IEA Joint SHC Task 40 / ECBCS Annex 52

Towards Net Zero Energy Solar Buildings

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DC.TR1
Solution Sets and Net Zero Energy Buildings A review of 30 Net ZEBs case studies worldwide

A report of Subtask C

IEA Task 40/Annex 52 Towards Net Zero Energy Solar Buildings

May 2014

Solution sets and Net Zero Energy Buildings : A review of 30 Net ZEBs case studies worldwide.

A technical report of Subtask C – DC.TR1

Date : May 2014

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The Energy+ model of all buildings and the climate classification of each factsheet have been performed respectively by Antony Gates, Postgraduate student at Victoria University of Wellington and Shaan Cory, PhD candidate at the same university, under the supervision of Dr. Michael Donn.

The template of the case studies has originally been developed by Dr. Michael Donn, Sub Task Leader.

1 Executive summary

This technical report gives a review of 30 fully documented net ZEBs case studies that have been identified by the Sub Task C participants. It reports a compilation of all technical and non-technical information of the 30 case studies that formed the foundation on which the analysis of Volume 3 of the Source Book was based.

1.1 Objectives of Sub Task C

The original objectives were to develop and test innovative, whole building net-zero solution sets for cold, moderate and hot climates with exemplary architecture and technologies that would be the basis for demonstration projects and international collaboration

1.2 Methodology :

The methodology to reach the above objectives is as follows :

- Documenting current NZEBs designs and technologies. Benchmarking with near NZEBs and other very low energy buildings (new and existing), for cold, moderate and hot climates ;
- Developing and assessing case studies and demonstration projects in close cooperation with practitioners;
- Investigating advanced integrated design concepts and technologies in support of the case studies, demonstration projects and solution sets;
- Developing Net ZEB solution sets and guidelines with respect to building types and climate.

A benchmark of Net ZEBs around the world has been created to identify the innovative solutions sets that makes up this new type of building.

Originally, a world map of all the Net ZEBs projects has been developed by Dr. Eike Musall of Wuppertal University, member of the Task 40 Annex 52. This map is available at the following address : http://www.enob.info/en/net-zero-energy-buildings/map/ and gives general information of each project when one click on the icon of the project –i.e. Name of the project, completion date, name of the Architect, web adress etc (see Figure 1)

Figure 1 : Map of the Net ZEBs projects worldwide (this map is available at http://www.enob.info/en/net-zero-energy-buildings/map/

To conduct a comprehensive analysis of Net ZEB solution sets, having general information is not enough. One must get more in-depth information and data about each project.

That is why a short list of 30 zero energy buildings and projects was established function of mandatory criteria, such as :

1. Innovative solution sets and/or innovative technologies clearly identified for each project (Ventilation/Daylighting/Architectural integration);
2. Net ZEB Lessons learned (feedback from Architect/builder);
3. Net ZEB Energy performance < 50% standard buildings (primary and final energy) ;
4. Energy supply/integration of Renewable Energy;
5. Monitoring mandatory (energy measurements)
6. Mismatch management (Near or Net zero energy building)
7. Indoor environment data (Temperature, RH, Illuminances…).

The 30 Net-ZEBs are listed and plotted on a world map (see Figure 2). Then, a template based on a spreadsheet has been developed by the STC members to describe each project in a consistent and same manner in terms of general information, passive solutions, energy efficient solutions and renewable energy systems. For each project, a contact person from STC was designated to collect from the design team and the users all the information needed to fill out the template. Table 1 gives the names of the contact person which was responsible of the Net ZEB project.

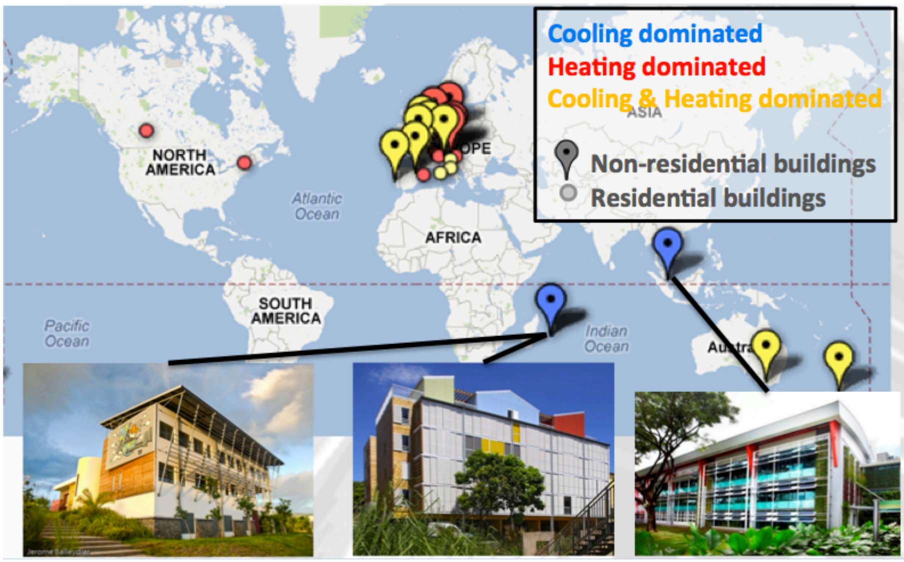

Figure 2 : World map of the STC Database : 30 Net ZEBs by climate challenge and by building type. The three pictures are the Net ZEBs in tropical climates : Enerpos (left) and Ilet du Centre (middle) in Reunion island and BCA Academy in Singapore (Right)

1.3 Presentation of the case studies

In this report, all the 30 projects are classified by building type (residential/non residential) and by climate type (cooling dominated, heating and cooling dominated, heating dominated) Four pages (taken from the spreadsheet) describe each project :

2 List of contact persons by country and building project

Table 1 : Contact person by country in green (Task participant) and by project

Name of the Net ZEB	Contact person	Organisation	Email address
Australia	*David Waldren, Grocon Group, davidwaldren@grocon.com.au*		
Pixel	David Waldren	Grocon Group	davidwaldren@grocon.com.au
Austria	*Tobias Weiß, Nussmueller Architekten ZT GmbH, tobias.weiss@nussmueller.at*		
Alpine Refuge - Schiestlhaus	Tobias Weiß		
Villach Offices & Apartment	Tobias Weiß		
Plus Energy Houses Weiz	Tobias Weiß		
Canada	*Michel Tardif, CanmetEnergy, Natural Resources Canada, Michel.tardif@rncan-nrcan.gc.ca*		
EcoTerra	Véronique Delisle	CanmetENERGY, Natural Resources Canada	Veronique.Delisle@nrcan-rncan.gc.ca
Riverdale	Michel Tardif	CanmetENERGY, Natural Resources Canada	mitardif@nrcan.gc.ca
Denmark	*Søren Østergard Jensen, Danish Technological Institute*		
EnergyFlexHouse	Mikael Grimming	Danish Technological Institute	mg@teknologisk.dk
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Enerpos, NR (Reunion)	François Garde Aurélie Lenoir	University of Reunion Island	francois.garde@univ-reunion.fr aurelie.lenoir@univ-reunion.fr
Green Office, NR	Alain Bornarel	Tribu consulting	tribu.conseil@wanadoo.fr
IESC Cargèse, R	Jonathan Leclère	LMOPS	Jonathan.leclere@
Ilet du Centre, NR (Reunion)	François Garde Aurélie Lenoir	University of Reunion Island	francois.garde@univ-reunion.fr aurelie.lenoir@univ-reunion.fr
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Limeil Brévannes, NR	Alain Bornarel	Tribu consulting	tribu.conseil@wanadoo.fr
Pantin primary school	Alain Bornarel	Tribu consulting	tribu.conseil@wanadoo.fr
Germany	*Eike Musall, University of Wuppertal, emusall@uni-wuppertal.de*		
Day Care Centre "Die Sprösslinge"	*Eike Musall*		
Kleehäuser	*Eike Musall*		
Plus Energy Settlement	*Eike Musall*		
Primary School Hohen Neuendorf	*Eike Musall*		
Italy	*Alessandra Scognamiglio, ENEA, alessandra.scognamiglio@enea.it*		
Casa Zero Energy	Antonio Frattari	University of Trento	antonio.frattari@ing.unitn.it
Lajon School	Annamaria Belleri	EURAC	annamaria.belleri@eurac.edu
Leaf House	Davide Nardi Cesarini	Loccioni Group	d.nardicesarini@loccioni.com
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NON RESIDENTIAL NET ZEBs

Cooling Dominated Climate

Office buildings

Ilet du Centre
Reunion, France
Arch. : A. Perrau and M. Reynaud

Educational Buildings

Enerpos,
Reunion, France
Arch. : T. Faessel Bohe

ZEB@BCA Academy
Singapore
Arch. : DP Architects Pte Ltd

Ilet du Centre - offices

Net Zero Energy Building Overview

Passive house with heat requirement of 9 kWh/m².yr according to KlimaHaus calculation - Intensive use of renewables energy with in particular an expected photovoltaic production 2.6 times higher than the yearly electricity demand.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2008

Location
139 rue François Isautier
Saint Pierre
Reunion
France

Latitude North	Longitude West
21° 33' 3'' S	55° 47' 5'' W

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Cooling Dominated

Building Type
Non-residential_Office

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
310

Conditioned Floor Area (m²)
11.6 m² (air-conditioned computer room)

Occupancy (m² per Person)
15.5

Number of Storeys

Cost US$/(Net) m² Floor Area
2,309

Cost US$/(Net) m² typical similar building

Web Address

For more information:
http://tinyurl.com/Ilet-du-Centre

Architectural Design Concept

Ilet du Centre has solar shading, night ventilationa and solar domestic hot water. Its exterior walkways are a distance from the facades to provide privacy within the offices.

Measured Energy Production and Consumption:

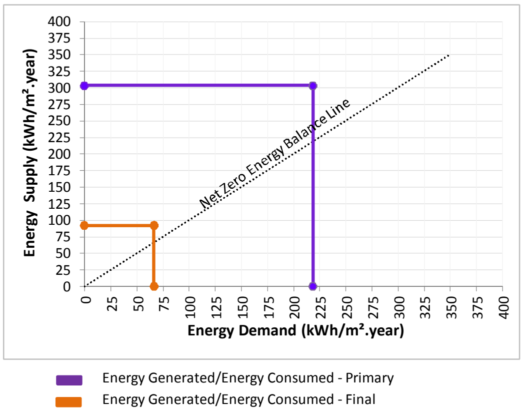
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 66
Primary: 219

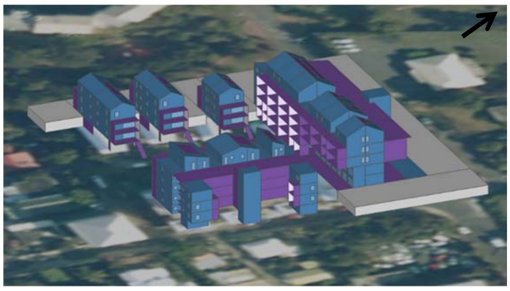
Energy Supply (kWh/m².year)
Renewable Energy
Final: 92
Primary: 304

Source to Site Conversion Factor (Electricity): 3.3

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



EnergyPlus Model

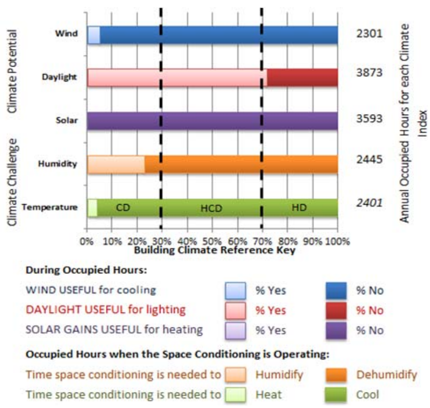


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 3.45

Solar Absorptivity 0.97

Wooden double skin (solar shadings) at 4.8m of the facade + native vegetation + 16cm of concrete wall

East

U-value (W/m² ºC)

Solar Absorptivity

Facing Polar Direction

U-value (W/m² ºC) 3.45

Solar Absorptivity 0.97

Vertical solar shadings at 1.6 m from the wall + glass or louvers

West

U-value (W/m² ºC)

Solar Absorptivity

Roofs

U-value (W/m² ºC)

Solar Absorptivity

Ground floor

U-value (W/m² ºC)

Windows - Construction Elements

Solar noon

U-value (W/m² ºC)

g-value

Louvers

East

U-value (W/m² ºC)

g-value

Polar direction

U-value (W/m² ºC)

g-value

One pannel of louvers, one pannel of frosted glass and 1 pannel of wall

West

U-value (W/m² ºC)

g-value

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

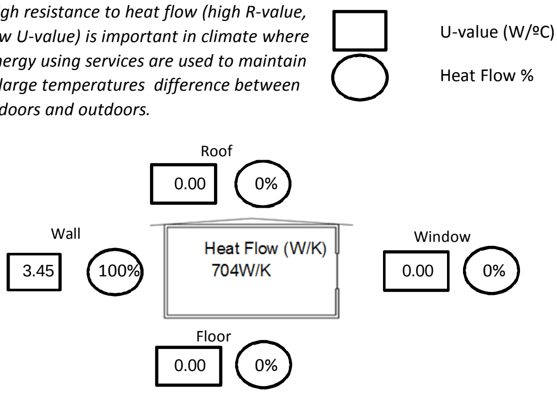
Compactness (m-1)

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Cooling

Natural Ventilation

The offices are open-plan, and cross ventilated owing to louvers on both the Northern and Southern sides.

Green Roof/Façade

Native vegetation has been used in front of the north facade to create a micro climate in front of the building and to avoid overheating from the tarmac of the street

Sunshading

North and south facade are protected with solar shadings (wooden double skin for the north facade and vertical shadings for the south facade)

Daylight Systems

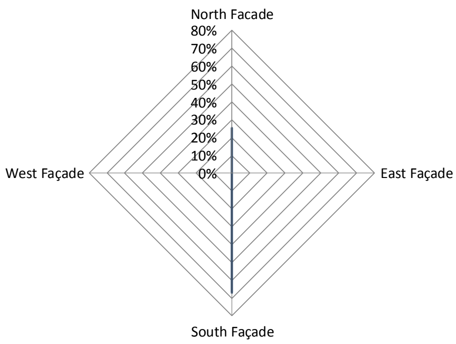
One pannel of louver, one pannel of frosted glass and one pannel of wall

The frosted glass panels let in natural light while still allowing privacy.

Window Distribution Information

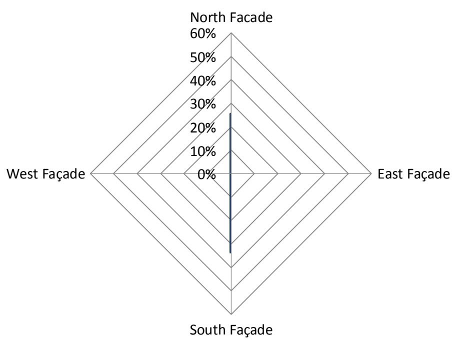
Distribution of Window Areas per Façade

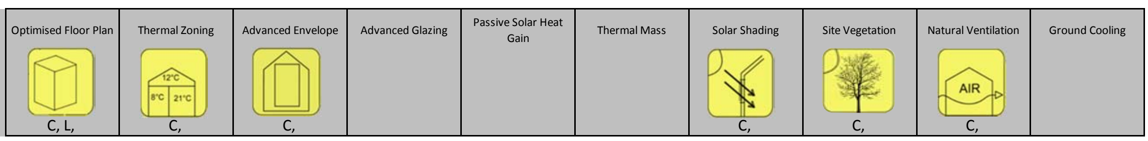
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
14

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) : 4

Computer Network
Power Density Installed (W/m²) : 6.9
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	Yes
Hydronic distribution	No
Air distribution	No

Description
No cooling plant for the offices. Only a technical room where all the computers central units are located is air-conditioned (11.6 m²)

Heating

Central Plant	No
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
No heating system

Ventilation System

Heat Recovery Type	No
Central Air supply	No
Local Air Recirc plus Central Fresh Air	No

Description

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	Yes
Electrical?	No
Other?	

Description
Electric hot water tank Ariston SG300R, 1500W

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description
Users can control natural ventilation, lighting and ceiling fans.

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Other

HVAC Systems
No AC except in technical room. High performance ceiling fans. Buffer zone. Vegetation.

Artificial Lighting
Use of natural lighting

Computer Management
All the central units are located in an air-conditioned technical room. The offices are only equipped with screens and keyboards

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
		C, P,									C,

Design Team

Engineer Civil

Name

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Funding

Source and Type of Funding

No more than 500 words

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Roof integrated
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	45°
Azimuth	0°
Technology	GIORDANO
Nominal Power (kWp)	20
Area (m²)	160
Yield (kWh/m².year)	137
Expected generation (kWh)	21860
Measured generation (kWh)	28517

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal
Technology
Position
Area (m²)
Production (kWh/m².year)
Annual % of Hot Water

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

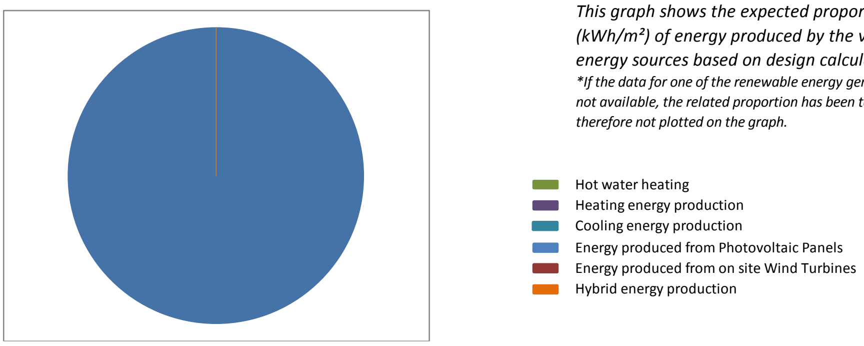
Renewable Production of Heating and Cooling

Heating Equipment There is no active heating system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².yr)
Annual % of Heating - (Produced by renewables)

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.

**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,	 E,					 I,		

References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

ENERPOS

Net Zero Energy Building Overview

ENERPOS is the first Net ZEB of the French overseas departments in tropical climates. The building has been designed with priority given to the passive components such as cross natural ventilation and solar shading. In terms of energy use, it consumes one seventh of the average for university buildings in Reunion Island and produces seven times its consumption by BIPV roofs. The building has a high level of monitoring with minutely data, separated by end use.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
Construction completed August 2008

Location
40 avenue de Soweto
Saint-Pierre
Reunion Island
France

Latitude	Longitude
South	West
21° 20'	55° 29'

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Cooling Dominated

Building Type
Non-residential_Educational

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
739

Conditioned Floor Area (m²)
681

Occupancy (m² per Person)
0.1

Number of Storeys

Cost US$/(Net) m² Floor Area
4,581

Cost US$/(Net) m² typical similar building

Web Address
http://lpbs.univ-reunion.fr/enerpos

For more information:
http://tinyurl.com/Enerpos-FR-RE

Architectural Design Concept

ENERPOS uses many passive techniques. These include cross natural ventilation (2 building wings orientated to be exposed to the summer thermal breezes), native plants around the building, Solar shading of all windows and walls and an insulated roof (+ BIPV over-roof).

Measured Energy Production and Consumption:

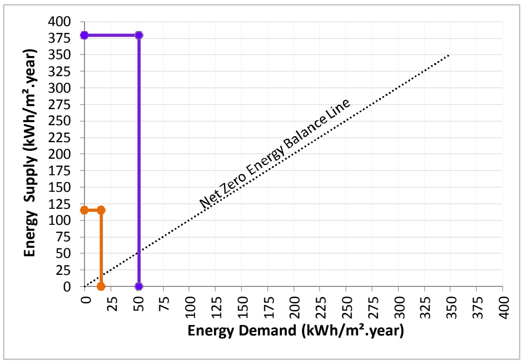
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 16
Primary: 52

Energy Supply (kWh/m².year)
Renewable Energy
Final: 115
Primary: 380

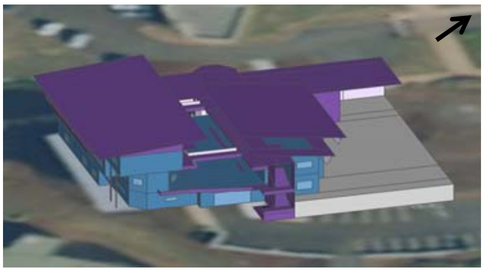
Source to Site Conversion Factor (Electricity): 3.3

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model

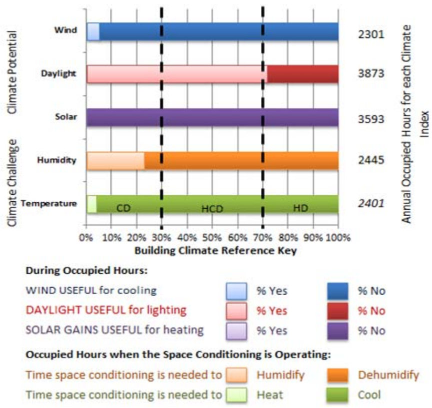


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating*
C *- Cooling*
L *- Lighting*
DHW *- Domestic Hot Water*
P *- Plug Loads*
E *- Electricity*
I *- Intergration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,			

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 3.79

Solar Absorptivity 0.40

Concrete (20 cm) + Solar shading

East

U- 0.90

Solar Absorptivity 0.40

Concrete (20 cm) + Insulation (mineral wool) + Wooden siding

Facing Polar Direction

U-value (W/m² ºC) 3.79

Solar Absorptivity 0.40

Concrete (20 cm) + Solar shading

West

U-value (W/m² ºC) 0.90

Solar Absorptivity 0.40

Concrete (20 cm) + Insulation (mineral wool) + Wooden siding

Roofs

U-value (W/m² ºC) 0.27

Solar Absorptivity 0.80

Concrete + Insulation (10 cm of polystyrene) + BIPV over-roof

Ground floor

U-value (W/m² ºC) 1.08

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 5.90

g-value 0.87

Saint-Gobain SGG STADIP Clear

East

U-value (W/m² ºC)

g-value

Polar direction

U-value (W/m² ºC) 5.90

g-value 0.87

Saint-Gobain SGG STADIP Clear

West

U-value (W/m² ºC)

g-value

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

Compactness (m-1)

Passive Approaches:

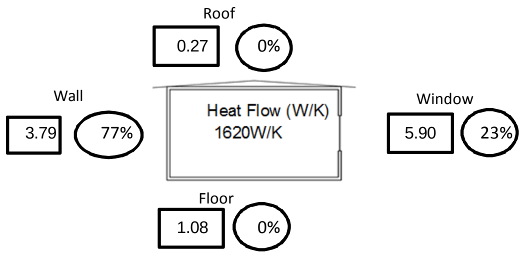
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Cooling

Natural Ventilation

Porosity of main facade : 30% (PERENE requirement : 20%), louvers.

Green Roof/Façade

The façade has vegetation to avoid overheating of incoming air. There is also vegetation over the patio over the underground parking. Native plants have been used to reduce the maintenance time.

Sun shading

Main facades (North and South) are solar protected with wooden strips that were sized with SketchUp and optimized with daylight simulation (Daysim).

