 kWh/m².year for this region in Sweden, according to BBR18 requirements.</td></tr>
<tr><td>Experiences/ lessons learned:</td><td colspan="5">The measured energy performance is very close to and even better than the expected energy performance. According to a questionnaire survey, the residents are very satisfied with the indoor climate.</td></tr>
<tr><td>Costs:</td><td colspan="5">The costs for the passive house design are approximately 10% higher than for the standard design.</td></tr>
<tr><td>Funding:</td><td colspan="5">Subsidies of 21-23% of the investment costs for solar collectors located at substations in the area. Financial support to evaluate the passive house residential area within a LÅGAN demonstration project (a Swedish programme for building having very low-energy use). Additional financial support from SBUF (the Swedish construction industry's organisation for research and development).</td></tr>
<tr><td>Marketing efforts:</td><td colspan="5">Study visits, presentations at conferences, articles, etc.</td></tr>
<tr><td>Awards:</td><td colspan="5">Nominated to the construction project of the year in Sweden, 'Årets bygge' 2013.</td></tr>
<tr><td>Links to further information:</td><td colspan="5">http://www.ncc.se/en/
http://www.eksta.se/pages.aspx?r_id=39985
http://www.laganbygg.se/UserFiles/Presentations/36._Session_10_E.Fahlen.pdf</td></tr>
</table>

4.20 United Kingdom

<table>
<tr><td colspan="6">4.20.1 University of East London, Stratford New Library, London</td><td></td></tr>
<tr><td>Author(s):</td><td colspan="6">Lionel Delorme, Cornelius Kelleher, AECOM</td></tr>
<tr><td>Illustration:</td><td colspan="6"></td></tr>
<tr><td>Project aim:</td><td colspan="6">The aim of the project was to provide modern library facilities for the students of the university. The building has achieved a design stage BREEAM Excellent (Higher Education 2008).</td></tr>
<tr><td>Building address:</td><td colspan="6">Stratford Library and Learning Centre, University of East London, Romford Road, London, E15 4LZ</td></tr>
<tr><td rowspan="3">Building type:</td><td>Residential</td><td>Non-residential</td><td>Public</td><td></td><td>New</td><td>Renovated</td></tr>
<tr><td></td><td></td><td>X
(students access only)</td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">University library</td></tr>
<tr><td>Building size:</td><td colspan="6">3,847 m^2 of total useful floor area</td></tr>
<tr><td>Building envelope construction:</td><td colspan="6">The roof is a well-insulated concrete slab; there are two wall types: insulated brick cavity wall and an insulated glazed spandrel curtain wall. The air permeability certificate was received (based on in-situ testing) and the building achieved an air permeability of 2.9 m^3/h per m^2 at 50 Pa. The building has a high thermal mass. A combination of windows and roof lights are used to provide daylighting, and there is also a PV array on the roof.</td></tr>
<tr><td rowspan="4">Building envelope U-values:</td><td colspan="2">Wall</td><td colspan="4">0.24-1.5 W/m^2.K</td></tr>
<tr><td colspan="2">Window</td><td colspan="4">1.5-1.88 W/m^2.K</td></tr>
<tr><td colspan="2">Roof/ceiling to the attic</td><td colspan="4">0.17 W/m^2.K</td></tr>
<tr><td colspan="2">Cellar ceiling/ground slab</td><td colspan="4">0.16 W/m^2.K</td></tr>
<tr><td>Building service systems:</td><td colspan="6">The building is heated at the perimeter by Low Temperature Hot Water (LTHW) via radiators, trench heaters or finned tubes in the wall, fed from a gas boiler.
Four Air Handling Units (AHUs) supply the ventilation and cooling system for the vast majority of the building via a Variable Air Volume (VAV) system. The systems include heat recovery and use demand control via CO_2 sensors, and provide cooling for the majority of the year.</td></tr>
<tr><td>Included renewable energy technologies:</td><td colspan="6">On the roof of the building, there is a PV array (409.7 m^2). It is expected to produce 12.21 kWh/m^2 (floor area) per year.</td></tr>
</table>

Final energy use:	Calculated	X	Calculation method:	Part L calculation method
	Measured		Monitored in year:	-
	Heating (gas)	8.15 kWh/m^2.year		
	Hot water (gas)	9.50 kWh/m^2.year		
	Cooling	2.54 kWh/m^2.year		
	Ventilation	incl. in auxiliary		
	Auxiliary (fans and pumps)	23.94 kWh/m^2.year		
	Lighting	30.06 kWh/m^2.year		
	Electrical appliances (unregulated)	33.85 kWh/m^2.year		
	Total	108.04 kWh/m^2.year		
Primary energy use:	Natural gas	18 kWh/m^2.year		Primary energy factor: 1.02 -> National Calculation Method (NCM)
	Grid electricity	265 kWh/m^2.year		Primary energy factor: 2.92 -> National Calculation Method (NCM)
	PV electricity	-36 kWh/m^2.year		Primary energy factor: -2.92 -> National Calculation Method (NCM)
	Total	247 kWh/m^2.year		
Renewable energy contribution ratio:	The PV array is expected to produce 12.21 kWh/m^2.year, equivalent to 35.65 kWh/m^2.year of primary energy. This represents 14.4% of the total primary energy demand of 248 kWh/m^2.year. Compared to the total (regulated) final energy, the ratio is 16.5%.			
Improvement compared to national requirements:	31.3%		Compared to:	Target CO_2 emission rate for the notional building.
Experiences/ lessons learned:	The library is currently taking part in the Soft Landing programme. This has identified a calibration issue with the energy meters which is being rectified.			
Costs:	Total project cost was £14 million.			
Funding:	Unknown, assumed to be mixed from University and other sources.			
Marketing efforts:	Press releases			
Awards:	Civic Trust Awards 2014 National/International Finals The building has achieved a design stage BREEAM Excellent (Higher Education 2008).			
Links to further information:	http://www.uel.ac.uk/news/press-releases/2014/03/stratpctadwards.htm			

**the apparently high value for auxiliary is due to the building use (university library with long opening hours) and the required ventilation air volume*

Co-funded by the Intelligent Energy Europe
Programme of the European Union

More details on the IEE Programme can be found at
ec.europa.eu/energy/intelligent

This report can be downloaded from
www.epbd-ca.eu and also from www.buildup.eu