Daylight Systems

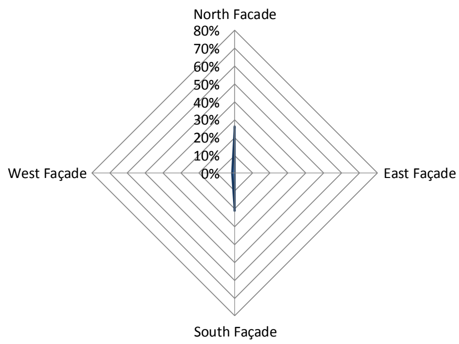
High value of porosity combined with solar shadings

Daylight autonomy in classrooms in about 90%

Window Distribution Information

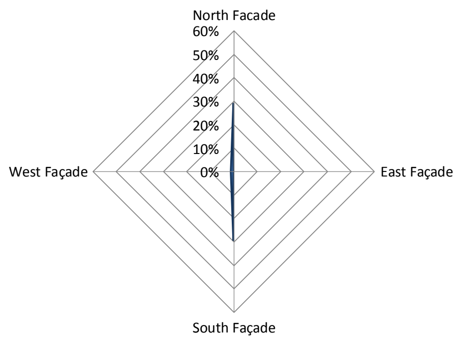
Distribution of Window Areas per Façade

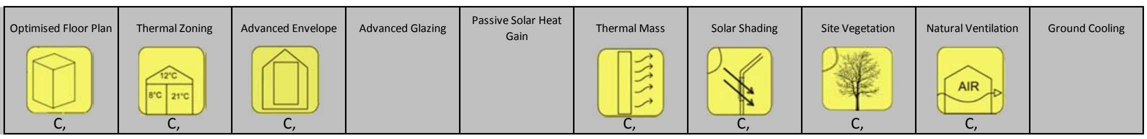
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) : 16

Artificial Lighting
Power Density Installed (W/m²) : 3.7 W/m² (offices) and 7.3 W/m²

Computer Network
Power Density Installed (W/m²) : 1.5
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	Yes
Hydronic distribution	No
Air distribution	Yes

Description
VRV air-conditioning (only for offices & computer rooms) - cooling period: 6 weeks/y

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description

Ventilation System

Heat Recovery Type	No
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description

DHW - Domestic Hot Water
Solar?
Waste Water Heat Recovery?
Gas?
Electrical?
Other?

Description

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
BMS for exterior lighting (timetable) + 2 hours timers for interior lighting in the classrooms.

HVAC
BMS: timetable, individual control in each offices of the set temperature

Energy Storage
Latent Storage?
Fuel Cell?
Compressed Air?

User Interactions
User Manual Provided? Yes

Description
The ceiling fans (approximately one per person in the offices) and windows are controlled manually. The lighting is also controlled manually except for in the classrooms where they are on a two hour timer. The VRV system functions on timetable.

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
e.g. Elevator : reduction of half the consumption with stand-by mode on (thanks to the measured data)

Energy Storage

Other
Ceiling fans in all rooms and offices (1/10m²)

HVAC Systems
VRV system for AC + split systems in the technical rooms

Artificial Lighting
Offices : mood lighting (100 Lux) + LED desk lamps (>300 Lux on the work area) 3,7 W/m²
Classrooms : 7,3 W/m²

Computer Management
Theory : computers delocalized in a technical room - not realized yet

Control of Systems
Building Management System

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation.	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		C, P,		P,							C,

Design Team

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Funding

Source and Type of Funding
General council of La Reunion (4M€) ; City of Saint Pierre (800 000€ ; land contribution) ; Regional council of La Reunion

Principal Actors
University of La Reunion (client) ; Thermal Engineer Office

Authors
François Garde / Aurélie Lenoir

Email
garde@univ-reunion.fr / aurelie.lenoir@univ-reunion.fr

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refridgerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV)

Building Integrated PV?	Roof integrated
Ground mounted	No
Roof mounted	yes
Position	Fixed
Tilt (angle)	9°
Azimuth	-166° North / 14° North
Technology	Polycrystalline cells
Nominal Power (kWp)	50
Area (m²)	365m²
Yield (kWh/m².year)	70
Expected generation (kWh)	77000
Measured generation (kWh)	50000

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal
Technology
Position
Area (m²)
Production (kWh/m².year)
Annual % of Hot Water

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

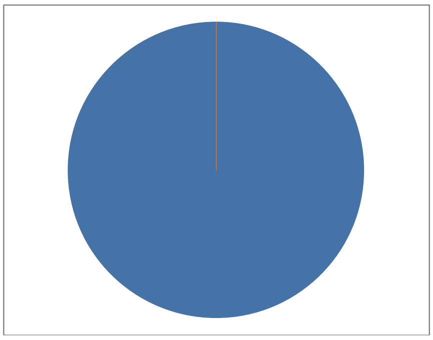
Renewable Production of Heating and Cooling

Heating Equipment There is no active heating system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².yr)
Annual % of Heating produced by renewable energy

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling produced by renewable energy



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	 E,					 I,		

References
American Society of Heating, Refridgerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

ZEB@BCA Academy

Net Zero Energy Building Overview

The ZEB@BCA Academy was conceived as a flagship research and development project under the Building and Construction Authority's Green Building Master plan. The ZEB innovatively adopted an integrated design approach that encompasses passive design to reduce the energy demand, active energy efficient system which is supported by the energy generated by the on site PV systems.

Completion Date
Operational since October 2009

Location
No. 200 Braddell Road
Singapore

Latitude	Longitude
North	West
1°20'41.17" N	103°51'29.78" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Cooling Dominated

Building Type
Non-residential_Educational

Site Context
Urban Centres - over 5 storey average height of neighbouring buildings, adjacent buildings touching, street widths 40m+

Net Floor Area (m²)
4500

Conditioned Floor Area (m²)
2180.5

Occupancy (m² per Person)
10.0

Number of Storeys

Cost US$/(Net) m² Floor Area
1,880

Cost US$/(Net) m² typical similar building

Web Address
http://www.bca.gov.sg/zeb/whatiszeb.html

For more information:
email: bca_gallery@bca.gov.sg
Ph.: +65 62489930

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

The ZEB project is intended as a functioning demonstration in the efficient use of energy in a building through both passive and active means. Low-e double glazing, lightweight wall systems, shading devices, light shelves and green walls are incorporated into the west facade. Some rooms at the ground level have ducting of natural light for illumination. Light tubes are also installed to direct light into the interior of an office environment. The roofs are covered with solar panels to generate sufficient electrical energy to be self sustaining. Part of the roof incorporates a ventilation stack to test the effect of convection air movement within a naturally ventilated environment. The ZEB is planned to provide a friendly interface with the public with inter-active exhibits and also as a collection of different possibilities for a more energy efficient and environmentally conscious way in the design and construction of buildings.

Measured Energy Production and Consumption:

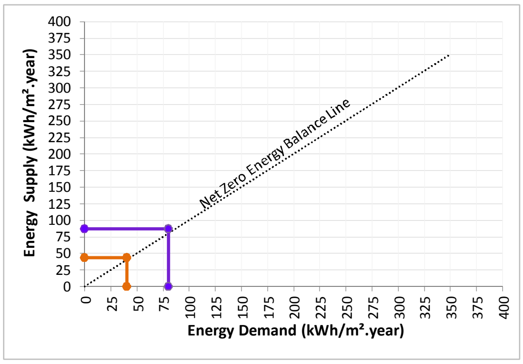
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 40
Primary: 80

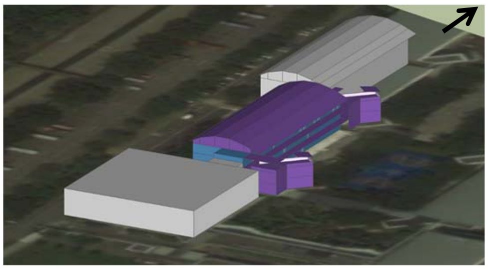
Energy Supply (kWh/m².year)
Renewable Energy
Final: 44
Primary: 87

Source to Site Conversion Factor (Electricity): 2

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



EnergyPlus Model



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Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

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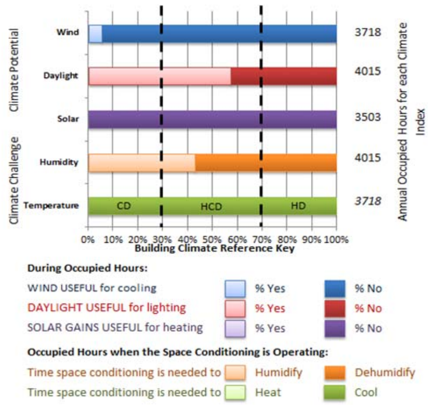
The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



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H *- Heating*
C *- Cooling*
L *- Lighting*
DHW *- Domestic Hot Water*
P *- Plug Loads*
E *- Electricity*
I *- Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
		 L,	 L,

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 4.05
Solar Absorptivity

120mm precast concrete (white)

East
U-value (W/m² ºC) 0.29
Solar Absorptivity

150mm Dry Wall (light grey)

Facing Polar Direction
U-value (W/m² ºC) 4.05
Solar Absorptivity

120mm precast concrete (white)

West
U-value (W/m² ºC) 0.29
Solar Absorptivity

150mm Dry Wall (light grey)

Roofs
U-value (W/m² ºC) 0.22
Solar Absorptivity

1mm thick PVDF coated, 150mm thick rockwool insulation, aluminium foil

Ground floor
U-value (W/m² ºC) 1.20

Existing Concrete floor (heavy weight)

Windows - Construction Elements

Solar noon (south)
U-value (W/m² ºC) 2.19
g-value 0.33

24mm thick tempered sungery green DGU glass

East
U-value (W/m² ºC) 4.10
g-value 0.42

6mm thick tempered sungery green low-e glass

Polar direction (north)
U-value (W/m² ºC)
g-value

No window

West
U-value (W/m² ºC) 2.19
g-value 0.33

24mm thick tempered sungery green low-e glass

Air permeability (m³/m²h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

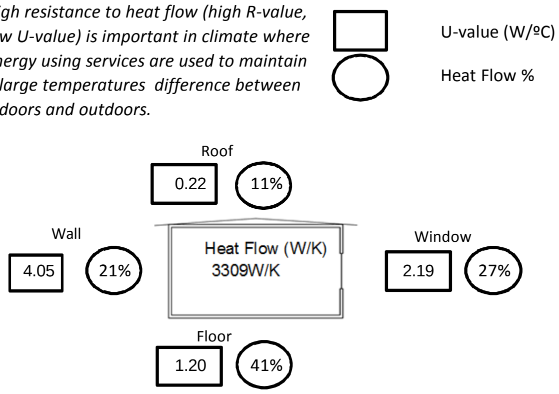
Compactness (m-1)

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

***Building Challenge Solution Set** - The set of solutions used to lower the energy needed by a particular building challenge.*

***Whole Building Solution Set** - The set of solutions used to lower the energy consumption of the whole building.*

Heating

Cooling

Natural Ventilation

During a typical hot day, surface temperature of the solar chimney can reach up to 60°C, while the air within can achieve temperature of 47°C and rises up at a speed of 1.9 m/s. This allows fresh cool air to enter the building through fenestration (pull effect), which is complemented by the push effect from the ambient wind. There is an average of 9 Air Change per Hour (ACH) in the afternoon.

Green Roof/Façade

There roof top and west facade greenery systems provide shading, reducing heat gains and causing a cooling effect due to evapotranspiration. The study shows that there is significant reduction on the wall and the roof surface temperature being shaded by the greenery systems when compared with a control wall. The reduction is up to 16°C for the vertical greenery on the west façade and 24°C for the rooftop greenery.

Daylight Systems

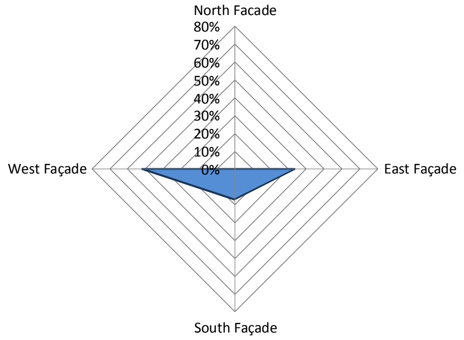
Light shelves, Mirror Ducts and Light Pipes

The light shelves are installed on the west façade windows. Field measurement were conducted which show light shelves with reflective surface can increase the illuminance level of around 50-100 lux. Unfortunately, this increases the mean radiant temperature by approximately 0.5°C. Six horizontal mirror ducts with three different internal reflective materials were installed on level 1 as they increase the daylight into the room to 11m from east facade. The light pipes have excellent colour neutrality and colour temperature.

Window Distribution Information

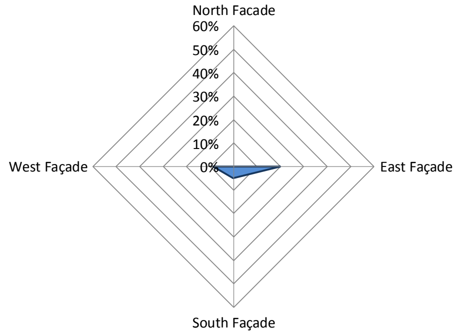
Distribution of Window Areas per Façade

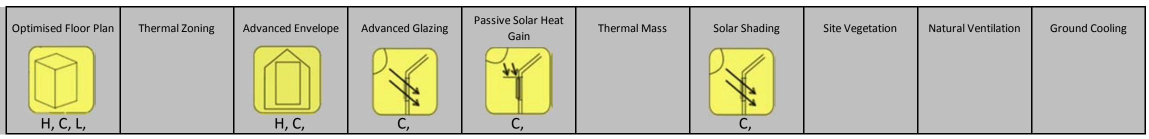
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
5.5 l/s/occupant

Appliances / Plug Loads
Power Density Installed (W/m²) : 2 - 5

Artificial Lighting
Power Density Installed (W/m²) : Actual consumption ranges from 4 to 7

Computer Network
Power Density Installed (W/m²) : 4.0
Datacentre ? Yes

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	No
Ceiling Fans	Yes
Hydronic distribution	Yes
Air distribution	Yes

Description
There are three chillers, supported by three chilled water pumps, condenser water pumps and cooling towers. A variable speed drive controls the fan speed based on the water temperature leaving the cooling tower. On the air side, an innovative air-conditioning and air distribution system is used to improve the occupants' thermal comfort and indoor air quality, whilst significantly saving energy. A single coil, twin fan air conditioning system provides demand ventilation and demand cooling based on CO2 and temperature sensors.

Heating

Central Plant	No
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description

Ventilation System

Heat Recovery Type	No
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	No

Description

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
The general lightings are controlled by motion sensors. The perimeter lights and areas near the daylight solutions are dimmer controlled by photosensors. The entire operation is monitored and recorded in Building Management System (BMS).

HVAC
HVAC systems are controlled and monitored by Building Management System (BMS). Real time monitoring was done using web based network.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? Yes

Description
The users are able to override the BMS to control the lighting and also the supply of fresh air.

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
Appliances are set to standby mode when not in use

Energy Storage

Other Systems
Light pipes and mirror ducts for daylighting, Solar chimneys for heat removal in naturally ventilated space, Green roof & vertical greenery on south and west façade walls to minimize heat infiltration

HVAC Systems
Single Coil Twin Fan Air Handling Unit and Fan Coil Unit to treat fresh air based on CO2 content and re-circulation air based on temperature and humidity.

Artificial Lighting
T5 lighting with on/off and dimmer control integrated with day lighting and task lighting in every office space.

Computer Management
Energy star products

Control of Systems
Building Management System (BMS)

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,	L,	kWh P,			C,				

Design Team

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Funding

Source and Type of Funding

This " ZEB @ BCA Academy" flagship R&D project was partially funded by the governments of Singapore, namely the Ministry of National Development's Research Fund and the Economic Development Board's Clean Energy Research Program.

Principal Actors

It is a tripartite collaborative effort between Building and Construction Authority (BCA), National University of Singapore (NUS) and private companies, partially funded by the Ministry of National Development (MND) Research Fund and Economic Development Board (EDB) Clean Energy Research Program.

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) -Final Energy

Building Integrated PV?	Yes
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	5 -20°
Azimuth	2° N
Technology	Polycrystalline/Amorphous
Nominal Power (kWp)	190
Area (m²)	1540
Yield (kWh/m².year)	128
Expected generation (kWh)	206700
Measured generation (kWh)	196493

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal
Technology
Position
Area (m²)
Production (kWh/m².year)
Annual % of Hot Water

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

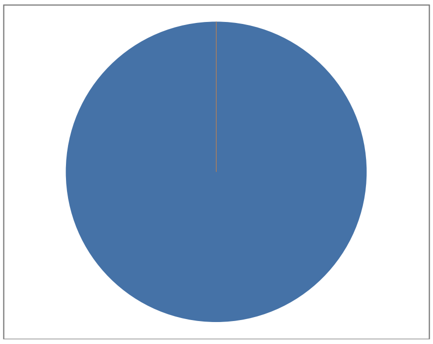
Renewable Production of Heating and Cooling

Heating Equipment There is no active heating system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².yr)
Annual % of Heating -
(Produced by renewables)

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling -
(Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	E,					I,	I,	

References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

NON RESIDENTIAL NET ZEBs

Heating and cooling dominated climate

Office buildings


Pixel
Australia
Arch. : Studio 55


Eithis Tower
France
Arch. : Arte Charpentier


Green Office
France
Arch. : Atelier 2M


Meridian
New Zealand
Arch. : Marc Woodbury


Solar XXI
Portugal
Arch. : Pedro Cabrita, Isabel Diniz


Circe
Spain
Arch. : Petra Jebens Zirkel

Educational Buildings


Kyoto High School, France
Arch. : SCAU, Guy Autran & François Gillard


Limeil Brévannes School
France
Arch. : Lipa & Serge Goldstein


Pantin High School
France
Arch. Méandre, architects


Lajon School
Italy
Arch. : arch.TV | architetti Trojer Vonmetz

Pixel Building

Net Zero Energy Building Overview

The world's first carbon neutral office building - Intensive use of energy efficient measures, also includes renewable energy sources. Biogas plant, solar PV and wind turbines provide a significant portion of the building's energy. The building is also water self-sufficient. It uses highly sustainable materials, has excellent indoor environment quality and is a ultra-low emissions building.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2010

Location
205 Queensberry St
Melbourne
Victoria
Australia

Latitude	Longitude
South	West
37° 48' 16" S	144° 57' 43" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Cooling Dominated

Building Type
Non-residential_Office

Site Context
Urban Centres - over 5 storey average height of neighbouring buildings, adjacent buildings touching, street widths 40+m

Net Floor Area (m²)
1084.6

Conditioned Floor Area (m²)
837.4

Occupancy (m² per Person)
14.3

Number of Storeys

Cost US$/(Net) m² Floor Area
4,556,548

Cost US$/(Net) m² typical similar building
3,500,000

Web Address
www.pixelbuilding.com.au

For more information:
http://tinyurl.com/Pixel-AU

Architectural Design Concept

A compact building shape with an S/V ratio of 0.53 m-1 minimizes the outer scattering surfaces. Toward the Passivhaus concept, a high thermal insulation of the external walls and of the glazed facade are provided. An extensive glazed surface on the south facade let in light to naturally illuminate the interior spaces and venetian blinds protect from glaring sunlight conditions. Also the main staircase is naturally lighted thanks to a skylight on the roof.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

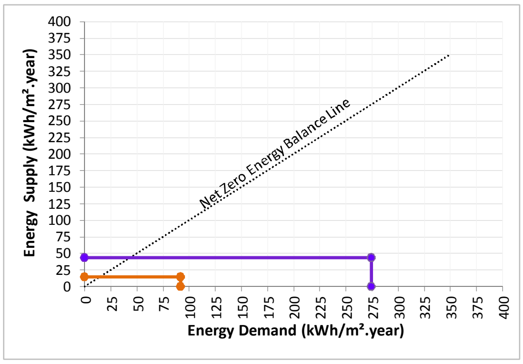
	Electricity	**Natural Gas**
Final:	57	35
Primary:	170	105

Energy Supply (kWh/m².year)
Renewable Energy

Final:	15
Primary:	44

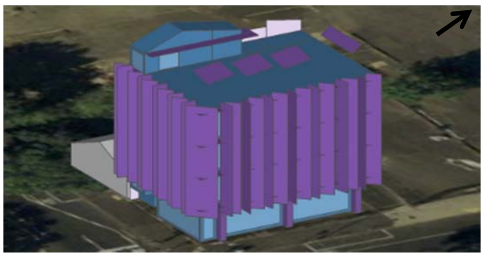
Source to Site Conversion Factor (Electricity): 3

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model

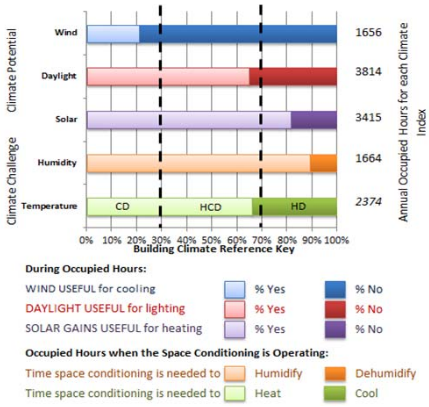


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating*	***P*** *- Plug Loads*
C *- Cooling*	***E*** *- Electricity*
L *- Lighting*	***I*** *- Integration*
DHW *- Domestic Hot Water*	

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,			 L,

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC)
Solar Absorptivity

East
U-value (W/m² ºC)
Solar Absorptivity

Facing Polar Direction
U-value (W/m² ºC)
Solar Absorptivity

West
U-value (W/m² ºC)
Solar Absorptivity

Roofs
U-value (W/m² ºC)
Solar Absorptivity

Ground floor
U-value (W/m² ºC)

Windows - Construction Elements

Solar noon
U-value (W/m² ºC)
g-value

East
U-value (W/m² ºC)
g-value

Polar direction
U-value (W/m² ºC)
g-value

West
U-value (W/m² ºC)
g-value

Air permeability (m³/m²h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

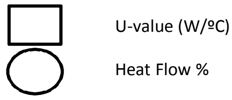
Compactness (m-1)

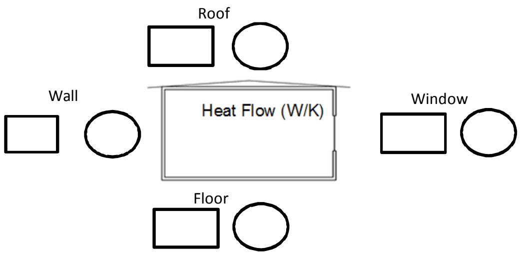
Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

***Building Challenge Solution Set** - The set of solutions used to lower the energy needed by a particular building challenge.*

***Whole Building Solution Set** - The set of solutions used to lower the energy consumption of the whole building.*

Heating

Heat Recovery

Air is exhausted from the building via the air handling unit through the toilet exhaust, photocopy exhaust and the spill air grilles. All of these exhausts are combined as part of a single exhaust system that is drawn through a sealed air to air heat exchanger in the air handling unit before being exhausted from the building.

Cooling

Green Roof/Façade

The planting on the roof and around the living edges of Pixel provide local environmental cooling and insulation to the building envelope.

Natural Ventilation

There are Windows to the North and West facades that are operated at night in summer by the BMS. These windows open for passive night purge but they are also enabled to flood the office floors with cool night air. The exposed ceiling absorbs the coolness, thus reducing the need for hydronic cooling.

Sunshading

The building is designed with an extensive system of external shading that extends across the north and west facades and partially across the south. In addition to providing glare control these panels shade the building in the warm summer months to reduce the thermal load on the fabric and office space.

Daylight Systems

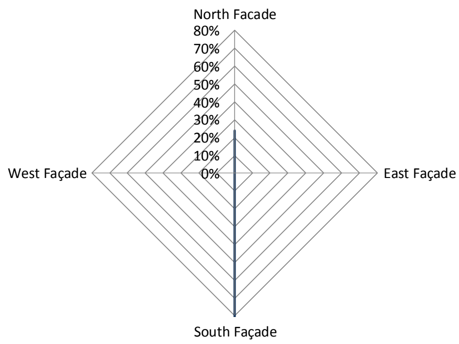
Exterior Panel System to the North, West and South

The building has extensive external shading across the North and West facades and partially across the South. This system of glare control enables the building to operate with very high levels of natural daylight without reliance on blinds. The lighting control system then adjusts the electric lighting level down to reduce energy use acknowledging the existing natural daylight levels.

Window Distribution Information

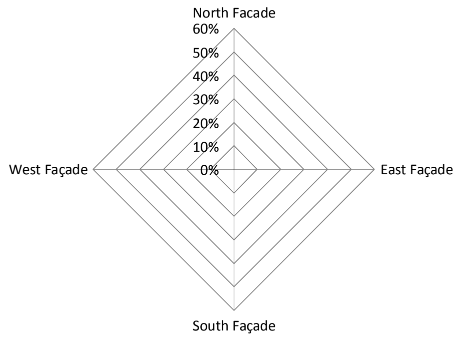
Distribution of Window Areas per Façade

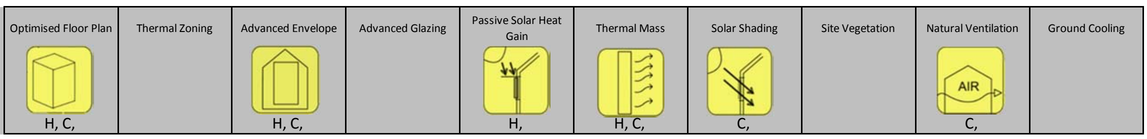
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Highly efficient appliances selected as policy

Energy Storage

No

Other

Active mass cooling system in conjunction with underfloor air delivery; use of anaerobic digester to generate biogas for domestic hot water generation; Living Edge wetlands on each level of building; 'Pixelcrete' high recycled content concrete; rainwater harvesting and processing for water self-sufficiency

HVAC Systems

Robur Units x 4

Artificial Lighting

Daylight Harvesting, general artificial lighting is max $2.5W/m^2$

Computer Management

Optergy BMS system

Control of Systems

Dynamic BMS management

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

19

Appliances / Plug Loads

Power Density Installed (W/m²) : 10

Artificial Lighting

Power Density Installed (W/m²) : 3

Computer Network

Power Density Installed (W/m²) : 4.2

Datacentre ? Yes

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	Yes
Air distribution	Yes

Description

Cooling is provided through hydronic in-slab pipework in chilled ceilings. Ceilings are 100% exposed concrete. Supplementary cooling is provided through air supply (underfloor air distribution) with 100% outdoor air.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	Yes

Description

Space heating is provided by via the ventilation air supply (100% outdoor air), with the heat for this provided by the gas-fired heat pump (heating hot water coil). Heating is required only intermittently throughout the year, mostly in mid-winter.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description

100% outdoor air with air to air heat exchanger

DHW - Domestic Hot Water

Solar?	
Waste Water Heat Recovery?	
Gas?	
Electrical?	Yes
Other?	

Description

Domestic hot water is generated using a gas-fired boiler. The primary fuel source for the DHW plant is biogas from the anaerobic digester (AD) that is produced from the vacuum toilet waste discharge. Backup is mains supplied natural gas, but full capacity is provided under normal operating conditions by the AD plant.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

Switching panels are located at the entrance to each floor, with each level separated into three zones. Lighting is switched on and off via occupancy sensors with daylight sensors controlling the lighting levels in response to daylight. Task lighting is located on each workstation, with occupancy sensors also connected to this system. Out of hours control is via switching in the space, with occupancy sensors switching off. All lighting is switched off during the hours of 11pm-5am.

HVAC

The building automation system controls space temperature, slab surface temperature and chilled/heating hot water temperatures to maintain the occupant comfort. The air handling unit maintains the average space temperature set point of 21.0°C. The heat pump is activated in either heating or cooling mode based on the average requirements of the air handling unit and slab cooling. Simultaneous cooling and heating operation is not possible with the plant.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided? Yes

Description

General temperature levels are controlled on the air side by user selection of temperature. Every individual then has control over the temperature at their workstation through the use of an adjustable floor diffuser for air supply quantity. Task lighting enables individual adjustment of the lighting levels at each workstation.

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,	L,				H, C,		C,	H, C,	

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Source and Type of Funding
No more than 500 words

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	No
Ground mounted	No
Roof mounted	Yes
Position	Tracking
Tilt (angle)	Tracking
Azimuth	Tracking
Technology	SunPower 210W panel
Nominal Power (kWp)	4
Area (m²)	27
Yield (kWh/m².year)	8
Expected generation (kWh)	6665
Measured generation (kWh)	Not yet finalised

Wind Turbine - Final Energy

Position	On-site
Number of Turbine	3
Technology	Vertical
Nominal Power (kWp)	1.7 kWp
Energy Production (kWh/m².year)	13.50

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	No
Technology	Biogas System
Position	Roof unit
Area (m²)	
Production (kWh/m².year)	3
Annual % of Hot Water	100

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

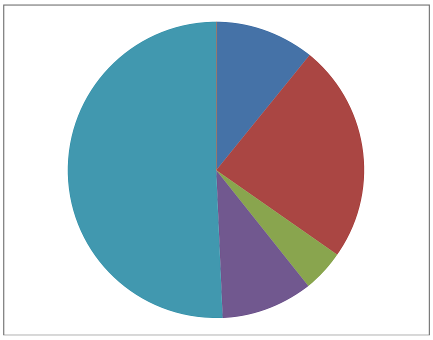
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Heat Pump
Technology	Robur gas-fired ammonia absorption heat pump
Power	100.8kW
Efficiency (%)	140
Production (kWh/m².yr)	5.65
Annual % of Heating - (Produced by renewables)	99% (5.60 kWh/m².year)

Cooling Equipment - Final Energy

	Heat Pump
Technology	Robur gas-fired ammonia absorption heat pump
Power	
Efficiency (%)	67
Production (kWh/m².year)	29
Annual % of Cooling - (Produced by renewables)	249% (71kWh/m².year)



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**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	E,	E,		DHW,		I,	I,	

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Elithis Tower

Net Zero Energy Building Overview

The Elithis Tower is the first positive energy office building (French regulation), producing six times less greenhouse gas emissions than traditional office structures. It is an experimental and demonstrational building. Experimental because many research and development are being done in order to improve building energy performance. Demonstrational because the main objective was to erect a NZEB with architecture fitted to an urban environment.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

The aim of this project was to combine aesthetics, urban integration, users' comfort, energy and environmental performance, and price. The Elithis Tower is open plan to ensure best internal air distribution and natural lighting. Being 33.5 meters high, the building is composed of 9 levels and 1 technical level (HVAC system). Most levels are occupied by engineering companies, and the others by the Ademe (Departmental Agency of Energy Management), X-rays medical services and a restaurant. The building has a concrete structure called the “central core” and the facades are made of wood and recyclable insulation (cellulose wadding). The surface fenestration is about 75% of the facades and, to enhance natural light, avoid glare and reduce solar gains, a special solar shading shield was designed. The Elithis Tower has very compact rounded shape effectively reducing building envelop area (10% less than in a conventional office tower), which has a positive effect regarding heat losses, solar gains and wind exposure (air infiltration)

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

	Electricity	Biofuel
Final:	38	11
Primary:	99	7

Energy Supply (kWh/m².year)

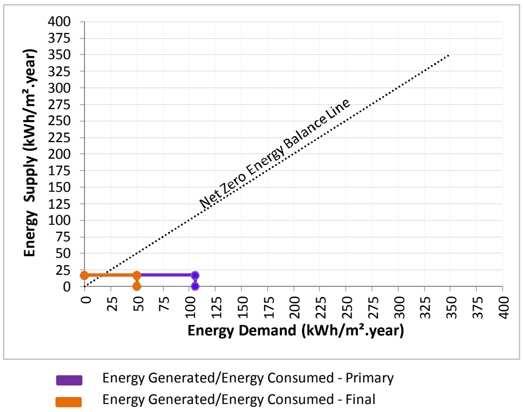
Renewable Energy

Final: 17

Primary: 17

Source to Site Conversion Factor (Electricity): 1

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:

Blue = Outside (sun and wind exposed)

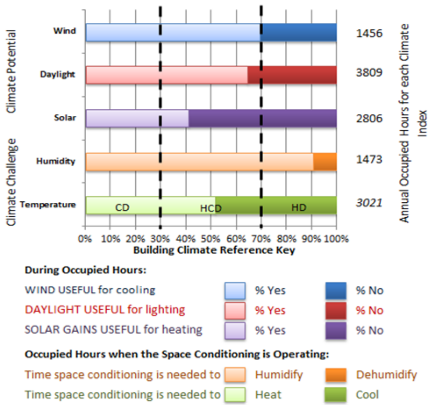
Yellow = Ground (floors and basement walls)

Purple = Building shading

Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

Completion Date
2009

Location
1C Boulevard de Champagne
21000 DIJON

France

Latitude North	Longitude West
47° 19' 44" N	05° 03' 08" E

Climate Challenge Definition

Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating Dominated

Building Type
Non-residential_Office

Site Context
Urban Centres - over 5 storey average height of neighbouring buildings, adjacent buildings touching, street widths 40+m

Net Floor Area (m²)
4567

Conditioned Floor Area (m²)
4500

Occupancy (m² per Person)
14.3

Number of Storeys

Cost US$/(Net) m² Floor Area
1,843

Cost US$/(Net) m² typical similar building
1,417

Web Address
www.elithis.fr

For more information:
http://tinyurl.com/ElithisTowerAlbum

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

***H** - Heating*
***C** - Cooling*
***L** - Lighting*
***DHW** - Domestic Hot Water*
***P** - Plug Loads*
***E** - Electricity*
***I** - Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,			

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 0.32
Solar Absorptivity

Concrete / Steel / Glass /Wood / Recyclable insulation (cellulose wadding)

East
U-value (W/m² ºC) 0.32
Solar Absorptivity

Concrete / Steel / Glass /Wood / Recyclable insulation (cellulose wadding)

Facing Polar Direction
U-value (W/m² ºC) 0.32
Solar Absorptivity

Concrete / Steel / Glass /Wood / Recyclable insulation (cellulose wadding)

West
U-value (W/m² ºC) 0.32
Solar Absorptivity

Concrete / Steel / Glass /Wood / Recyclable insulation (cellulose wadding)

Roofs
U-value (W/m² ºC) 0.22
Solar Absorptivity

Concrete (+ insulation)

Ground floor
U-value (W/m² ºC) 0.39

Concrete (+ insulation)

Windows - Construction Elements

Solar noon
U-value (W/m² ºC) 1.10
g-value 0.40

Double-glazed 8/20/6 Argon, Low E

East
U-value (W/m² ºC) 1.10
g-value 0.40

Double-glazed 8/20/6 Argon, Low E

Polar direction
U-value (W/m² ºC) 1.10
g-value 0.40

Double-glazed 8/20/6 Argon, Low E

West
U-value (W/m² ºC) 1.10
g-value 0.40

Double-glazed 8/20/6 Argon, Low E

Air permeability (m³/m²h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built
1.45 1/h @ 50Pa

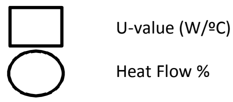
Compactness (m-1)

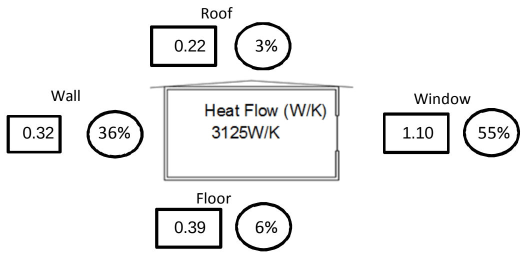
Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Compactness

The Elithis Tower has a very compact rounded shape. In comparison to a conventional office tower, its envelope area is about 10% less. This has a positive effect regarding heat losses and solar gains. The exposure to the wind is also reduced and the infiltration can be better controlled. Also, the air distribution is more homogeneous.

Sunspaces

Solar energy is the main source of heating and lighting used in this building. Therefore, most parts of the building are in an open plan distribution. This also ensures a good internal air distribution and thus, a reduction of energy needs for space heating and cooling. The solar shield allows the building to warm up during the cold periods.

Heat Recovery

For typical heating conditions (outdoor temperature lower than 10°C), the building is ventilated by mechanical systems with heat recovery controlled/bypassed by the BEM. Supply air is between 16 and 18°C and, for the rest of heating needs (indoor temperature of 22°C), the wood boiler is used. Solar and internal heat gains also contribute to heating.

Cooling

Sunshading

A passive solar shading shield has been designed in order to combine natural light and reduce solar gains. It provides the necessary natural light and the solar protection during hot periods.

Night Cooling

During summer nights, the building can be overventilated using the low pressure central atrium exhaust fan. The 32 air valves in facades per level are opened in order to ventilate the building with two or three times higher air flow rates than the design one.

Evaporate Cooling

When rooms temperature reach 26°C, a cooling system is used. There are two stages of cooling and the first one consists of an adiabatic unit where heat is evacuated by the water evaporation in a air/water plate interchange. The second stage (heat pump, EER = 11) is started when the outdoor temperature is higher than the indoor one.

Daylight Systems

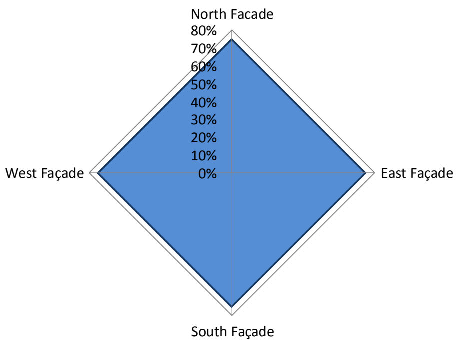
Lighting Control by BMS

The large number of windows reduces the need for artificial lighting while shading enhances natural lighting and reduces glare. Light fittings in the ceiling provide average-strength lighting (300 lux-French building standard codes) over the entire office space. In the case of low natural light conditions, motion sensors are coupled with lighting sensors. Installed lighting electrical power is only approx. 2W/m2. “Nomadic lamps” can be used for greater task illumination when needed.

Window Distribution Information

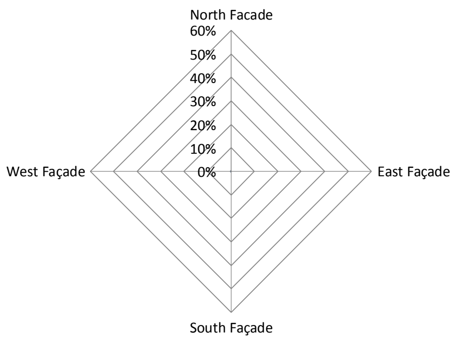
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C, L,		H, C,		H,		C,		C,	

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
7

Appliances / Plug Loads
Power Density Installed (W/m²) : 6

Artificial Lighting
Power Density Installed (W/m²) : 2

Computer Network
Power Density Installed (W/m²) :
Datacentre ? Yes

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	Yes
Air distribution	Yes

Description
The triple flow ventilation system (heat recovery with possible fresh air intakes) covers the most important part of the cooling needs. When the room's temperature reaches 24°C, a cooling system consisting of adiabatic unit (water evaporation) and heat pump (EER = 11) are activated to maintain the temperature below 26°C (French regulation). The heat pump is only needed to operate for extreme outside weather conditions (outdoor temperature higher than 30°C) and produces cold water circulating in the chilled beams.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	Yes

Description
The major part of the building heating needs is covered by solar and internal gains (users, personal computers and computer servers). For the rest of heating needs (in case of low external temperatures and cloudy days), one very low-power wood boiler (100 kW) provides the heat to ensure the thermal comfort. This system is used to maintain the 22°C room temperature all over the building. A second wood boiler can be activated in case of failure of the first boiler.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description
The ventilation system is mechanical and the air distribution principle is mixing. The building is ventilated by façade slits or by chilled beams (supply air nozzle jets) depending on the season. The system is controlled by the BEM system and is operated in three modes: winter mode (double flux with heat recovery), middle season (triple flux with fresh air intakes), and summer mode (free cooling). 32 slits (air valves) in facades and 32 chilled beams are installed per level. Air valves and chilled beams are controlled by the BEM system.

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	Biomass

Description
DHW is produced by individual electric water tanks (15 l).

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC
The three ventilation modes are controlled by the BEM, depending on the season.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? Yes

Description
Computer cut-off devices installed.

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Other

HVAC Systems
In mid-seasons, a triple flow mixed mode system, which is an Elithis innovation, is used. It gives the possibility for ventilative cooling with fresh air intakes and central atrium exhaust ventilation.

Artificial Lighting
Motion sensors combined with illumination sensors

Computer Management

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,	L,		H,				C,	H,	C,

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Funding

Source and Type of Funding
Private funding (Elithis Group), supported by the City of Dijon and ADEME Bourgogne

Principal Actors
Client: Elithis Group. Architect: Arte Charpentier. Engineer Civil and structural: C3B. Engineer MEP: Elithis

Authors
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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Primary Energy

Building Integrated PV?	Roof integrated
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	0°
Azimuth	
Technology	240 Wc Polycrystalline
Nominal Power (kWp)	82
Area (m²)	560
Yield (kWh/m².year)	332
Expected generation (kWh)	185760
Measured generation (kWh)	181100

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal
Technology
Position
Area (m²)
Production (kWh/m².year)
Annual % of Hot Water

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

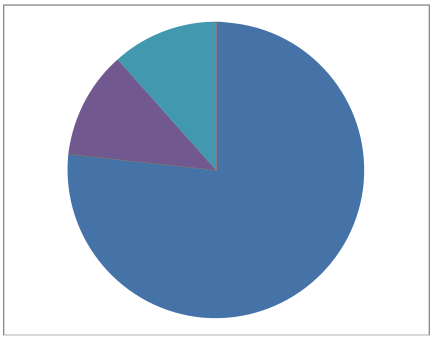
Renewable Production of Heating and Cooling

Heating Equipment - Primary Energy

	Biomass - Wooden Pellet Boiler
Technology	Low-power wood furnace
Power	100 kW
Efficiency (%)	95
Production (kWh/m².yr)	6.22
Annual % of Heating - (Produced by renewables)	

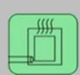
Cooling Equipment - Primary Energy

	Heat Pump
Technology	Water/Air Menerga unit (combination of adiabatic and thermodynamic systems)
Power	
Efficiency (%)	EER = 11 max
Production (kWh/m².year)	6
Annual % of Cooling - (Produced by renewables)	109 (6.7 kWh/m².year heat from the air)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	 E,			 H,		 I,		

References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Green Office

Net Zero Energy Building Overview

Passive House building with heat requirement of 9 kWh/m².yr according to KlimaHaus calculation - Intensive use of renewable energy with in particular an expected photovoltaic production 2.6 times higher than the yearly electricity demand.

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Completion Date
2011

Location
11 avenue du maréchal Juin (Meudon)
Paris
France

Latitude	Longitude
North	West
48.80° N	2°E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Office

Site Context
Urban Centres - over 5 storey average height of neighbouring buildings, adjacent buildings touching, street widths 40+m

Net Floor Area (m²)
21807

Conditioned Floor Area (m²)
21 500m²

Occupancy (m² per Person)
14.3

Number of Storeys

Cost US$/(Net) m² Floor Area
2,109

Cost US$/(Net) m² typical similar building

Web Address
www.green-office.fr

For more information:
http://tinyurl.com/Green-Office-FR

Architectural Design Concept

A compact building shape with an surface to volume ratio of 0.53 m-1 minimizes the outer scattering surfaces. Toward the Passivhaus concept, a high thermal insulation of the external walls and of the glazed facade are provided. An extensive glazed surface on the south facade lets in light to naturally illuminate the interior spaces and venetian blinds protect from glaring sunlight conditions. Also the main staircase is naturally lit thanks to a skylight on the roof.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

	Electricity	Biofuel
Final:	38	43
Primary:	97	13

Energy Supply (kWh/m².year)

Renewable Energy

Final:	20
Primary:	51

Source to Site Conversion Factor (Electricity): 2.58

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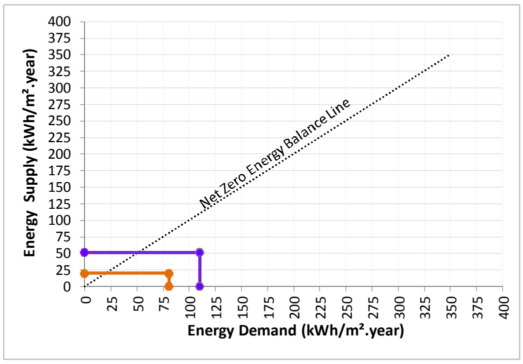

Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

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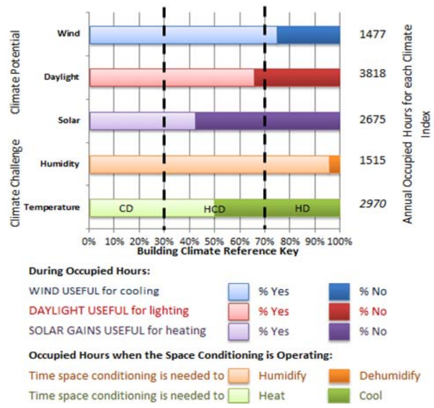

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L - *Lighting*	***I*** - *Integration*
DHW - *Domestic Hot Water*	

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,			

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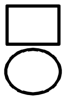

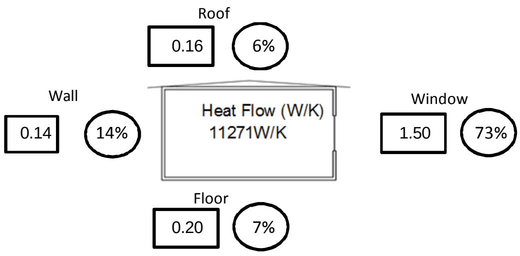

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Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Thermal Mass

External insulation and concrete structure

Cooling

Natural Ventilation

The building has openings at opposite ends to allow for natural ventilation.

Green Roof/Façade

This building has a green roof.

Night Cooling

Night cooling naturally for the cool storage

Daylight Systems

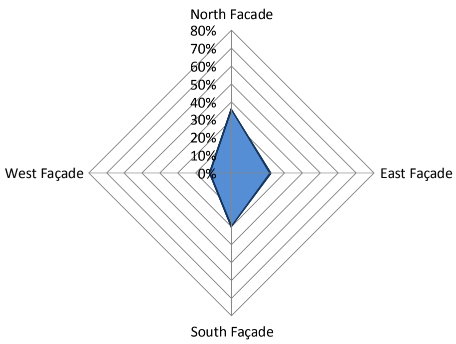
Motorized opening and controlled by the utilsateur from his post - OVM

Use of motorized opening and controlled by the Central Technical Management and building automation.

Window Distribution Information

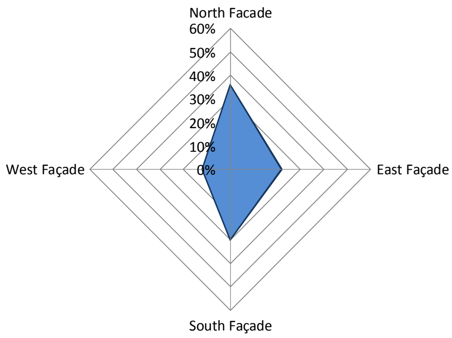
Distribution of Window Areas per Façade

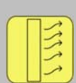
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
 H, C,		 H, C,	 H, C,		 H, C,	 C,		 C,	

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.14

Solar Absorptivity 0.40

Exterior wall of concrete with 20 cm of mineral wool (2 crossed layers): External insulation / Solar shading with photovoltaic cells /shade screen exterior.

East

U-value (W/m² ºC) 0.14

Solar Absorptivity 0.40

Exterior wall of concrete with 20 cm of mineral wool (2 crossed layers): External insulation / Solar shading with photovoltaic cells /shade screen exterior.

Facing Polar Direction

U-value (W/m² ºC) 0.14

Solar Absorptivity 0.40

Exterior wall of concrete with 20 cm of mineral wool (2 crossed layers): External insulation / Solar shading with photovoltaic cells /shade screen exterior.

West

U-value (W/m² ºC) 0.14

Solar Absorptivity 0.40

Exterior wall of concrete with 20 cm of mineral wool (2 crossed layers): External insulation / Solar shading with photovoltaic cells /shade screen exterior.

Roofs

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.30

Steel deck roof - Velum

Ground floor

U-value (W/m² ºC) 0.20

Low floor on crawlspace and parking

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 1.50

g-value

Facade with OVM

East

U-value (W/m² ºC) 1.50

g-value

Facade with OVM

Polar direction

U-value (W/m² ºC) 1.50

g-value

Facade with OVM

West

U-value (W/m² ºC) 1.50

g-value

Facade with OVM

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

Compactness (m-1)

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Other

HVAC Systems
Radiant ceiling heating

Artificial Lighting
AML / presence detector / brightness scale

Computer Management

Control of Systems

System Design Parameters

Outside Air Requirements per Person (L/s-p)
unknown

Appliances / Plug Loads
Power Density Installed (W/m²) : Unknown

Artificial Lighting
Power Density Installed (W/m²) : 7 W/m²

Computer Network
Power Density Installed (W/m²) : 9 W/m²
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
No cooling plant

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
Space heating (radiant floors)

Ventilation System

Heat Recovery Type	No
Central Air supply	No
Local Air Recirc plus Central Fresh Air	Unknown

Description

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	

Description
The water supply in the building is kept above 20C°. The water taps are also calibrated to run at 20C°.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description
The system allows users to manage their level of personal comfort. If they need assistance they can access this via their computer.

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,						H,	C,	H, C,	C,

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Funding
Source and Type of Funding
Bouygues Immobilier

Principal Actors
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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV)

Building Integrated PV?	Roof/cladding integrated.
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	
Azimuth	
Technology	Monocrystalline Tedlar Glass
Nominal Power (kWp)	
Area (m²)	3758
Yield (kWh/m².year)	
Expected generation (kWh)	427850
Measured generation (kWh)	

Wind Turbine
Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal	Yes
Technology	Flat plate collectors
Position	Roof
Area (m²)	
Production (kWh/m².year)	
Annual % of Hot Water	

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power
Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

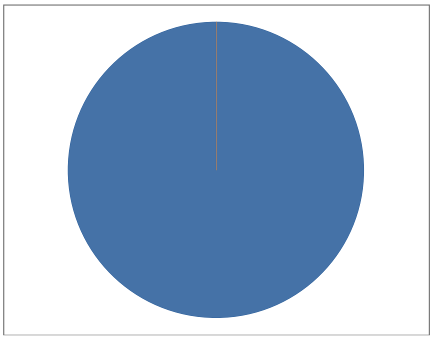
Renewable Production of Heating and Cooling

Heating Equipment

	Heat Pump
Technology	
Power	
Efficiency (%)	
Production (kWh/m².yr)	
Annual % of Heating - (Produced by renewables)	

Cooling Equipment

	Heat Pump
Technology	
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,	 E,		 H,		 H, C,	 I,	 I,	

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Meridian Building

Net Zero Energy Building Overview

One of the closest to Net Zero in New Zealand, and also has architectural merit. It is claimed to be a high-performance, low energy building, using 60% less energy than a typical office building in New Zealand.

Completion Date
Finished September 2007

Location
33 Customhouse Quay
Wellington

New Zealand

Latitude South	Longitude East
41° 28' 31" S	174° 77' 90" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Office

Site Context
Urban Centres - over 5 storey average height of neighbouring buildings, adjacent buildings touching, street widths 40+m

Net Floor Area (m²)
5246

Conditioned Floor Area (m²)
4795

Occupancy (m² per Person)
19.5

Number of Storeys

Cost US$/(Net) m² Floor Area

Cost US$/(Net) m² typical similar building

Web Address
http://www.meridianbuilding.co.nz

For more information:
http://tinyurl.com/Meridian-NZ

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

This building consists of a ground floor that contains publicly accessible activities, with three levels of offices above. The buildings form is in an 'L' shape which appears as two separate forms– a glass pavilion that floats on the harbour edge, and a smaller curved annex building that links to the adjacent heritage warehouses. External louvres cover the exterior glazing of this portion of the building. The top floor of the annex has been set back above the louvred screen. The design intent was to develop a high performance, low energy building. Meridian building includes as many environmentally sustainable design principles as practicable. The envelope includes double glazing, with openable windows to allow for natural ventilation. Thermal mass is used to moderate the internal temperature.

Measured Energy Production and Consumption:

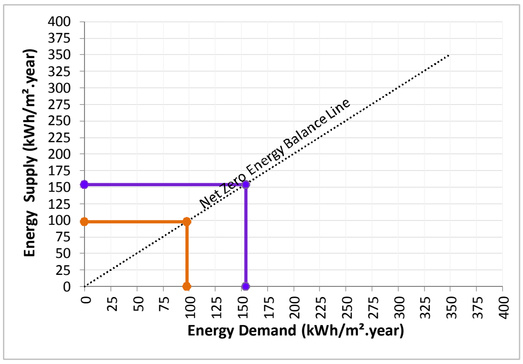
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 98
Primary: 154

Energy Supply (kWh/m².year)
Renewable Energy
Final: 98
Primary: 154

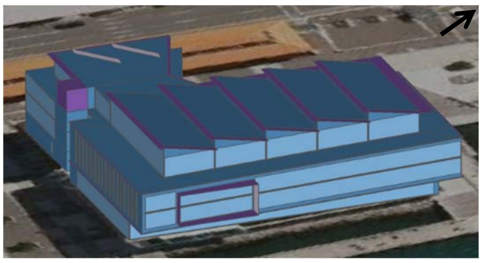
Source to Site Conversion Factor (Electricity): 1.57

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model

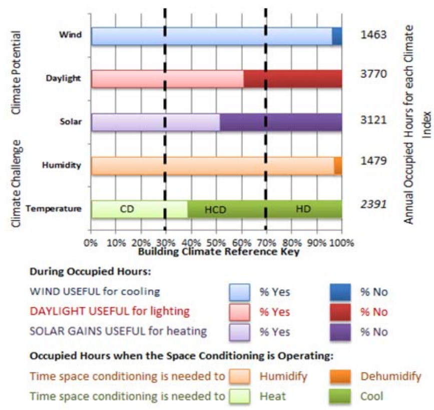


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

***H** - Heating*
***C** - Cooling*
***L** - Lighting*
***DHW** - Domestic Hot Water*
***P** - Plug Loads*
***E** - Electricity*
***I** - Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,			

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC)	0.38
Solar Absorptivity	0.40

Largely glazing - Glazing 77% Spandrels 10%, Concrete 13% - 150mm concrete, 90mm insulation

East

U-value (W/m² ºC)	0.38
Solar Absorptivity	0.40

Glazing 68%, Spandrels 3%, Concrete 29%

Facing Polar Direction

U-value (W/m² ºC)	0.38
Solar Absorptivity	0.40

Concrete panels with windows punched in on pavilion and cedar weatherboards on Annex - Glazing 54%, Spandrels 5%, Concrete 26%, Cedar 14%, Vents 1%

West

U-value (W/m² ºC)	0.38
Solar Absorptivity	0.40

Glazing 72%, Spandrels, 9%, Concrete 15%, Cedar 1%, Vents 3%

Roofs

U-value (W/m² ºC)	0.20
Solar Absorptivity	

2 layer torch on APP modified Bitumen (vented on concrete)

Ground floor

U-value (W/m² ºC)	0.40

Concrete Slab

Windows - Construction Elements

Solar noon

U-value (W/m² ºC)	2.00
g-value	0.44

29mm blue-green with clear Low E IGU (6mm - 17mm - 6mm)

East

U-value (W/m² ºC)	2.00
g-value	0.67

Pavilion - double skin façade (clear low e IGU). Annex - Clear Low E IGU

Polar direction

U-value (W/m² ºC)	2.00
g-value	0.44

29mm blue-green with clear Low E IGU (6mm - 17mm - 6mm)

West

U-value (W/m² ºC)	2.00
g-value	0.67

Pavilion - double skin façade (clear low e IGU). Annex - Clear Low E IGU

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

Compactness (m-1)

Passive Approaches:

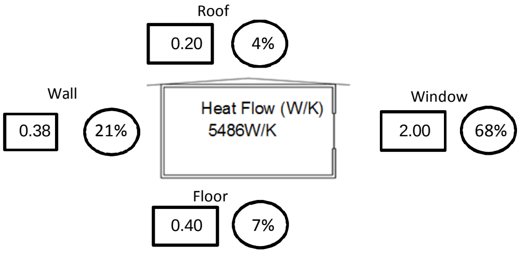
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set *- The set of solutions used to lower the energy consumption of the whole building.*

Heating

Thermal Mass

Heat is absorbed through gaps in the ceiling panels to the concrete panels above, and is released back in the environment at night.

Cooling

Natural Ventilation

There are openable windows on every facade. These are controlled by the BMS system, but have manual override.

Sunshading

The facades are tailored to the context and environment that they are in. There are extensive louvres over the north, west, and south facades, with a double skin facade on the east and west to allow uninterrupted views, with automated blinds within the skins.

Night Cooling

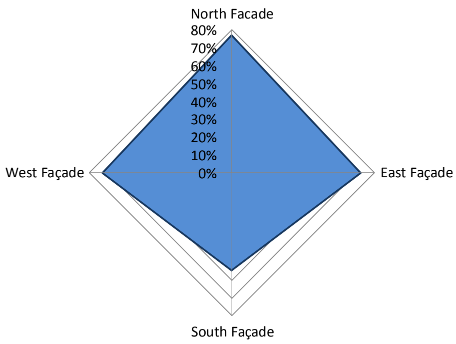
The heat that is absorbed by the thermal mass during the day is released back into the environment at night, and is then expelled from the building in a night purge.

Daylight Systems

Window Distribution Information

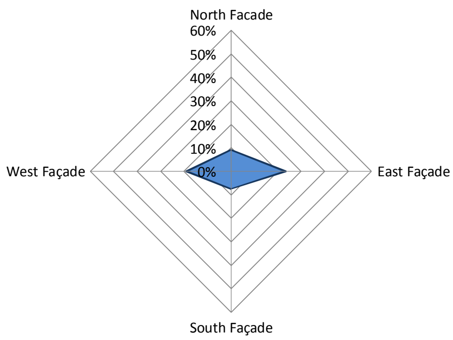
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C,		C,		H,		C,			

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Other

HVAC Systems

Artificial Lighting

Computer Management

Control of Systems

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) : 9.5W/m²

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	Yes

Description

Chilled water is provided by two packaged air cooled chillers located in the rooftop plant enclosure.
An air-cooled chiller supplies chilled water to the chilled beams at 15C.
Night purging adds to the overall cooling system for the building.
Windows automatically open at night to allow cool air in, flushing warm air out and cooling the exposed structural soffits.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	Yes

Description

The facade performance and ventilation heat recovery reduce the heating requirements - a reverse cycle heat pump provides the remaining heating needs.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description

The HVAC system uses an energy recovery wheel, with a thermal efficiency of 75%, to reduce heating and cooling energy. The outdoor air supply rate is 1.5 litres/m²

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	Yes
Electrical?	No
Other?	

Description

The heat production of solar thermal collectors cover 70% of the domestic water heating, the final 30% is provided by 2 electric water cylinders.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

The BMS system also automatically adjusts the lighting level. This includes the movement of the hydraulic solar blinds and sun louvres, as well as automatically reducing artificial lighting when daylight is available.
Controls for the automated blinds include a control to close when incident solar radiation onto the outer surface of the glass is 150W/m² or greater/

HVAC

The BMS system automatically controls the various systems, including HVAC and lighting. A weather station is incorporated on to the roof so the BMS is able to adjust to the weather conditions. The BMS controls the windows for natural ventilation, regulates zone temperature. There are CO2 sensors that signal for more ventilation when the CO2 levels reach 600ppm.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided? No

Description

Most of the systems are controlled by the BMS operated, but there is also manual override.

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,	L,	P,	H,	DHW,			C,	H, C,	

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Builder/Contractor
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Address

Email

Web Address
www.fletcherconstruction.co.nz/

Funding
Source and Type of Funding
Wellington Waterfront initially funded the project, which was bought by Dominion Property and they funded the rest.

Principal Actors
The building was initiated by Wellington Waterfront Ltd, with consultants Studio Pacific Architects, Dunning Thornton structural engineers, and Beca Environmental and Services Engineers. Once Resource Consent had been granted, Dominion Property Fund bought the development and Meridian Energy signed as the sole tenant for the commercial office space.

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	
Ground mounted	
Roof mounted	
Position	
Tilt (angle)	
Azimuth	
Technology	
Nominal Power (kWp)	
Area (m²)	
Yield (kWh/m².year)	
Expected generation (kWh)	561322
Measured generation (kWh)	513065

Wind Turbine - Final Energy

Position	Off-site
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	167.99

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Flat plate collectors
Position	On the roof of the annex
Area (m²)	18
Production (kWh/m².year)	21
Annual % of Hot Water	70

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

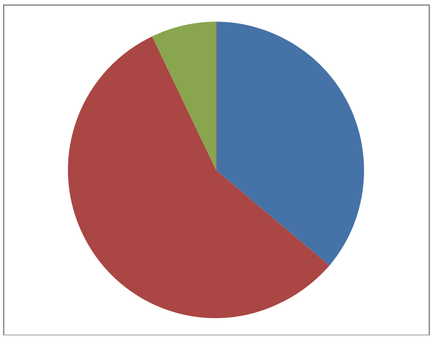
Renewable Production of Heating and Cooling

Heating Equipment There is no active heating system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².yr)
Annual % of Heating - (Produced by renewables)

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,	 E,							 I,

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

SOLAR XXI

Net Zero Energy Building Overview

Solar XXI building is considered a highly efficient building. Its energy consumption is only one tenth of a standard Portuguese office building. From the NZEB goal perspective, the building, may be currently considered, a "plus (electric) Energy Building" and a "nearly Zero Energy Building" in terms of the overall building energy consumption.

Completion Date
Construction completed August 2006

Location
Paço do Lumiar, 22
Lisbon
Lisbon
Portugal

Latitude	Longitude
North	West
38°46'20.27" N	9°10'39.83" W

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Cooling Dominated

Building Type
Non-residential_Office

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
1500

Conditioned Floor Area (m²)
1200

Occupancy (m² per Person)
62.5

Number of Storeys

Cost US$/(Net) m² Floor Area
1100 (800 euros)

Cost US$/(Net) m² typical similar building

Web Address
www.lneg.pt

For more information:
http://tinyurl.com/SolarXXI

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

The design of SOLAR XXI is based on a combination of passive design techniques with renewable energy technologies, including PV and solar collectors. An extensive glazed surface on the south façade lets in light to naturally illuminate the interior spaces, with venetian blinds protect from glaring sunlight. The main staircase is naturally lit by a ceiling skylight. Increasing the solar heat gains in winter was one of the foremost purposes of the building's design, location, orientation and size of the glazed area was considered crucial. In addition to direct solar gains through the windows, the PV system on the south facade contributes to the indoor climate in cooler weather when heat released in the process of converting solar radiation into power is recovered.

Measured Energy Production and Consumption:

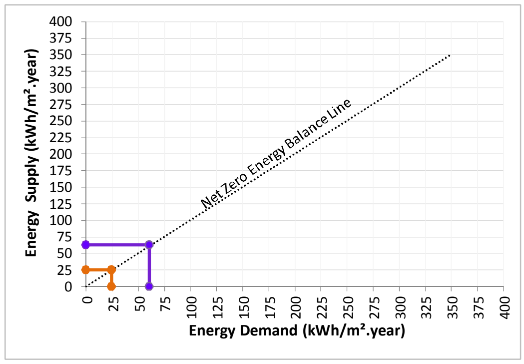
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 24
Primary: 60

Energy Supply (kWh/m².year)
Renewable Energy
Final: 25
Primary: 63

Source to Site Conversion Factor (Electricity): 2.5

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

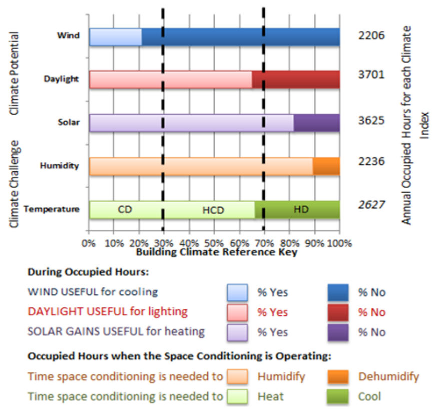
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H - Heating
C - Cooling
L - Lighting
DHW - Domestic Hot Water
P - Plug Loads
E - Electricity
I - Integration

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,	 L,		

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 0.45
Solar Absorptivity

22 cm thickness brick masonry wall externally insulated with extruded polystyrene 6 cm thick

East
U-value (W/m² ºC) 0.45
Solar Absorptivity

22 cm thickness brick masonry wall externally insulated with extruded polystyrene 6 cm thick

Facing Polar Direction
U-value (W/m² ºC) 0.45
Solar Absorptivity

22 cm thickness brick masonry wall externally insulated with extruded polystyrene 6 cm thick

West
U-value (W/m² ºC) 0.45
Solar Absorptivity

22 cm thickness brick masonry wall externally insulated with extruded polystyrene 6 cm thick

Roofs
U-value (W/m² ºC) 0.26
Solar Absorptivity

externally insulated with extruded polystyrene 10 cm thick

Ground floor
U-value (W/m² ºC) 0.80

Windows - Construction Elements

Solar noon
U-value (W/m² ºC) 3.50
g-value 0.75

transparent, double glazing

East
U-value (W/m² ºC) 3.50
g-value 0.75

transparent, double glazing

Polar direction
U-value (W/m² ºC) 3.50
g-value 0.75

transparent, double glazing

West
U-value (W/m² ºC) 3.50
g-value 0.75

transparent, double glazing

Air permeability (m³/m²h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

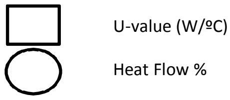
Compactness (m-1)

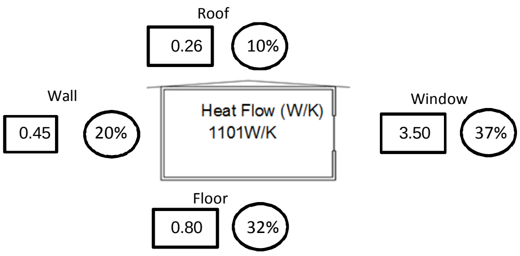
Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

***Building Challenge Solution Set** - The set of solutions used to lower the energy needed by a particular building challenge.*

***Whole Building Solution Set** - The set of solutions used to lower the energy consumption of the whole building.*

Heating

Heat Recovery

BIPVT: PV system integrating south building façade, contributes to the improvement of the indoor climate during heating season in the day time hours, when the heat released in the process of converting solar radiation into power is successfully recovered.

Thermal Mass

Envelope optimization - the building is constructed to provide high internal thermal capacity. The building envelope is externally insulated with expanded polystyrene in order to reduce heat conduction gains and losses.

Solar Heat Gains

Increasing the solar heat gains in winter time consisted one of the dominant strategies in the building design, by adopting essential features such as location, size and orientation (south) of the main glazing area

Cooling

Natural Ventilation

Natural ventilation is provided due to cross wind and stack effect via openings in the façade and roof. The façade openings, together with adjustable vents on all office room doors, provide the cross ventilation, allowing the air to flow from inside to outside and vice versa.

Sunshading

Venetian blinds were placed outside the glazing to limit direct solar gains

Ground Cooling

Ground cooling system provides incoming pre-cooled air into the building using the earth as a cooling source. The air enters into the tubes array 15m away from the building, crosses the tubes circuit cooling to a temperature near the ground and is injected into the building office rooms by natural convection or forced convection using small fans.

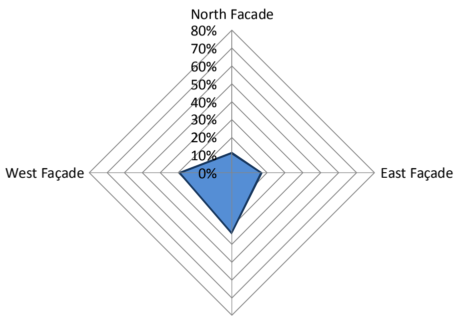
Daylight Systems

The location and dimension of a central skylight as a main light distributor in the central hall is fundamental. This is also true of the translucent vents in the doors at the southern and northern ends of the corridors, and the extensive use of glazing in the building envelope. These are significant features in the reduction of the building's consumption of electric lighting.

Window Distribution Information

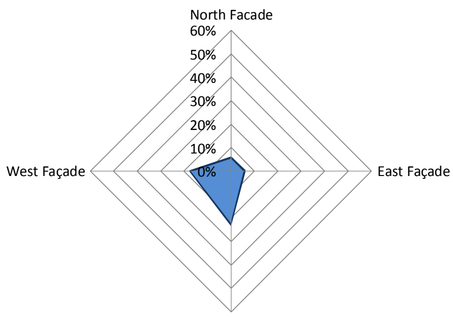
Distribution of Window Areas per Façade

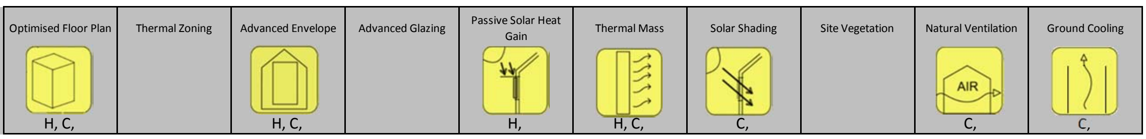
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Earth Tube Cooling

Earth tube system providing passive cooling

HVAC Systems

Artificial Lighting

Computer Management

Control of Systems

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads

Power Density Installed (W/m²) : Approx. 8.3W/m^2

Artificial Lighting

Power Density Installed (W/m²) : Approx. 6.7W/m^2

Computer Network

Power Density Installed (W/m²) :

Datacentre ?

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description

No cooling active systems

Heating

Central Plant	No
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description

Space heating provided by solar thermal collectors system, assisted by a natural gas boiler.

Ventilation System

Heat Recovery Type	No
Central Air supply	No
Local Air Recirc plus Central Fresh Air	Yes

Description

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	Yes
Other?	

Description

Space heating provided by solar thermal collectors system, assisted by a natural gas boiler.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided? No

Description

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,			L,	kWh P,							

Design Team

Engineer Civil

Name

Obrecol SA

Address

Email

Web Address

Engineer MEP

Name

Lomarisco Lda / Aquadomos Lda

Address

Email

Web Address

Engineer Structural

Name

Address

Email

Web Address

Architect

Name

Pedro Cabrita, Isabel Diniz

Address

Email

Web Address

Builder/Contractor

Name

Address

Email

Web Address

Funding

Source and Type of Funding

Principal Actors

Authors

Helder Gonçalves/Laura Aelenei

Email

helder.goncalves@lneg.pt / laura.aelenei@lneg.pt

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Façade/roof integrated
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	90º façade; 30º car park
Azimuth	South
Technology	Multicrystalline/amorphous silicon
Nominal Power (kWp)	30
Area (m²)	300
Yield (kWh/m².year)	127
Expected generation (kWh)	37960
Measured generation (kWh)	38000

Wind Turbine

Position

Number of Turbine

Technology

Nominal Power (kWp)

Energy Production (kWh/m².year)

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	CPC flat plate collectors
Position	Fixed, South
Area (m²)	20
Production (kWh/m².year)	4
Annual % of Hot Water	

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type

Fuel

Efficiency (%)

Electricity

Water Heating

Space Heating

Cooling

Production (kWh/m².year)

Electricity

Water Heating

Space Heating

Cooling

Renewable Production of Heating and Cooling

Heating Equipment There is no active heating system installed in the building.

Technology

Power

Efficiency (%)

Production (kWh/m².yr)

Annual % of Heating - (Produced by renewables)

Cooling Equipment There is no active cooling system installed in the building.

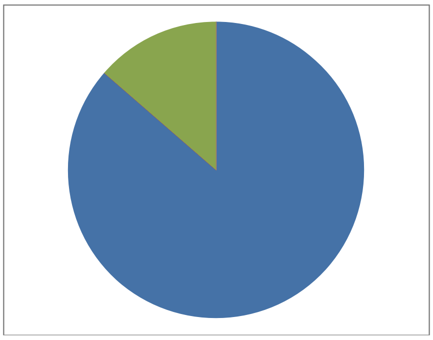
Technology

Power

Efficiency (%)

Production (kWh/m².year)

Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.

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- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 H,	 E,					 I,		

References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

CIRCE Zaragoza

Net Zero Energy Building Overview

This is the headquarters of CIRCE (research centre which works on emission reduction). The building includes green construction concepts and technologies (natural materials and the like), and will be used as an example for technology transfer to companies and university students (University of Zaragoza).

Completion Date
Already operational (since June 2010)

Location
15, Mariano Esquillor Gómez
Zaragoza
Zaragoza
Spain

Latitude	Longitude
North	West
41º41'N	0º53'W

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating Dominated

Building Type
Non-residential_Office

Site Context
Open Site

Net Floor Area (m²)
1743

Conditioned Floor Area (m²)
1700

Occupancy (m² per Person)
9.0

Number of Storeys

Cost US$/(Net) m² Floor Area

Cost US$/(Net) m² typical similar building

Web Address
www.fcirce.eu or www.circe.cps.unizar.es

For more information:
http://maps.google.es/maps?ll=41.685196,-0.888264&z=16&t=h&hl=es

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

A compact, two storey building shape. There are three main elements: round core topped by a dome, office rooms around the core and rectangular body for laboratories which protects against dominant winds.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

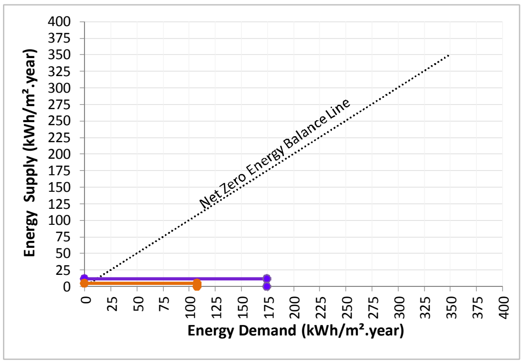
	Electricity	Natural Gas
Final:	87	20
Primary:	67	21

Energy Supply (kWh/m².year)
Renewable Energy

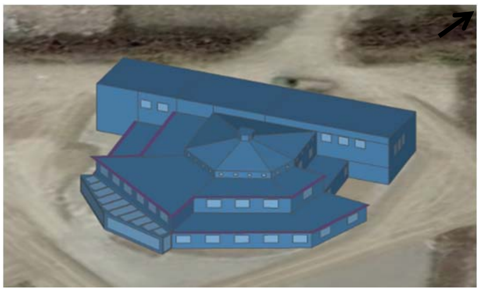
Final:	5
Primary:	12

Source to Site Conversion Factor (Electricity): 2.28

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



EnergyPlus Model

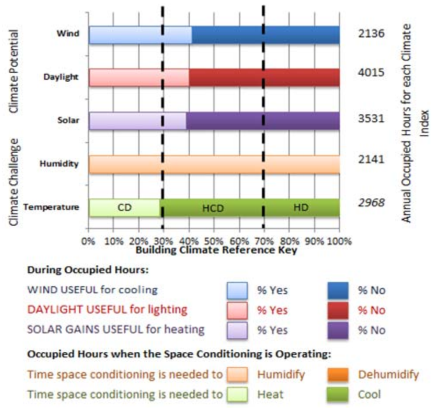


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating*
C *- Cooling*
L *- Lighting*
DHW *- Domestic Hot Water*
P *- Plug Loads*
E *- Electricity*
I *- Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
	 L,		

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.67

Solar Absorptivity 0.43

from inside to outside: gypsum layer, hollow brick, air gap, 3cm fiberglass insulation, concrete layer, light clay brick

East

U-value (W/m² ºC) 0.67

Solar Absorptivity 0.43

from inside to outside: gypsum layer, hollow brick, air gap, 3cm fiberglass insulation, concrete layer, light clay brick

Facing Polar Direction

U-value (W/m² ºC) 0.57

Solar Absorptivity 0.43

from inside to outside: gypsum layer, hollow brick, air gap, 4cm fiberglass insulation, concrete layer, light clay brick

West

U-value (W/m² ºC) 0.67

Solar Absorptivity 0.43

from inside to outside: gypsum layer, hollow brick, air gap, 3cm fiberglass insulation, concrete layer, light clay brick

Roofs

U-value (W/m² ºC) 0.25

Solar Absorptivity 0.30

green roof

Ground floor

U-value (W/m² ºC) 0.48

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 1.10

g-value 0.40

Double pane glazing low emissivity 4/15/4

East

U-value (W/m² ºC) 1.10

g-value 0.40

Double pane glazing low emissivity 4/15/4

Polar direction

U-value (W/m² ºC) 1.10

g-value 0.40

Double pane glazing low emissivity 4/15/4

West

U-value (W/m² ºC) 1.10

g-value 0.40

Double pane glazing low emissivity 4/15/4

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

Compactness (m-1)

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

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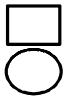
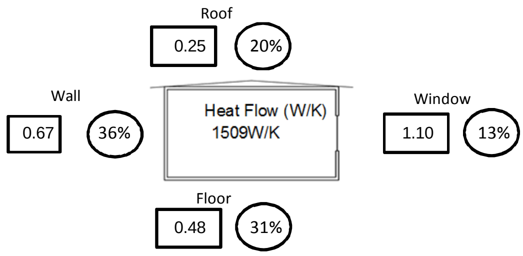


U-value (W/ºC)

Heat Flow %



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Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set *- The set of solutions used to lower the energy consumption of the whole building.*

Heating

Sunspaces

Greenhouse corridor around the core. High solar availability and high heating demand in winter. Solar energy is stored in thick wall. In summer, greenhouse is opened.

Thermal Mass

Attenuate high daily temperature range by means of thermal storage in light clay bricks.

Cooling

Natural Ventilation

To prevent summer overheating there are dome openings. As well as this, there is night cooling in summer time through solar chimneys.

Sun shading

Overhangs to intercept direct solar radiation in summer.

Green Roof/Façade

Green roof above office rooms.

Daylight Systems

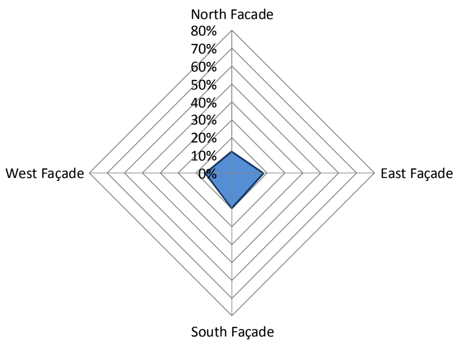
skylight over interior corridor

Daylight access to interior corridor (East wing) 37m2

Window Distribution Information

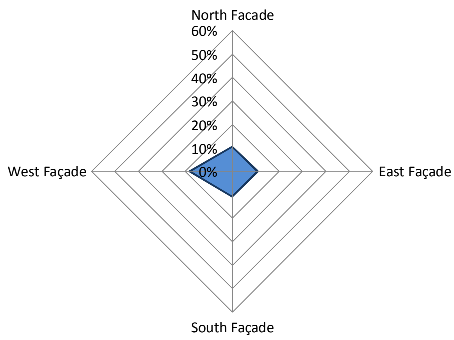
Distribution of Window Areas per Façade

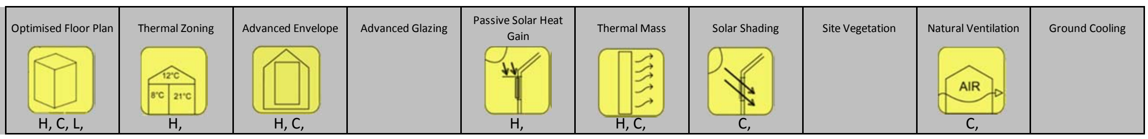
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) : Variable: [6-15] W/m2

Computer Network
Power Density Installed (W/m²) :
Datacentre ?

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	Yes
Air distribution	No

Description
Ground coupled electric heat pump.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	No

Description
Space heating is covered by: 1) a ground coupled electric heat pump, and 2) a condensing boiler. A biomass boiler is expected in the future.

Ventilation System

Heat Recovery Type	No
Central Air supply	No
Local Air Recirc plus Central Fresh Air	No

Description

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	Yes
Other?	

Description
Solar thermal system, complemented with natural gas condenser boiler

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC
Zoning control of temperature and flow.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided?

Description

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

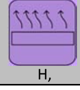
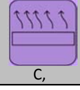
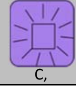
Other
Greenhouse, green roof, solar chimney, evaporative cooling.

HVAC Systems
Radiant floor for both heating and cooling. Ground source heat pump

Artificial Lighting

Computer Management

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
								 H,	 C,		 C,

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Source and Type of Funding

Aragón Government and FEDER

Principal Actors

University of Zaragoza and CIRCE (Centre of Research for Energy Resources and Consumption)

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) -Final Energy

Building Integrated PV?	No
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	30º
Azimuth	Solar noon
Technology	6 different PV technologies
Nominal Power (kWp)	Total: 5.34
Area (m²)	Unknown
Yield (kWh/m².year)	4
Expected generation (kWh)	7322
Measured generation (kWh)	7302

Wind Turbine

Position	On-site
Number of Turbine	1
Technology	Horizontal
Nominal Power (kWp)	6
Energy Production (kWh/m².year)	7.73

Solar Water Heating

Hot Water -Final Energy

Solar Thermal	Yes
Technology	Vacuum tube collector
Position	Tilt 50º. Solar noon
Area (m²)	12
Production (kWh/m².year)	2
Annual % of Hot Water	10%

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type

Fuel

Efficiency (%)

Electricity

Water Heating

Space Heating

Cooling

Production (kWh/m².year)

Electricity

Water Heating

Space Heating

Cooling

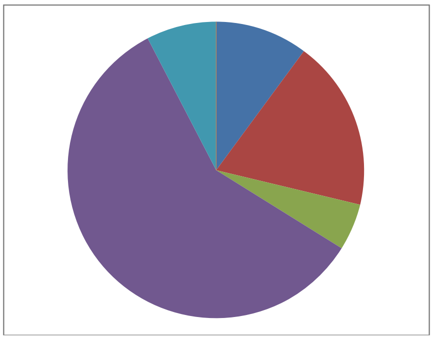
Renewable Production of Heating and Cooling

Heating Equipment

	Condensing boiler, natural gas	Ground / Water Source Heat Pump
Technology		
Power	160 kW	66 kW
Efficiency (%)	98	450
Production (kWh/m².yr)	24.10	0.15
Annual % of Heating - (Produced by renewables)		No

Cooling Equipment -Final Energy

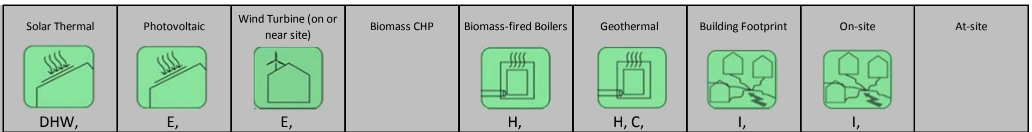
	Heat Pump
Technology	Ground source electric heat pump
Power	
Efficiency (%)	450
Production (kWh/m².year)	3
Annual % of Cooling - (Produced by renewables)	122 (3.9 kWh/m².year cool from the ground)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.

**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production



References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

LYCEE KYOTO HIGH SCHOOL

Completion Date
2009

Location
26 avenue de la fraternité
Poitiers
Poitou-Charentes
France

Latitude	Longitude
North	West
46° 34' 55" N	00° 20' 10" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating Dominated

Building Type
Non-residential_Educational

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
13942

Conditioned Floor Area (m²)
11593

Occupancy (m² per Person)
20.0

Number of Storeys

Cost US$/(Net) m² Floor Area
2,564

Cost US$/(Net) m² typical similar building
2,207

Web Address
www.lycee-kyoto.eu

For more information:
http://tinyurl.com/Kyoto-FR

Net Zero Energy Building Overview

Kyoto high school was Europe's first post-oil high school using 100% clean energy. Energy needs are optimised through the use of tailored architectural features and materials (very effective building insulation, green roofs, low-energy lighting and equipment). It also makes use of local and renewable energy (heat storage tank, MCHP running on vegetable oil and solar panels) and water is managed (recovery of rainwater, specific vegetation).

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

Products of the land and their transformation "from land to plate" link all the dimensions of the landscape. The high school thus relies on the exploitation of the geography of the site, allowing room within the site for a "plain" which will continue to be a reminder and witness to the agricultural site. This protects the views from future urbanisation. The sobriety of the architecture emphasises this approach to the landscape. Volumetrics, highlighting the topography, are reminiscent of the particular nature of blocks of stone in neighbouring quarries. Wood cladding is a reminder of the agricultural architecture of the tobacco drying barns of which there are some remnants in the region. Chalk at the site is used on some of the buildings' supporting walls. Landscaping of the planted areas is organised around this plain. Like trees isolated in the middle of fields, remarkable trees have been planted at the heart of the site.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

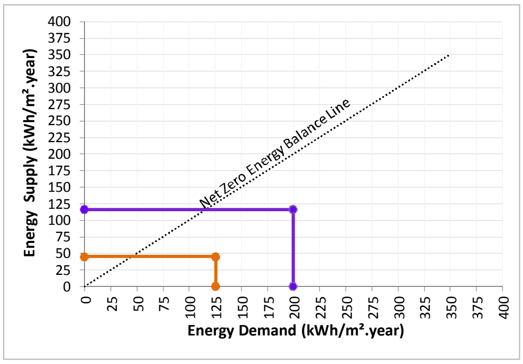
	Electricity	Others
Final:	47	78
Primary:	121	78

Energy Supply (kWh/m².year)
Renewable Energy

Final:	45
Primary:	116

Source to Site Conversion Factor (Electricity): 2.58

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

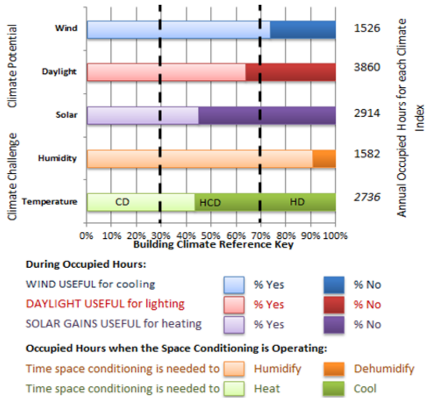
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating*	***P*** *- Plug Loads*
C *- Cooling*	***E*** *- Electricity*
L *- Lighting*	***I*** *- Integration*
DHW *- Domestic Hot Water*	

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 H, L,			

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 0.17
Solar Absorptivity

Mix ETI (concrete) / ETI + wood cladding (ETI : U = 0.19 W/m2K / ETI + wood cladding : U = 0.14 W/m2K)

East
U-value (W/m² ºC) 0.17
Solar Absorptivity

Mix ETI (concrete) / ETI + wood cladding (ETI : U = 0.19 W/m2K / ETI + wood cladding : U = 0.14 W/m2K)

Facing Polar Direction
U-value (W/m² ºC) 0.17
Solar Absorptivity

Mix ETI (concrete) / ETI + wood cladding (ETI : U = 0.19 W/m2K / ETI + wood cladding : U = 0.14 W/m2K)

West
U-value (W/m² ºC) 0.17
Solar Absorptivity

Mix ETI (concrete) / ETI + wood cladding (ETI : U = 0.19 W/m2K / ETI + wood cladding : U = 0.14 W/m2K)

Roofs
U-value (W/m² ºC) 0.19
Solar Absorptivity

Mix ETI (concrete) / ETI + vegetation

Ground floor
U-value (W/m² ºC) 0.19

ITI (concrete)

Windows - Construction Elements

Solar noon
U-value (W/m² ºC) 1.30
g-value 0.67

Sonic 44-12-4, Face Low E

East
U-value (W/m² ºC) 1.30
g-value 0.67

Sonic 44-12-4, Face Low E

Polar direction
U-value (W/m² ºC) 1.30
g-value 0.67

Sonic 44-12-4, Face Low E

West
U-value (W/m² ºC) 1.30
g-value 0.67

Sonic 44-12-4, Face Low E

Air permeability (m³/m²h@4pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built
0.93 m3/h.m^2 @ 4 Pa

Compactness (m-1)

Passive Approaches:

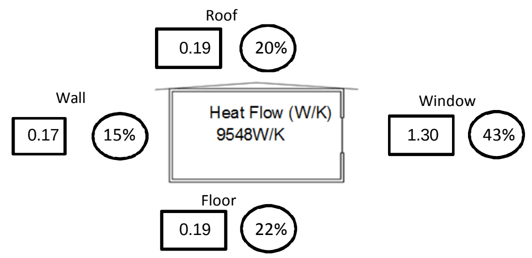
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

***Building Challenge Solution Set** - The set of solutions used to lower the energy needed by a particular building challenge.*

***Whole Building Solution Set** - The set of solutions used to lower the energy consumption of the whole building.*

Heating

Sunspaces

Bioclimatic design with the creation of a large atrium within the main building.

Heat Recovery

Ventilation and cooking equipments (used by apprentices) are equiped with energy recovery systems. All rooms are ventilated by a double-flow ventilation system in winter.

Thermal Mass

The heating system focuses on "summer" energy: a 1000 cubic meter water tank is used to store the energy stored during the summer, through the urban heating network, for use throughout the year. In addition, 2 MCHP units running on rapeseed oil provides replenishment during the heating season. MCHP units also produce DHW.

Cooling

Natural Ventilation

All rooms are ventilated by a natural ventilation system in summer. The atrium is naturally ventilated as soon as a temperature of 27°C is reached (shutter and automatic canopy opening system).

Sunshading

Fixed and moving sunscreens on all buildings, scaled for direction and each season.

Green Roof/Façade

Green roof for thermal comfort and recovery of rain water (200 cubic metres rainwater tank for watering and toilet facility water supply purposes).

Daylight Systems

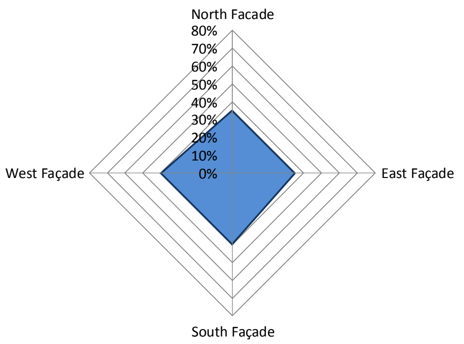
Optimised automatic lighting in all parts of high school

Optimised automatic and low consumption lighting in all parts of high school.

Window Distribution Information

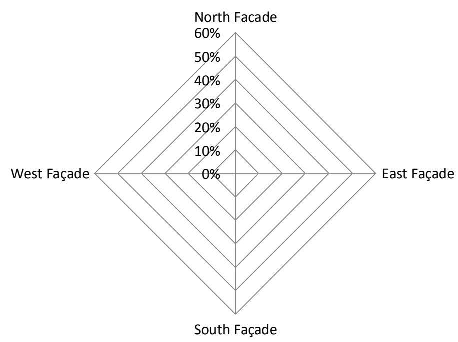
Distribution of Window Areas per Façade

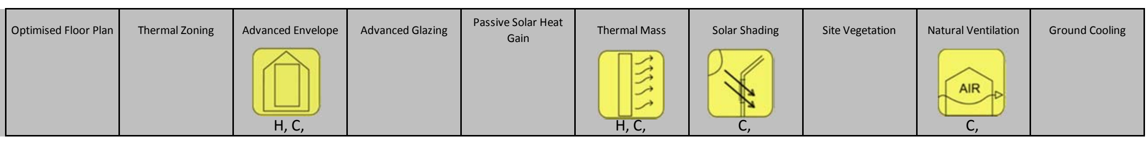
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

A 1000 cubic metres hot water storage tank (for heating) stores during summer energy through the urban heating network (linked to a waste incineration plant). MCHP units provide replenishment during the heating season

Other

HVAC Systems

Artificial Lighting

Computer Management

Control of Systems

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

5

Appliances / Plug Loads

Power Density Installed (W/m²) :

Artificial Lighting

Power Density Installed (W/m²) : 10

Computer Network

Power Density Installed (W/m²) :

Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description

No cooling plant.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	Yes

Description

Hot water radiators and AHU with heat recovery (thermal wheels, efficiency = 0.80). Mechanical balanced ventilation for dwellings (plate heat echangers, efficiency = 0.95). The heating system focuses on "summer" energy (heat stored during summer in a 1000 cubic meter water tank).

Ventilation System

Heat Recovery Type	Yes
Central Air supply	No
Local Air Recirc plus Central Fresh Air	No

Description

Mechanical balanced ventilation for dwellings. Plate heat echangers, efficiency = 0.95.

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	MCHP

Description

Produced by MCHP units running on vegetable oil.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided?

Description

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,	P,		kWh P,	AIR H,						

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www.poitou-charentes.fr

Funding
Source and Type of Funding
Poitou-Charentes Region

Principal Actors
Client : Conseil Regional de Poitou-Charentes (the Lycée Kyoto Highschool belongs to the Poitou-Charentes Region). Construction cordination : Société d'Equipement du Poitou. Architect : agence SCAU. Engineer MEP : Technip TPS, Hérvé Thermique (heating and MCHP), Forclum (elctricity and PV), Energy System (monitoring). Engineer Civil : Eiffage Construction.

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Primary Energy

Building Integrated PV?	No
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	25°
Azimuth	10°
Technology	Conergy C 180M
Nominal Power (kWp)	118
Area (m²)	961
Yield (kWh/m².year)	128
Expected generation (kWh)	123000
Measured generation (kWh)	123288

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water

Solar Thermal	
Technology	
Position	
Area (m²)	
Production (kWh/m².year)	
Annual % of Hot Water	

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power - Primary Energy

Type	COGENGREEN EcoGEN
Fuel	Biofuel (rapesed oil)
Efficiency (%)	88
Electricity	25 kW
Water Heating	44 kW (heating + DHW)
Space Heating	
Cooling	No
Production (kWh/m².year)	30.00
Electricity	18
Water Heating	12
Space Heating	No
Cooling	No

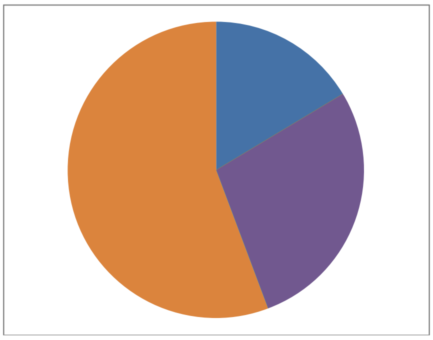
Renewable Production of Heating and Cooling

Heating Equipment - Primary Energy

Technology	**Water tank (1000m³)**
Power	
Efficiency (%)	
Production (kWh/m².yr)	15
Annual % of Heating - (Produced by renewables)	

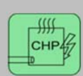
Cooling Equipment There is no active cooling system installed in the building.

Technology	
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	 E,		 H,			 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Limeil Brévannes

Completion Date
2007

Location
7 Jean Marie Prugnot
Limeil-Brévannes

France

Latitude	Longitude
North	East
48.7	2.5

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Educational

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
2935

Conditioned Floor Area (m²)
2736

Occupancy (m² per Person)
8.3

Number of Storeys

Cost US$/(Net) m² Floor Area
2,921

Cost US$/(Net) m² typical similar building

Web Address
http://www.limeil-brevannes.fr/?page_id=2397

For more information:
http://tinyurl.com/Limeil-Brevannes-FR

Net Zero Energy Building Overview

Limeil Brévannes is a low consumption primary school with a high level of bioclimatic design (South orientated façades, high insulation, daylighting and natural ventilation). Its energy use is assessed through integrated monitoring separated into end-users. This determines if this is a zero energy building as was the aim in the project brief.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

The building has 2 levels. The main facades are South-South East orientated with narrow thickness. The building use daylighting, cross natural and insulation, ventilation and moveable solar shading devices (sliding shutters with exterior venitian blinds). The South orientated large indoor corridor uses large windows for efficient daylighting. The windows are triple glazed. All the classrooms have large windows to use the daylight of the corridor.

Measured Energy Production and Consumption:

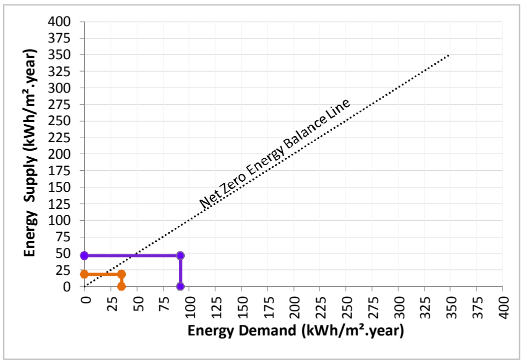
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 36
Primary: 92

Energy Supply (kWh/m².year)
Renewable Energy
Final: 18
Primary: 47

Source to Site Conversion Factor (Electricity): 2.58

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



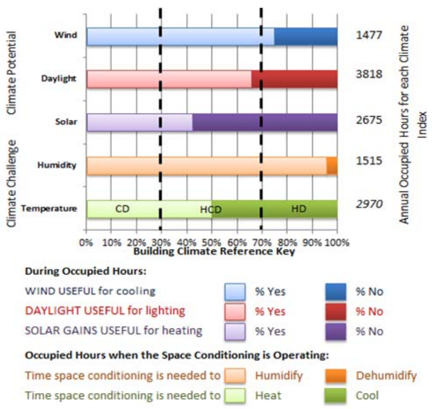
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 H, L,			

Passive Approaches:

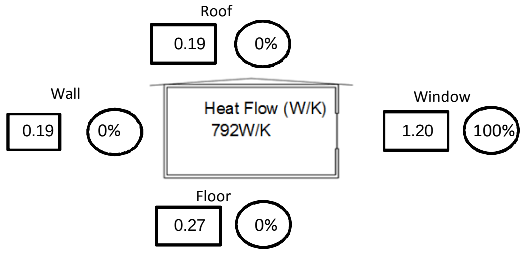
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Thermal Mass

Concrete structure externally insulated associated with large openings

Cooling

Natural Ventilation

North/South natural cross ventilation

Sunshading

External moveable blinds

Daylight Systems

Skylight + Large windows

Glass strip integrated into the ceiling of the ground floor and 1st floor + large windows in the corridors and classrooms

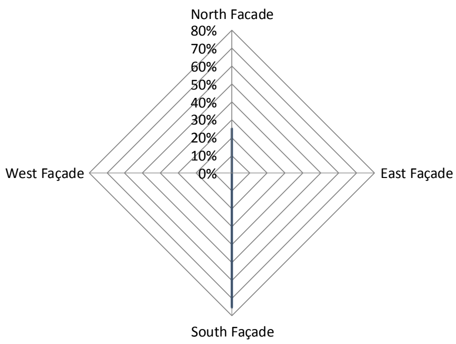
Window Distribution Information

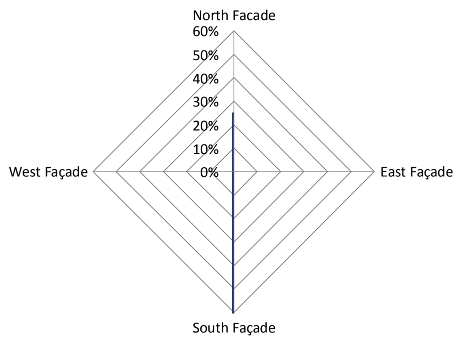
Distribution of Window Areas per Façade

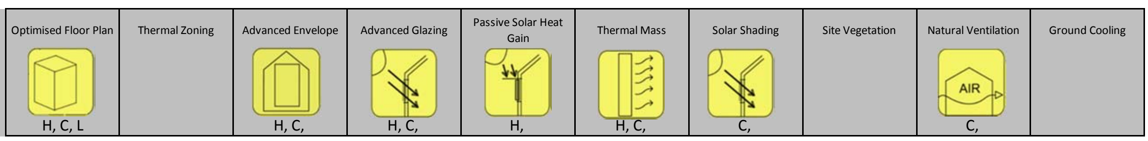
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.

Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.







Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC)	0.19
Solar Absorptivity	0.60

East

U-value (W/m² ºC)	0.19
Solar Absorptivity	0.40

Facing Polar Direction

U-value (W/m² ºC)	0.19
Solar Absorptivity	0.40

West

U-value (W/m² ºC)	0.19
Solar Absorptivity	0.40

Roofs

U-value (W/m² ºC)	0.19
Solar Absorptivity	0.40

Green roof

Ground floor

U-value (W/m² ºC)	0.27

Windows - Construction Elements

Solar noon

U-value (W/m² ºC)	1.20
g-value	1.60

Heat Miror

East

U-value (W/m² ºC)

g-value

Polar direction

U-value (W/m² ºC)	1.20
g-value	1.60

Heat Miror

West

U-value (W/m² ºC)

g-value

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

Compactness (m-1)

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Other

HVAC Systems

CTA double flux / Pompe à chaleur / Circuit chauffage

Artificial Lighting

Eclairage T5 et fluo compacts

Computer Management

Control of Systems

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads

Power Density Installed (W/m²) :

Artificial Lighting

Power Density Installed (W/m²) : 9 W/m²

Computer Network

Power Density Installed (W/m²) :

Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description

No cooling plant

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description

Heating is provided by two Viessmann heat pumps VITOCAL 300 WW232 on groundwater. A radiator circuit and a circuit heating coil on the air handling units, provide heating in the school.

Ventilation System

Heat Recovery Type	Unknown
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description

The heat recovery system is used in winter.

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	Yes
Gas?	Yes
Electrical?	No
Other?	

Description

60% of the need of hot water is furnished by thermal solar panel, we use electric supply for the rest

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

Lighting is controlled by the building management system.

HVAC

Two Modes: Graphical mode: Each floor helps to find geographically facilities and see the status of your points. Navigation via buttons ups and downs can move between each view. The equipment will be detailed on a dedicated each CTA will have its own graphical view accessible from the view of the stage. Measurements will be displayed in the boxes in the form of analogue value. It is not decided to pilot installations from the BMS. Textual Mode: Navigation tree form allows viewing points in their raw format.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided? No

Description

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,			L,	kWh P,	AIR H,			H,	C,		

Design Team

Engineer Civil
Name
BERIM
Address

Email

Web Address
www.berim.fr

Engineer MEP
Name
BERIM
Address

Email

Web Address
www.berim.fr

Engineer Structural
Name
BERIM
Address

Email

Web Address
www.berim.fr

Architect
Name
Lipa & Serge GOLDSTEIN
Address

Email

Web Address
http://archiguide.free.fr/AR/goldstein.htm

Builder/Contractor
Name
CARI (Structure), BILLIET (Windows), LUCA:
Address

Email

Web Address

Funding
Source and Type of Funding
City Council of Limeil Brevannes

Principal Actors
City Council of Limeil Brevannes and AURIS

Authors
Alain Bornarel

Email
tribu.conseil@wanadoo.fr

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Roof/façade Integrated
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	0.14
Azimuth	South / South East
Technology	Type TE 2000
Nominal Power (kWp)	75
Area (m²)	532
Yield (kWh/m².year)	110
Expected generation (kWh)	70
Measured generation (kWh)	74

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Viesmann Vitosol 100
Position	South Façade
Area (m²)	30
Production (kWh/m².year)	2
Annual % of Hot Water	60

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

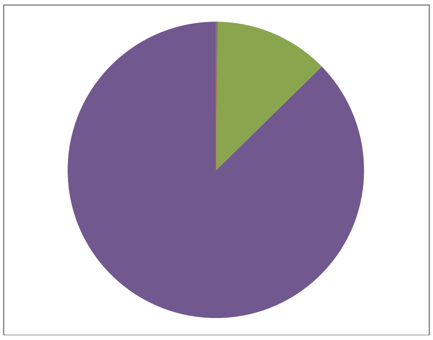
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Ground sources heat pump	**Ground / Water Source Heat Pump**
Technology	VITOCAL 300 WW232	Ground source heat pump
Power	70 kW/ 90kW elect	
Efficiency (%)	77.78	
Production (kWh/m².yr)	10.50	
Annual % of Heating - (Produced by renewables)	99	

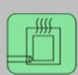
Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,	 E,				 H, C,	 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Pantin Primary School

Net Zero Energy Building Overview

This school is designed to have low energy consumption. The buildings are designed bioclimatically. They are orientated towards the south, are highly insulated, and make substantial use of natural light and ventilation. They are closely monitored for zero energy use.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2010

Location
40 Quai de l'Aisne
Pantin (93)

France

Latitude	Longitude
North	West
48.9	2.4

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Educational

Site Context
Urban Centres - over 5 storey average height of neighbouring buildings, adjacent buildings touching, street widths 40+m

Net Floor Area (m²)
3560

Conditioned Floor Area (m²)
2959

Occupancy (m² per Person)
9.1

Number of Storeys

Cost US$/(Net) m² Floor Area
4,859

Cost US$/(Net) m² typical similar building
1500-3000

Web Address
www.ien-pantin.ac-creteil.fr/blog_St-Ex/

For more information:
http://tinyurl.com/Pantin-Primary-School-FR

Architectural Design Concept

Passive solar design with narrow buildings and main facades facing North and South to use cross natural ventilation, to optimize solar gains and daylight. Triple glazed windows. High level of insulation. External insulation with light facades in wood as well as te structure of the building.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

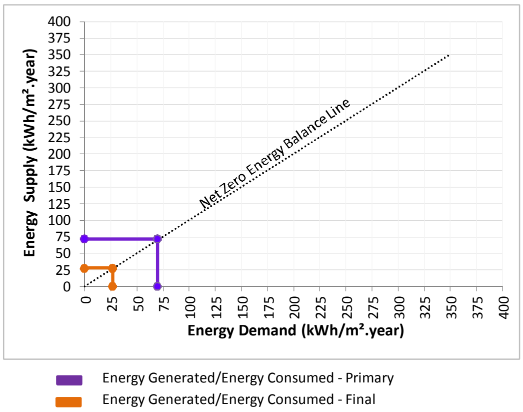
	Electricity	**Natural Gas**
Final:	27	
Primary:	70	

Energy Supply (kWh/m².year)
Renewable Energy

Final:	28
Primary:	71

Source to Site Conversion Factor (Electricity): 2.58

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



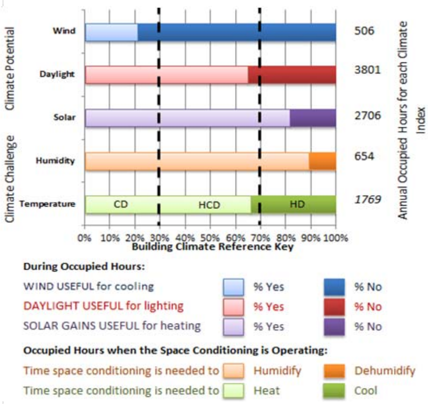
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

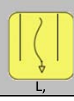
The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H - Heating | *P - Plug Loads*
C - Cooling | *E - Electricity*
L - Lighting | *I - Integration*
DHW - Domestic Hot Water

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
		 L	

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.60

37 cm wooden frame incorporating insulating TH 38 and 20cm to the right occasionally beams

East

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.60

37 cm wooden frame incorporating insulating TH 38 and 20cm to the right occasionally beams

Facing Polar Direction

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.60

37 cm wooden frame incorporating insulating TH 38 and 20cm to the right occasionally beams,

West

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.60

37 cm wooden frame incorporating insulating TH 38 and 20cm to the right occasionally beams

Roofs

U-value (W/m² ºC) 0.15

Solar Absorptivity 0.40

Vegetated roof terrace, or 25 concrete cm/15cm Rockwool TH38

Ground floor

U-value (W/m² ºC) 0.44

Concrete 22 cm / 6 cm extruded polystyrene

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.80

g-value 0.80

Triple glazed argon and two leaf layers weakly emissive (Ug = 0.6)

East

U-value (W/m² ºC) 0.80

g-value 0.80

Triple glazed argon and two leaf layers weakly emissive (Ug = 0.6)

Polar direction

U-value (W/m² ºC) 0.80

g-value 0.80

Triple glazed argon and two leaf layers weakly emissive (Ug = 0.6)

West

U-value (W/m² ºC) 0.80

g-value 0.80

Triple glazed argon and two leaf layers weakly emissive (Ug = 0.6)

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

RT2005bis_doe pechon

Compactness (m-1)

Passive Approaches:

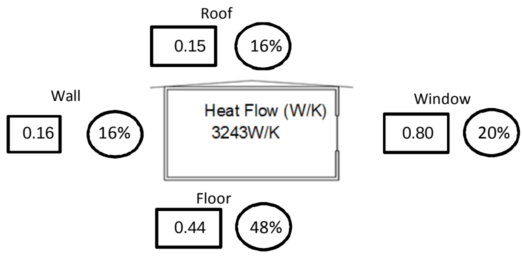
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Thermal Mass

Concrete and exterior insulation

Heat Pump

Heat pump energy pile (COP = 3)

Daylight Systems

Light Pipe

Light pipes in roof

Cooling

Natural Ventilation

Building with two opposite facades having openings

Sunshading

Effective sun protection

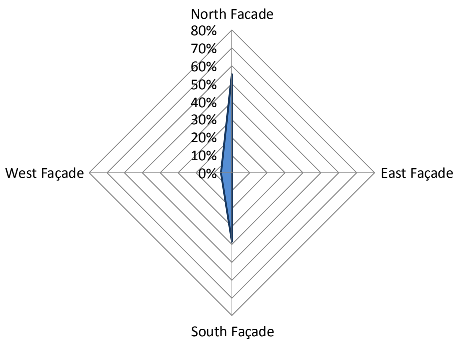
Night Cooling

Night cooling ventilation

Window Distribution Information

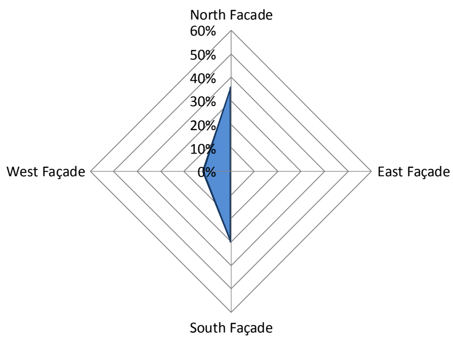
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C, L,		H, C,		H,	H, C,	C,		AIR	

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Other

HVAC Systems
Double flow with heat recovery (yield above 75%)

Artificial Lighting
Lighting with electronic ballasts

Computer Management
BMS

Control of Systems
BMS

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) : 8 W/m²

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
Night cooling ventilation

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
Low temperature radiators powered by a heat pump (COP 3.6, temperature 40 ~ 45 ° C) vertical probes

Ventilation System

Heat Recovery Type	Unknown
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description
Double flow with heat recovery (yield above 75%)

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	Yes
Gas?	Yes
Electrical?	No
Other?	

Description
Solar collectors for hot water (22m ² covered 100% of requirements)

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
Sensors and dimming

HVAC
HVAC is controlled by a BMS (Building Management System).

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description
Unknown

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,			L,	P,	H,	DHW,				H, C,	

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Funding
Source and Type of Funding
Ville de Pantin

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV)

Building Integrated PV?	In roof
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	12°
Azimuth	South
Technology	SOLARWOOD Megaslate type 6
Nominal Power (kWp)	128
Area (m²)	1116
Yield (kWh/m².year)	27
Expected generation (kWh)	113400
Measured generation (kWh)	unknown

Wind Turbine

Position	On-site
Number of Turbine	
Technology	Horizontal
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water

Solar Thermal	Yes
Technology	Flat plate collectors
Position	Roof of the cafeteria
Area (m²)	22
Production (kWh/m².year)	0
Annual % of Hot Water	10000%

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

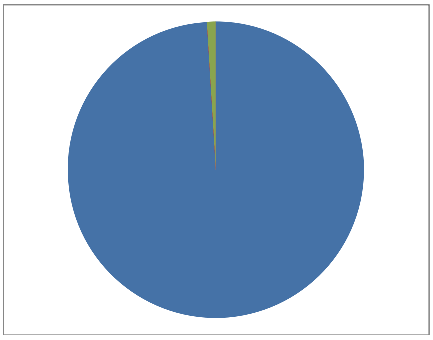
Renewable Production of Heating and Cooling

Heating Equipment There is no active heating system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².yr)
Annual % of Heating - (Produced by renewables)

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
DHW,	E,				H, C,	I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Primary School of Laion

Net Zero Energy Building Overview

An example of a design approach considering all aspects of the net zero energy design. This building maximises passive design techniques and energy efficiency systems to reduce energy use. On-site renewable energy production has also been used.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2006

Location
141 Novale
Laion/Lajen
Bolzano
Italy

Latitude	Longitude
North	West
46° 36' 34" N	11° 34' 1" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Educational

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
700

Conditioned Floor Area (m²)
657

Occupancy (m² per Person)
16.4

Number of Storeys

Cost US$/(Net) m² Floor Area
3,056

Cost US$/(Net) m² typical similar building
1,426

Web Address
www.archtv.net

For more information:
Primary school Laion.kmz

Architectural Design Concept

The foundations of this energy concept is to reduce the energy demand through maximising the passive design. The building space is compact with a high level of thermal insulation in the external walls, thus adding to the user's comfort and lowering the cost of energy. Large windows maximise natural lighting and venetian blinds reduce glare. A mechanical ventilation system with heat recovery assures high air quality and comfort for the students. A cross flow heat exchanger recovers heat from the exhaust air and transfers it to the incoming air. Geothermal and solar energy renewable energy is used to aim for this to be a Net ZEB.

Measured Energy Production and Consumption:

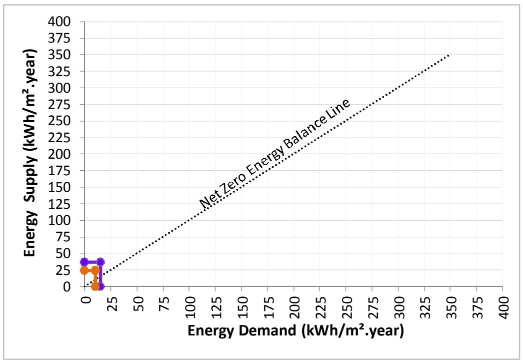
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 10
Primary: 15

Energy Supply (kWh/m².year)
Renewable Energy
Final: 25
Primary: 37

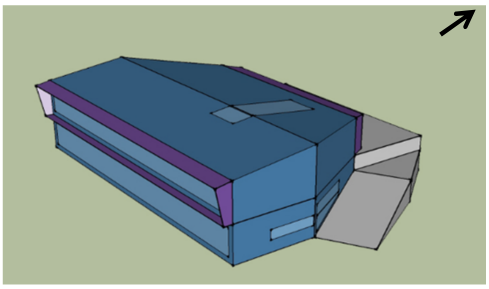
Source to Site Conversion Factor (Electricity): 1.5

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model

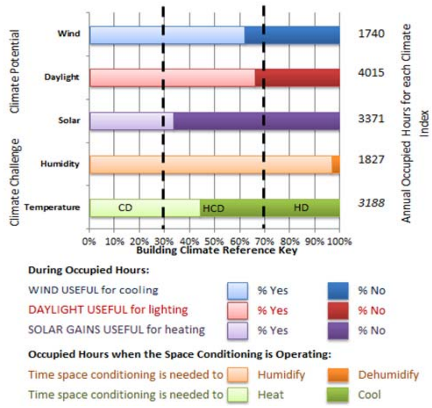


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

***H** - Heating*
***C** - Cooling*
***L** - Lighting*
***DHW** - Domestic Hot Water*
***P** - Plug Loads*
***E** - Electricity*
***I** - Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,	 L,		

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 0.22
Solar Absorptivity 0.10

Concrete structure completely covered with 16 cm of polystyrene.

East
U-value (W/m² ºC) 0.22
Solar Absorptivity 0.10

Concrete structure completely covered with 16 cm of polystyrene.

Facing Polar Direction
U-value (W/m² ºC) 0.22
Solar Absorptivity 0.10

Concrete structure completely covered with 16 cm of polystyrene.

West
U-value (W/m² ºC) 0.22
Solar Absorptivity 0.10

Concrete structure completely covered with 16 cm of polystyrene.

Roofs
U-value (W/m² ºC) 0.14
Solar Absorptivity 0.10

Wooden roof with 24 cm of wood fibre thermal insulation.

Ground floor
U-value (W/m² ºC) 0.24

Concrete slab foundation with 10 cm Foamglas board + 5 cm of polystyrene.

Windows - Construction Elements

Solar noon
U-value (W/m² ºC) 0.78
g-value 0.34

Triple coated panes filled with Argon and window frames in oak.

East
U-value (W/m² ºC) 0.78
g-value 0.34

Triple coated panes filled with Argon and window frames in oak.

Polar direction
U-value (W/m² ºC) 0.78
g-value 0.34

Triple coated panes filled with Argon and window frames in oak.

West
U-value (W/m² ºC) 0.78
g-value 0.34

Triple coated panes filled with Argon and window frames in oak.

Air permeability (m³/m²h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built
0.6 h-1

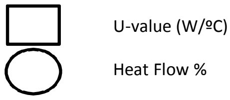
Compactness (m-1)

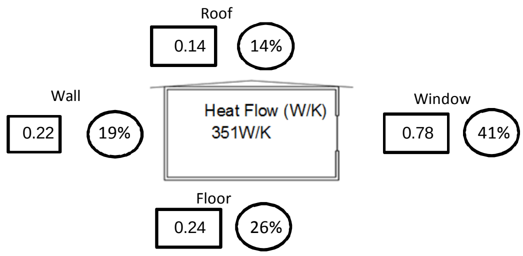
Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

***Building Challenge Solution Set** - The set of solutions used to lower the energy needed by a particular building challenge.*

***Whole Building Solution Set -** The set of solutions used to lower the energy consumption of the whole building.*

Heating

Sunspaces
Large windows on the south façade and a skylight increase solar gains.

Heat Recovery
Air to the ventilation system is pre-heated through an underground air duct.

Thermal Insulation
The external walls have been entirely covered with 16 cm of polystyrene, except for the roof where 24 cm wood fibre panels have been used.

Cooling

Sunshading
An overhang solar shading of about 1.50 metres protects the South façade's glazing.

Ground Cooling
Air to the ventilation system is pre-cooled through an underground air duct.

Ground Cooling
During the summer months, heat from the building is dissipated into the ground to cool the building.

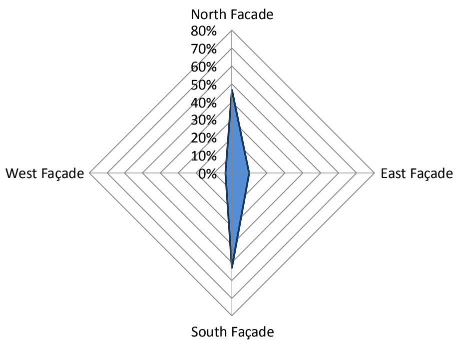
Daylight Systems

South glazed facade and skylight
Large windows on the South facing facade and a skylight on the roof let in light to naturally illuminate the interior spaces. Venetian blinds protect from glaring sunlight conditions.

Window Distribution Information

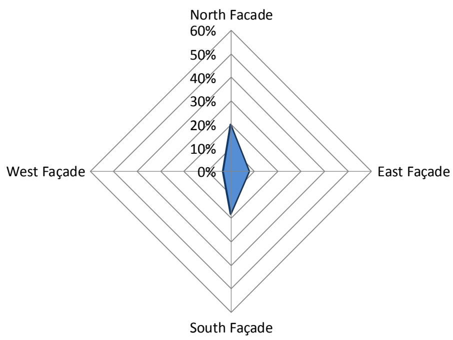
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C, L,		H, C,		H,	H, C,	C,			

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Ground works as a seasonal storage that is regenerated during the summer, when the school is closed.

Other

HVAC Systems

High efficiency heat pump operating with geothermal probes and electricity produced by PV plant.

Artificial Lighting

Computer Management

Control of Systems

Centralized control of heat pump, heating system, DHW and solar thermal plant.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

6

Appliances / Plug Loads

Power Density Installed (W/m²) : Unknown

Artificial Lighting

Power Density Installed (W/m²) : 6.5 - 7.0

Computer Network

Power Density Installed (W/m²) :

Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description

No cooling plant

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	No

Description

Space heating (radiant floors) and domestic hot water demands are covered by an electric heat pump operating with three ground probes and by the heat produced from flat plate solar thermal collectors in the facade at first floor.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description

Air-air cross flow heat exchanger

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	No

Description

The heat production of solar thermal collectors can basically cover the monthly heat demand for DHW. The storage has an external plate heat exchanger that transfer the heat from the heating water to the drinking water.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

There is no lighting control system

HVAC

The heat pump has a control system that manages heating, DHW and solar thermal plant.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided? No

Description

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
					 H,					 H,	

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Funding
Source and Type of Funding
In 2003 the Municipality decided for a refurbishment and an energy retrofitting of the whole building.

Principal Actors
Arch.TV won the architectural competition in 2004. The municipality fixed the CasaClima A limit with 30kWh/m²a as minimum standard.

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Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Roof integrated
Ground mounted	No
Roof mounted	No
Position	Fixed
Tilt (angle)	10°
Azimuth	27°
Technology	Polycrystalline silicon
Nominal Power (kWp)	17
Area (m²)	140
Yield (kWh/m².year)	118
Expected generation (kWh)	16471
Measured generation (kWh)	17175

Wind Turbine - Final Energy

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Flat plate collectors
Position	On South façade
Area (m²)	18
Production (kWh/m².year)	13
Annual % of Hot Water	0.83%

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

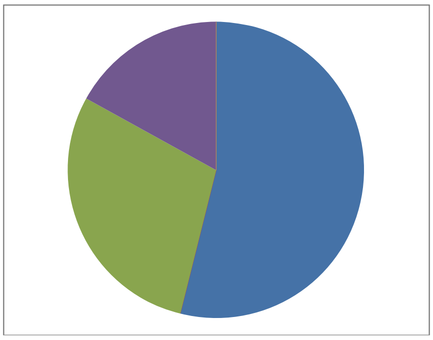
Renewable Production of Heating and Cooling

Heating Equipment - Final En

	Heat Pump	Ground / Water Source Heat Pump
Technology	Solar thermal/GSHP	Vertical probes
Power	Nominal power of 1.83 kWel and 8.3 kWth	
Efficiency (%)	453	
Production (kWh/m².yr)	7.40	
Annual % of Heating - (Produced by renewables)	100	

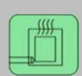
Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 H, DHW,	 E,				 H,	 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

NON RESIDENTIAL NET ZEBs

Heating dominated climate

Alpine Refuge
Austria
Arch. : ARGE pos architekten und Treberspurg & P

Villach Offices and Apartment
Austria
Arch. : Anton Oitzinger

Primary school - Grundschule Hohen Neuendorf
Germany
Arch. : Architect, engineers and researchers

Kindergarten Die Sprösslinge
Germany
Arch. : tr achitekten, Köln

Marché Kempthal
Switzerland
Arch. : kämpfen für architektur ag

Kraftwerk B
Switzerland
Arch. : grab architektur ag

Alpine Refuge - Schiestlhaus

Completion Date
2005

Location
Hochschwab
Hochschwab
Styria
Austria

Latitude	Longitude
North	West
47°63'19	15°17'18

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating Dominated

Building Type
Non-residential_Other

Site Context
Open Site

Net Floor Area (m²)
550

Conditioned Floor Area (m²)
333m^2

Occupancy (m^2 per Person)
15.6

Number of Storeys

Cost US$/(Net) m² Floor Area
4000 US$/m2

Cost US$/(Net) m² typical similar building
No similar buildings known (zero energy al

Web Address

For more information:

Net Zero Energy Building Overview

Alpine mountain refuges are a typical example of buildings in "island locations" in the whole alpine region. They are situated in locations that are exposed, difficult to reach, and ecologically very sensitive. Their location, often far from public networks of water and power, can cause problems - of both supply, and environmental impact caused by gaining access to supplies. However, the advantage of their location is that solar irradiation is significantly higher than average and therefore offers great potential for the use of solar systems.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

Architectural and overall building concepts are based on the principles of solar building construction. The building site on Mount Hochschwab, has a South facing orientation to utilise solar irradiation, which is particularly favourable at this altitude. Technically, the concept follows passive house standards, and is adapted to meet the meteorological and geological requirements prevailing in alpine regions. Designers developed a clear-cut principle of construction and a simple structure with prefabricated building elements, which can be realised within short building and assembly times. The South-facing facade has been designed as an energy- facade system and is the main energy supplier of the building. The bottom storey has large windows and serves the passive use of solar energy. The upper storey features 46m^2 of facade-integrated solar collectors for the generation of thermal energy. A photovoltaic system with a total surface area of 68m^2 has been installed in front of the solid construction bottom storey.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

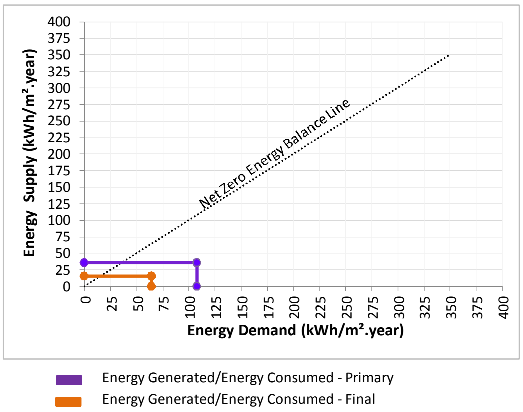
	Electricity	**Solar Thermal**
Final:	30	16
Primary:	70	17

Energy Supply (kWh/m².year)
Renewable Energy

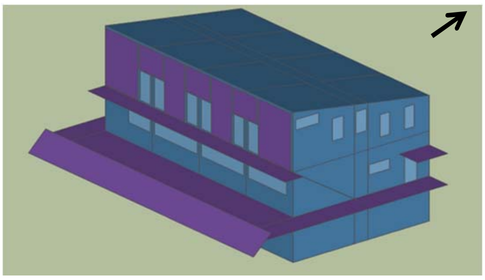
Final:	15
Primary:	36

Source to Site Conversion Factor (Electricity): 2.35

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



EnergyPlus Model

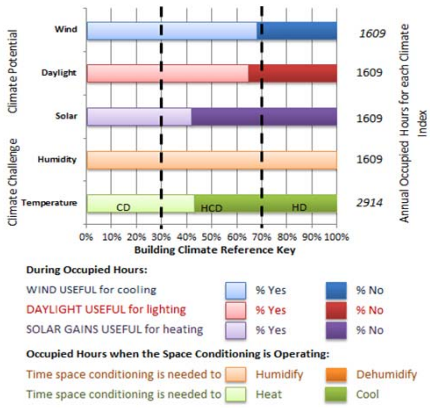


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

***H** - Heating*
***C** - Cooling*
***L** - Lighting*
***DHW** - Domestic Hot Water*
***P** - Plug Loads*
***E** - Electricity*
***I** - Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 0.13
Solar Absorptivity

Larch cladding ; vertical battens; Wind seal permeable; WDP; Cross battens, WDF, wood uprights; Air-tight vapour barrier; waxed pine shuttering

East
U-value (W/m² ºC) 0.13
Solar Absorptivity

Larch cladding ; vertical battens; Wind seal permeable; WDP; Cross battens, WDF, wood uprights; Air-tight vapour barrier; waxed pine shuttering

Facing Polar Direction
U-value (W/m² ºC) 0.13
Solar Absorptivity

Larch cladding ; vertical battens; Wind seal permeable; WDP; Cross battens, WDF, wood uprights; Air-tight vapour barrier; waxed pine shuttering

West
U-value (W/m² ºC) 0.13
Solar Absorptivity

Larch cladding ; vertical battens; Wind seal permeable; WDP; Cross battens, WDF, wood uprights; Air-tight vapour barrier; waxed pine shuttering

Roofs
U-value (W/m² ºC) 0.12
Solar Absorptivity

Ground floor
U-value (W/m² ºC) 0.19

Windows - Construction Elements

Solar noon
U-value (W/m² ºC) 0.7
g-value 0.55

Wood - Aluminium Passive House Windows

East
U-value (W/m² ºC) 0.7
g-value 0.55

Wood - Aluminium Passive House Windows

Polar direction
U-value (W/m² ºC) 0.7
g-value 0.55

Wood - Aluminium Passive House Windows

West
U-value (W/m² ºC) 0.7
g-value 0.55

Wood - Aluminium Passive House Windows

Air permeability (m³/m²h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built
0.32 at 50pa air pressure

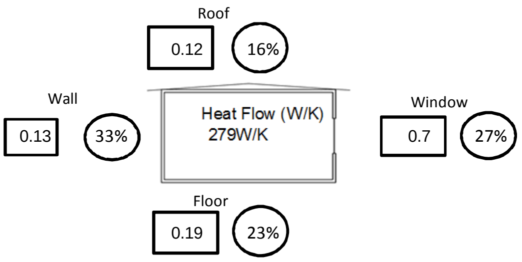
Compactness (m-1)

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Heat Recovery

Ventilation complies with passive house standards. It uses fresh air equipment with high-performance heat exchangers with an efficiency of up to 85%. Bypass valves are used to avoid overheating in summer operation through internal heat sources. The ventilation units take in air from outside through a snow-protected opening at the Northern facade and blow out the exhaust air through a roof mounted duct.

Zoning

The interior of the building ins organized in different climate zones: a constantly heated core zone surrounded by zones that can be added to the heated zone and an outer unheated zone serving as an energy buffer space.

Insulation

Extremely high insulation levels

Cooling

None (alpine refugee) - low average exterior temperatures

Daylight Systems

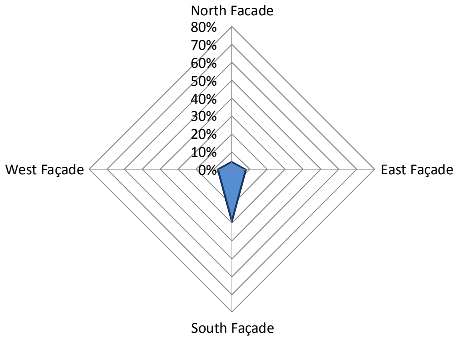
Building Configuration

Large South facing windows, shallow floor plan.

Window Distribution Information

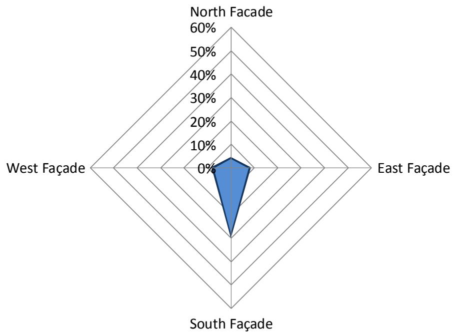
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.

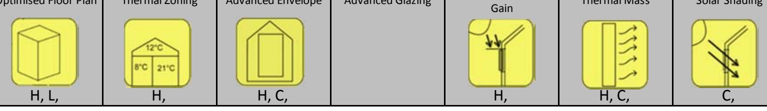


Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, L,	H,	H, C,		H,	H, C,	C,			



Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
Low Energy Consuming appliances; cooking with biogas

Energy Storage
Battery system to store pv energy without grid connection

Other
Grey Water Recycling System

HVAC Systems
Mechanical ventilation with heat recovery

Artificial Lighting
Energy saving lamps

Computer Management

Control of Systems
Energy Load Management System / battery storage

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) : No special measures taken

Computer Network
Power Density Installed (W/m²) : No special measures taken
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
No Cooling System needed (alpine refugee)

Heating

Central Plant	Yes
Distributed Plant	Yes
Hydronic distribution	Yes
Air distribution	Yes

Description
Heat supply relies on the following systems: The solar collector transfers heat via heat exchanger to the buffer storage tanks. A rape oil operated unit (see below) loads heat directly into the buffer storage. The solid fuel range can also transfer heat into the buffer storage tanks. Problems of overheating are not likely to occur in this system because even in mid-summer temperatures are moderate and range between 0° and 20° C.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	No
Local Air Recirc plus Central Fresh Air	Yes

Description
Ventilation complies with passive house standards and uses fresh air equipment with high-performance heat exchangers with an efficiency of up to 85%. In addition, they use bypass valves in order to avoid overheating in summer operation through internal heat sources. The ventilation units take in air from outside through a snow-protected opening at the northern facade and blow out the exhaust air through a roof mounted duct. In order to avoid disturbing sound transfer from the ventilation ducts (telephone effect), the individual rooms are acoustically separated by means of sound absorbers.

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	

Description
Heat supply thus relies on the following system: The solar collector transfers heat via heat exchanger to the buffer storage tanks. A rape oil operated unit (see below) loads heat directly into the buffer storage. The solid fuel range can also transfer heat into the buffer storage tanks.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC
Load Management Control System

Energy Storage

Latent Storage?	Yes
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided?

Description

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,		E,	H,	DHW,				H, C,	

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Email

Web Address

Funding
Source and Type of Funding
Funding by Haus der Zukunft - Österreichischer Touristenclub / Bäckerstraße 16 Wien

Principal Actors
Government Client

Authors
Tobias Weiß

Email
tobias.weiss@nussmueller.at

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Facade Integrated
Ground mounted	No
Roof mounted	No
Position	Fixed
Tilt (angle)	45°
Azimuth	0°
Technology	Polycrystalline silicon
Nominal Power (kWp)	8
Area (m²)	68
Yield (kWh/m².year)	15kWh/m^{2}a Electricity
Expected generation (kWh)	10450
Measured generation (kWh)	8250

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water

Solar Thermal	Yes
Technology	Flat plate collectors
Position	Facade Integrated
Area (m²)	46m^2
Production (kWh/m².year)	16
Annual % of Hot Water	80%

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type	Facade-integrated ST; fuel stove
Fuel	Solar thermal and solid fuel stove
Efficiency (%)	
Electricity	72 kWh/m²yheat-21 kWh/m²yel.
Water Heating	
Space Heating	
Cooling	
Production (kWh/m².year)	22
Electricity	
Water Heating	
Space Heating	
Cooling	

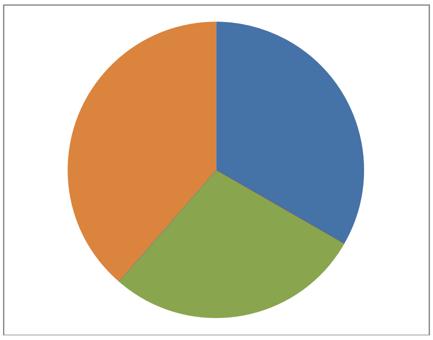
Renewable Production of Heating and Cooling

Heating Equipment There is no active heating system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².yr)
Annual % of Heating - (Produced by renewables)

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
H, DHW,	E,		H, E,				I,	

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Villach Offices & Apartment

Net Zero Energy Building Overview

The goal of this project was to visibly implement the aims of the AEE by erecting an energy plus passive building as a demonstration object. The starting point of the concept was the integration of large scale solar thermal systems into the façade to draw thermal energy for the building. Thanks to the passive house standard, periodic heat surplus from the solar thermal system can be transferred to neighbouring buildings.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2002

Location
Unterer Heidenweg 7
9500Villach
Kärnten
Austria

Latitude North	Longitude West
13.8/13°51'21''	46.6/46°36'37''

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating Dominated

Building Type
Non-residential_Office

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
292

Conditioned Floor Area (m²)
292m2

Occupancy (m² per Person)
33.3

Number of Storeys

Cost US$/(Net) m² Floor Area
1050€/m2

Cost US$/(Net) m² typical similar building

Web Address
0

For more information:
http://tinyurl.com/Office-Building-with-Apartment

Architectural Design Concept

The individual work spaces are interconnected, while still offering sufficient individual areas where people work in privacy. The design uses flexible internal partitions and features an atrium at the centre of the building that connects the ground floor with the first floor. In designing this office building the architect not only emphasizes the professional focus of its occupants, but also created a visual demonstration of research activity for the AEE Inetc through the solar collectors in the façade.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

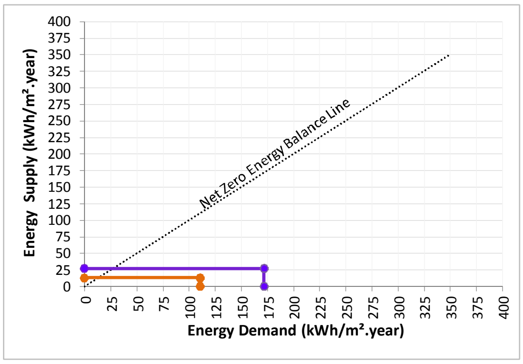
	Electricity		Biofuel
Final:	46		65
Primary:	96		76

Energy Supply (kWh/m².year)
Renewable Energy

Final:	13
Primary:	27

Source to Site Conversion Factor (Electricity): 2.07

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



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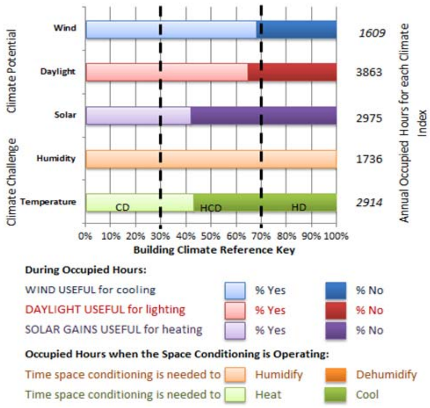
The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating*	***P*** *- Plug Loads*
C *- Cooling*	***E*** *- Electricity*
L *- Lighting*	***I*** *- Integration*
DHW *- Domestic Hot Water*	

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,			

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.1

Solar Absorptivity

Prefabricated wooden elements with blow filled cellulose insulation

East

U-value (W/m² ºC)

Solar Absorptivity

Facing Polar Direction

U-value (W/m² ºC)

Solar Absorptivity

West

U-value (W/m² ºC)

Solar Absorptivity

Roofs

U-value (W/m² ºC) 0.12

Solar Absorptivity

Prefabricated wood beam roof infilled with 36cm of mineral wool insulation and covered with PV panels.

Ground floor

U-value (W/m² ºC) 0.16

30cm polystyrol insulation above 30cm concrete floor slab and 3cm insulation below floor screed

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.80

g-value 0.50

Triple-glazed windows with insulated wood frames

East

U-value (W/m² ºC)

g-value

Polar direction

U-value (W/m² ºC)

g-value

West

U-value (W/m² ºC)

g-value

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.4

Compactness (m-1)

Passive Approaches:

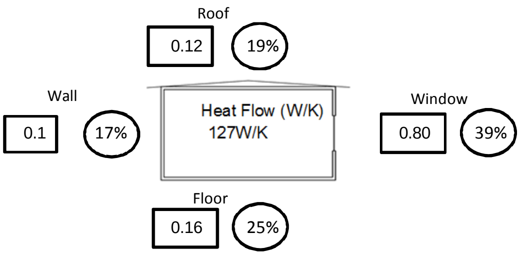
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

▭ U-value (W/ºC)

◯ Heat Flow %



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***Building Challenge Solution Set** - The set of solutions used to lower the energy needed by a particular building challenge.*

***Whole Building Solution Set -** The set of solutions used to lower the energy consumption of the whole building.*

Heating

Heat Recovery

Decentral ventilation system with heat recovery and earth tube heat exchanger system (75%).

Passive Solar Heat Gains

Maximising passive solar energy gains via the envelope, form, and orientation of the building.

Cooling

Sunshading

Exterior sunshading lamellas.

Decentral Ventilation

Natural ventilation is possible.

Daylight Systems

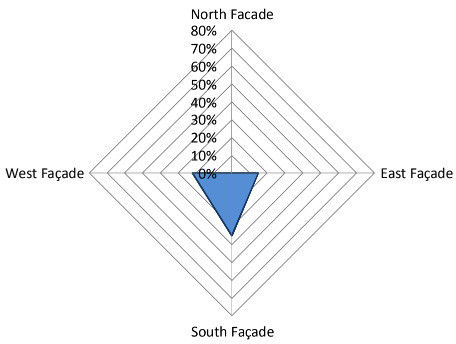
Large Windows

Window sizes of the office a very large and offer good daylight condition

Window Distribution Information

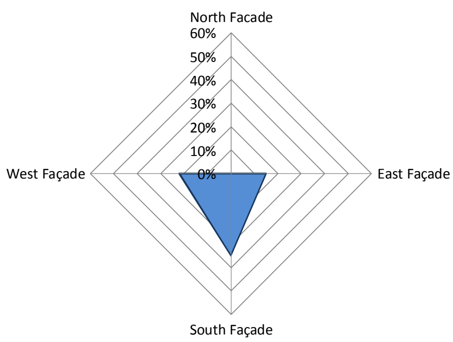
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
 H, C, L,		 H, C,		 H,	 H, C,	 C,			

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage
decentral storage coupled with local heating grid

Other

HVAC Systems
CHP in heating grid

Artificial Lighting

Computer Management

Control of Systems

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) : A+ appliances used

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	Yes
Ceiling Fans	No
Hydronic distribution	No
Air distribution	Yes

Description

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
A district heating grid supplies heat for space heating and hot water. This grid is fed by a combined heat and power plant fired by pellets, located in the building. Transfer stations in each of the neighbouring buildings with decentralized hot water storage tanks. There are also 76m2 of solar thermal collectors.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description
The building has a centralized compact ventilation systems with integrated heat recovery. Air ducts are made for preheating the air in this centralized design

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	

Description

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC
The district heating grid does not operate in summer.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? Yes

Description

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
	P,	P,			H,						

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Funding
Source and Type of Funding
Building Owner - Contraction Model

Principal Actors
In designing this office building the architect not only emphasizes the professional focus of its occupants, but also created for the AEE Inetc a part of its demonstration and research activity, visibly represented by the large area of solar collectors in the facade.

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	22°
Azimuth	
Technology	Poly-crystalline cells
Nominal Power (kWp)	4
Area (m²)	29
Yield (kWh/m².year)	13.30Wp/m^2 207kWh/m^{2}yr.
Expected generation (kWh)	4380
Measured generation (kWh)	3842

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	No
Technology	Flat Plate I Pellets CHP
Position	90° Facade Integrated
Area (m²)	76m^2
Production (kWh/m².year)	148
Annual % of Hot Water	100

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

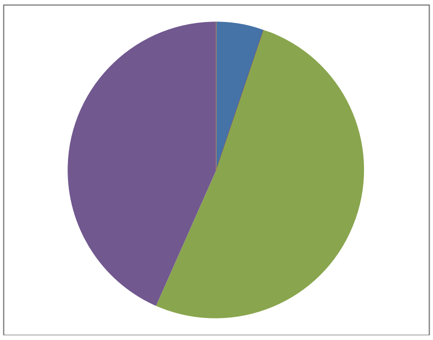
Renewable Production of Heating and Cooling

Heating Equipment

	CHP - Pellets
Technology	
Power	
Efficiency (%)	
Production (kWh/m².yr)	125
Annual % of Heating - (Produced by renewables)	100% for office building

Cooling Equipment There is no active cooling system installed in the building.

Technology	
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
H, DHW,	E,		H,		H,	I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Primary School Hohen Neuendorf

Net Zero Energy Building Overview

The integral design concept of the school takes into consideration both the use of energy in general and the buildings' specific purpose. Each classroom has independent ventilation and makes optimal use of natural light.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2011

Location
Goethestraße 1
16540 Hohen Neuendorf
Brandenburg
Germany

Latitude North	Longitude West
52°40'39.22"N	13°15'25.02"E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Educational

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
6563

Conditioned Floor Area (m²)
6563

Occupancy (m² per Person)
12.2

Number of Storeys

Cost US$/(Net) m² Floor Area
1,300

Cost US$/(Net) m² typical similar building

Web Address
www.ibus-berlin.de

For more information:
http://tinyurl.com/Primary-School-Hohen-DE

Architectural Design Concept

The form of the complex is derived from functional and technical requirements. A long central, light flooded hall forms the spine of the school from which the school extends westwards, the various functions are laid out like the teeth of a comb that opens onto the schoolyard. All functional zones can be reached directly from the hall (on the eastern side a library, special classrooms and the assembly hall, which is a multi-purpose space). The classrooms are organized in three wings, face south and are mostly organized on a single-loaded corridor system that allows daylight to be obtained from two sides thanks to partly glazed internal walls. The corridor zones and service areas face North. The sports hall with its ancillary spaces adjoins the third projecting wing. The technical concept is directly tied to the spatial configuration. Natural lighting in the classrooms is made possible by the fact that light enters from several sides.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

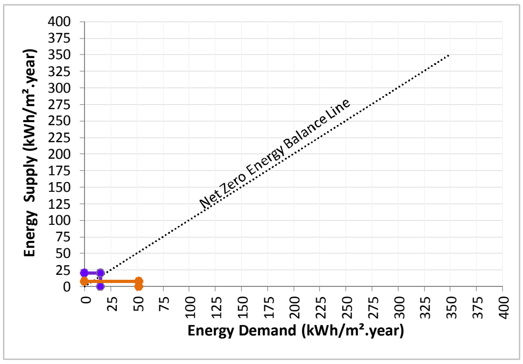
	Electricity	Biofuel
Final:	2	50
Primary:	5	10

Energy Supply (kWh/m².year)
Renewable Energy

Final:	8
Primary:	21

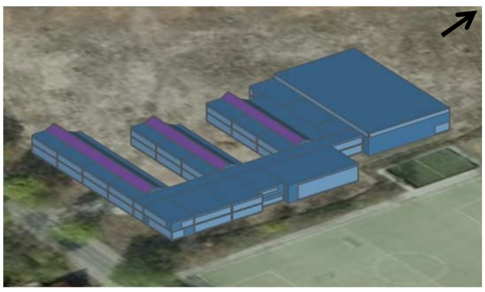
Source to Site Conversion Factor (Electricity): 2.6

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model

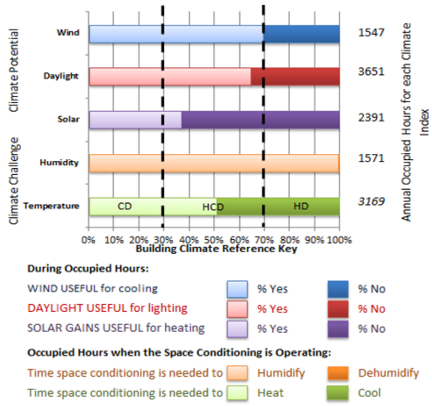


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

***H** - Heating*
***C** - Cooling*
***L** - Lighting*
***DHW** - Domestic Hot Water*
***P** - Plug Loads*
***E** - Electricity*
***I** - Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 H, L,	 H, L,		

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.15

Solar Absorptivity

The solid load-bearing walls are built of reinforced concrete. The twin leaf façade has an external brick skin and mineral wool insulation (20 cm).

East

U-value (W/m² ºC) 0.15

Solar Absorptivity

The solid load-bearing walls are built of reinforced concrete. The twin leaf façade has an external brick skin and mineral wool insulation (20 cm).

Facing Polar Direction

U-value (W/m² ºC) 0.15

Solar Absorptivity

The solid load-bearing walls are built of reinforced concrete. The twin leaf façade has an external brick skin and mineral wool insulation (20 cm).

West

U-value (W/m² ºC) 0.15

Solar Absorptivity

The solid load-bearing walls are built of reinforced concrete. The twin leaf façade has an external brick skin and mineral wool insulation (20 cm).

Roofs

U-value (W/m² ºC) 0.11

Solar Absorptivity

The roof of reinforced concrete is insulated with 35 cm of mineral wool under extensive roof planting.

Ground floor

U-value (W/m² ºC) 0.08

A (load transferring) insulation is above and below the concrete floor slab.

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.80

g-value 0.45

Triple pane insulating glazing in wood-aluminium frames.

East

U-value (W/m² ºC) 0.80

g-value 0.45

Triple pane insulating glazing in wood-aluminium frames.

Polar direction

U-value (W/m² ºC) 0.80

g-value 0.45

Triple pane insulating glazing in wood-aluminium frames.

West

U-value (W/m² ºC) 0.80

g-value 0.45

Triple pane insulating glazing in wood-aluminium frames.

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.6

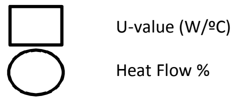
Compactness (m-1)

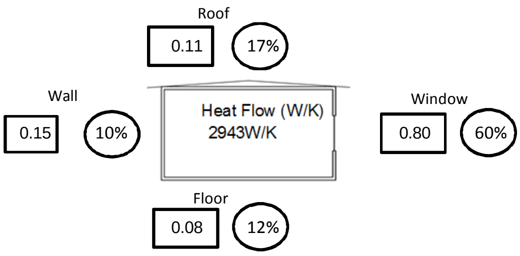
Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Heat Recovery

Decentralised ventilation plant with heat recovery (82 %). Air transport routes and pressure losses are kept to a minimum. Fresh air is provided in the classrooms, flows across the corridor areas and is extracted in the cloakrooms and WCs. If required, the ventilation system can by switched to a second, higher setting.

Solar Heat Gain

Maximising passive solar energy gains via the envelope, form, and orientation of the building was a conceptual precondition.

Thermal Mass

To lower the overheating during summer, to store thermal energy in winter and to increase the efficiency of the heat recovery.

Cooling

Sunshading

Partly fixed shading, specific sunshade systems respond to requirements of different teaching methods: Nano gel glazing (scatters light), electrochromic glazing (directs light; transparency can be altered by a switch).

Night Cooling

Motorised opening windows combined with storage mass of the building enable natural night time ventilation To not detract from the storage effect of the floor and ceiling slabs, broadband absorbers are used on the walls. only.

Daylight Systems

Windows

Daylight is provided by large windows. Partly electrochromic glazing directs light.

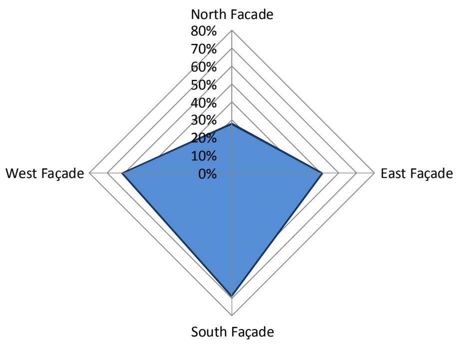
Window Distribution Information

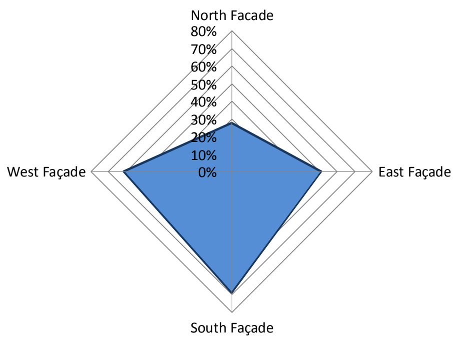
Distribution of Window Areas per Façade

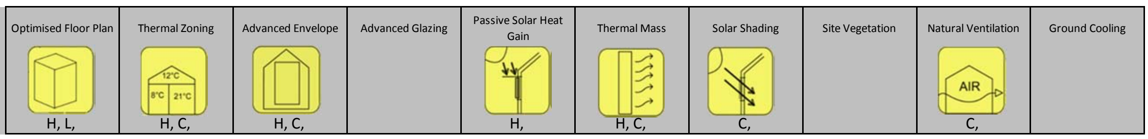
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.

Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.







Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
Indoor air changed 1/2 per hour.

Appliances / Plug Loads
Power Density Installed (W/m²) : Unknown

Artificial Lighting
Power Density Installed (W/m²) : Not documented

Computer Network
Power Density Installed (W/m²) : Not documented
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	Yes
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
No active cooling

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
A 220-kWth wood pellet boiler covers the building's main heating load. A 10-kWth pellet CHP (1.5 kWth) was planned to assist the provision of hot water and to compensate for circulation losses.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	No
Local Air Recirc plus Central Fresh Air	No

Description
Each class room area has a decentralised ventilation plant with heat recovery (82 %). In this way air transport routes and pressure losses can be kept to a minimum. Fresh air is provided in the classrooms, flows across the corridor areas and is extracted in the cloakrooms and WCs. If required, the ventilation system can by switched to a second, higher setting. Ventilation appliances with double ventilators were planned so that the motors work with maximum efficiency at all settings.

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	Yes, pellet boiler and CHP

Description
See heating system.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
The classrooms have a light control system that is linked to the depth of the room, with bands of light fittings running parallel to the windows and light sensors distributed in the depth of the space. This allows the reduction in the amount of daylight with the increasing depth of the space to be compensated for with low use of light and energy, and the lighting intensity in the entire room to be kept at the same level.

HVAC
No special system used

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? Yes

Description
No system used

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
Not possible because of Typology

Energy Storage
Coupled buffer storage tanks

Others
Sunshading (intelligent electro chrome glazing and moveable blinds between window slices), ventilation appliances with double ventilators were planned so that the motors work with maximum efficiency at all settings.

HVAC Systems
Efficient ventilation and CHP units

Artificial Lighting
LED lighting

Computer Management
Not necessary because of Typology

Control of Systems
Building automation system, light control system

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
C, L,		C, L,	L,	H, P, E,	H,	DHW,					

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Builder/Contractor
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Stadt Hohen Neuendorf - building manage
Address

Email

Web Address

Funding
Source and Type of Funding
Funded by the city of Hohen Neuendorf and partly by ministry of economics and technology (research program called EnOB)

Principal Actors
Architect, engineers and researchers

Authors
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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV)

Building Integrated PV?	Roof integrated
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	28°
Azimuth	0°
Technology	Multi-crystalline cells
Nominal Power (kWp)	55
Area (m²)	412
Yield (kWh/m².year)	8
Expected generation (kWh)	97526
Measured generation (kWh)	52121

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water

Solar Thermal	
Technology	
Position	
Area (m²)	
Production (kWh/m².year)	
Annual % of Hot Water	

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type	
Fuel	Biomass/Pellets
Efficiency (%)	90
Electricity	0.3
Water Heating	0.05
Space Heating	0.55
Cooling	0
Production (kWh/m².year)	20.76
Electricity	6.92
Water Heating	1.15
Space Heating	12.69
Cooling	0

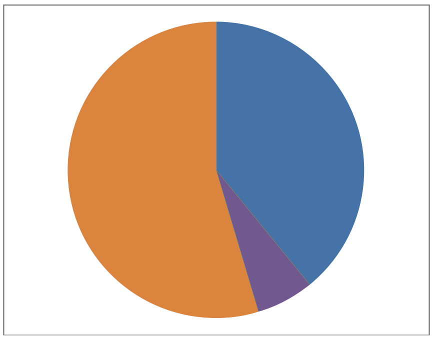
Renewable Production of Heating and Cooling

Heating Equipment

	Biomass - Wooden Pellet Boiler
Technology	
Power	220 kW
Efficiency (%)	100 (condensing technology)
Production (kWh/m².yr)	2.36
Annual % of Heating - (Produced by renewables)	100

Cooling Equipment There is no active cooling system installed in the building.

Technology	
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	E,		H, DHW, E,	H, DHW,		I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Day Care Centre "Die Sprösslinge"

Net Zero Energy Building Overview

This day care centre is designed using the passive house concept. An integral design concept shows how a day care centre can be optimised in the field of energy use and energy generation. The building is part of an energy initiative of the Bayer company hence is highly monitored.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2009

Location
Alfred-Nobel-Straße 50
40789 Monheim
NRW
Germany

Latitude	Longitude
North	West
51° 4' 36.08" N	6° 54' 8.93" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Educational

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
969

Conditioned Floor Area (m²)
969

Occupancy (m² per Person)
13.6

Number of Storeys

Cost US$/(Net) m² Floor Area
2,961

Cost US$/(Net) m² typical similar building

Architectural Design Concept

The day care centre is a sustainable, environmentally friendly, economically feasible project based on integrated material selection and strategies that meet future challenges. Transparent partitions instead of solid walls and large, triple glazed windows offer views towards the exterior. Maximising passive solar energy gains via the envelope, form, and orientation of the building was already a conceptual precondition. The floor layout was optimised during construction to improve the compact character of the building with simultaneous increase of daylight. The PassivHaus standard has been met through a compact layout as well as the external façade having good thermal insulation and cladding.

Measured Energy Production and Consumption:

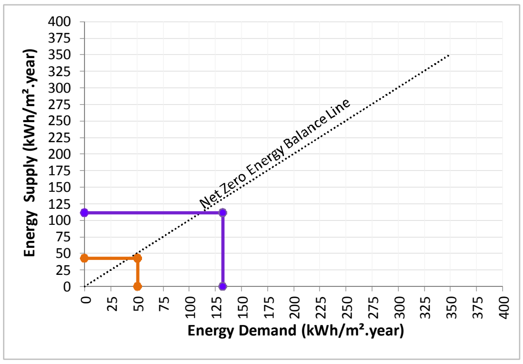
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 51
Primary: 132

Energy Supply (kWh/m².year)
Renewable Energy
Final: 43
Primary: 111

Source to Site Conversion Factor (Electricity): 2.6

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

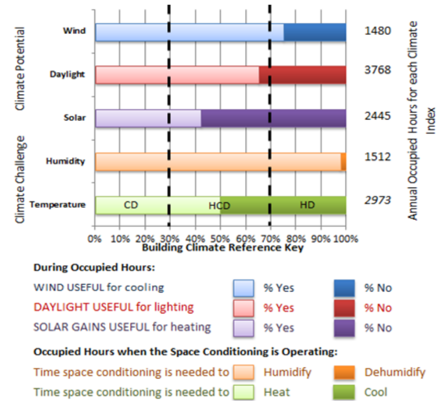
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

Web Address
www.tr-architekten.de/index.php?aktion=projekt

For more information:
http://tinyurl.com/Day-Care-Centre-DE

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
	 L,	 L,	

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.14

Solar Absorptivity

Timber stud construction is insulated by 24cm of polyurethane infilled and 10cm of mineral fibre in the external composite thermal insulation

East

U-value (W/m² ºC) 0.14

Solar Absorptivity

Timber stud construction is insulated by 24cm of polyurethane infilled and 10cm of mineral fibre in the external composite thermal insulation

Facing Polar Direction

U-value (W/m² ºC) 0.14

Solar Absorptivity

Timber stud construction is insulated by 24cm of polyurethane infilled and 10cm of mineral fibre in the external composite thermal insulation

West

U-value (W/m² ºC) 0.14

Solar Absorptivity

Timber stud construction is insulated by 24cm of polyurethane infilled and 10cm of mineral fibre in the external composite thermal insulation

Roofs

U-value (W/m² ºC) 0.09

Solar Absorptivity

Prefabricated wood construction infilled with 40cm polyurethane plus 10cm tapered rigid insulation.

Ground floor

U-value (W/m² ºC) 0.10

18cm polyurethane, concrete floor slab, 10cm perimeter insulation

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.94

g-value 0.51

Triple-glazed, thermally separated insulated wood frames.

East

U-value (W/m² ºC) 0.94

g-value 0.51

Triple-glazed, thermally separated insulated wood frames.

Polar direction

U-value (W/m² ºC) 0.94

g-value 0.51

Triple-glazed, thermally separated insulated wood frames.

West

U-value (W/m² ºC) 0.94

g-value 0.51

Triple-glazed, thermally separated insulated wood frames.

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.18

Compactness (m-1)

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

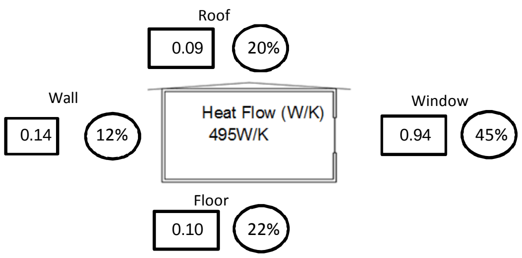
U-value (W/ºC)

Heat Flow %

Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*



Heating

Heat Recovery

Central ventilation system with heat recovery (85%).

Solar heat gain

Maximising passive solar energy gains via the envelope, form, and orientation of the building was already a conceptual precondition (large windows).

Cooling

Sunshading

North facing skylights, exterior sunscreen with an Fc value of 0.2 and fixed, angled Retro blinds installed in the gap between skylight panes (protects them from manipulation).

Daylight Systems

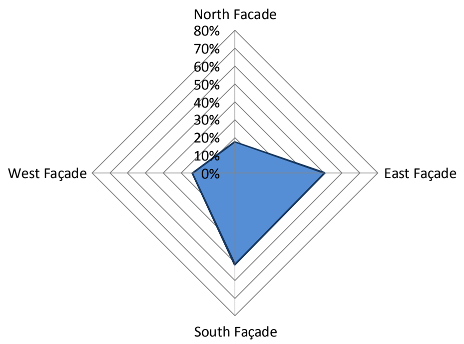
Skylights

The particular roof geometry enables natural daylight intake in the central and inner areas via skylights facing north without excessive heat intake.

Window Distribution Information

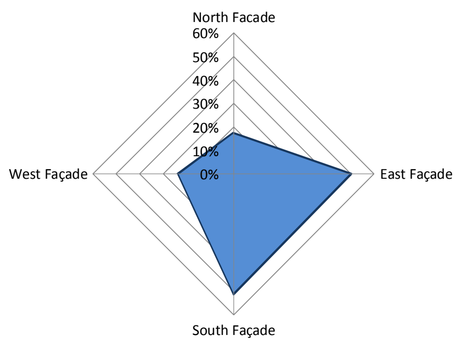
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C,	H, C,	H, C,	H, C,	H,		C,			

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
Efficient lights and computers

Energy Storage

Sunshading
Sunshading (moveable between slices)

HVAC Systems
Efficient heat pump and ventilation system

Artificial Lighting
LED lighting

Computer Management
Not necessary because of Typology

Control of Systems

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	Yes
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
In summer, the under floor heating system (see heating system) can be used to provide cooling with a heat exchanger via the vertical ground loops if required.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
Heat is supplied by a brine/water heat pump that uses the geothermal potential on-site via four vertical heat loops. Solar heat is fed in by solar collectors. The roof-mount vacuum tube collectors are positioned and arranged to maximize coverage of space heating according to the demands. The rooms are heated by a under floor radiant heating system. Low pre-heating temperatures in the heating system along with vertical ground loops specified for high temperature output improve performance.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description
All rooms receive fresh air via a central ventilation system. Its vents are discreetly integrated into walls, wardrobe cabinetry, inbuilt furniture, and floors. Ventilation is designed for energy savings by reduced pressure loss within ducts and high efficiency ventilators with performance rates of 0.71 W/(m³/h). Fresh air is mainly routed into group spaces and flows into the centre of the building via cross flow vents. Air is extracted via vents or restrooms and storage rooms and discharged to the exterior.

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	Yes
Electrical?	No
Other?	No

Description
Decentralised domestic water heaters use heat exchangers and operate similarly to tankless water heaters; they are fed from the storage tank and are located in each restroom.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
No lighting control system

HVAC
Normal control system coupled with the heat pump

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description
No user interaction due to the fact that children are the main users

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,			H, C,	DHW,		H,	C,		

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Roof integrated
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	30°
Azimuth	0°
Technology	Multi-crystalline cells
Nominal Power (kWp)	49
Area (m²)	344
Yield (kWh/m².year)	45
Expected generation (kWh)	38000
Measured generation (kWh)	41444

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water - Final

Solar Thermal	Yes
Technology	Vacuum tube collectors
Position	Roof mounted
Area (m²)	22
Production (kWh/m².year)	8
Annual % of Hot Water	Around 60 %

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

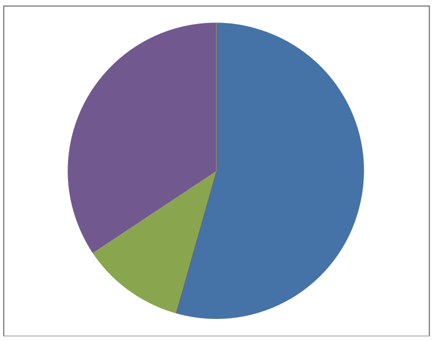
Renewable Production of Heating and Cooling

Heating Equipment - Final En

	Heat Pump
Technology	Brine to water heat pump
Power	28-kWth, 6,1 kWel
Efficiency (%)	459
Production (kWh/m².yr)	24.77
Annual % of Heating - (Produced by renewable)	100

Cooling Equipment

	Heat Pump
Technology	Under floor heating system can be coupled to vertical ground loops via heat
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewable)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 P,	 E,					 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

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Funding
Source and Type of Funding
Funded by the project owner, the chemical concern Bayer, build in the context of the EcoCommercial Building Program.

Principal Actors
project owner, the chemical concern Bayer, the building research group Bayer MaterialScience and the Architects together with the engineers

Authors
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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Marché Kempthal

Completion Date
2007

Location
Alte Poststrasse 2
Kempthal
Zürich
Switzerland

Latitude	Longitude
North	West
47.2	8.3

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Non-residential_Office

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
1267

Conditioned Floor Area (m²)
1550

Occupancy (m² per Person)
31.0

Number of Storeys

Cost US$/(Net) m² Floor Area

Cost US$/(Net) m² typical similar building

Web Address

For more information:
http://tinyurl.com/Marchre-CH

Net Zero Energy Building Overview

The reduction of energy demand based on a compact building shape, well insulated envelope, south orientated main facade and energy efficiency office equipment and lighting. A ground source heat pump and a mechanical ventilation system are used to control the indoor climate. A roof integrated photovoltaic system covers the whole energy demand.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

Compact design with wenn insulated envelope. Passive solar design includes large windows facing South and balconies for shading.

Measured Energy Production and Consumption:

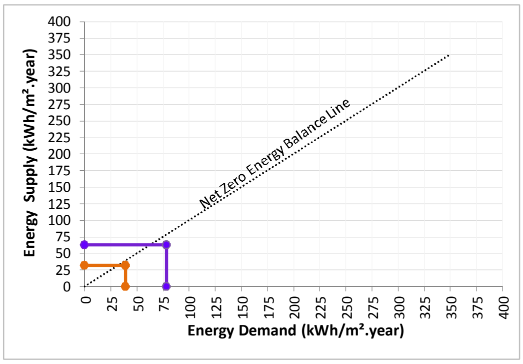
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 39
Primary: 78

Energy Supply (kWh/m².year)
Renewable Energy
Final: 32
Primary: 63

Source to Site Conversion Factor (Electricity): 2

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

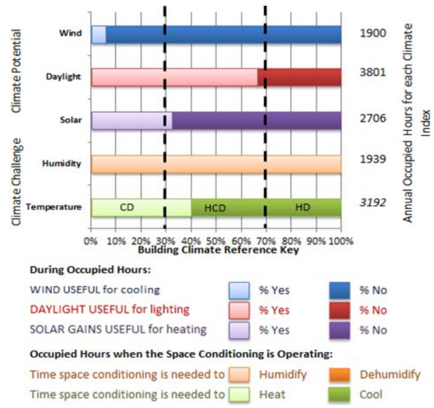
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

***H** - Heating* | ***P** - Plug Loads*
***C** - Cooling* | ***E** - Electricity*
***L** - Lighting* | ***I** - Integration*
***DHW** - Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Passive Approaches:

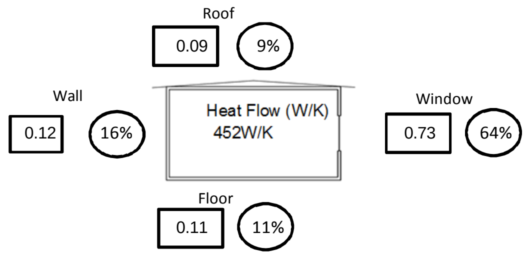
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Thermal Mass

As the main construction is a light weight construction, 80mm cement is added in the floor construction to increase the thermal mass.

Thermal Mass

The South façade is a phase change material (PCM) to increase the thermal mass. The PCM parts are used as a blind and anti glare.

Cooling

Daylight Systems

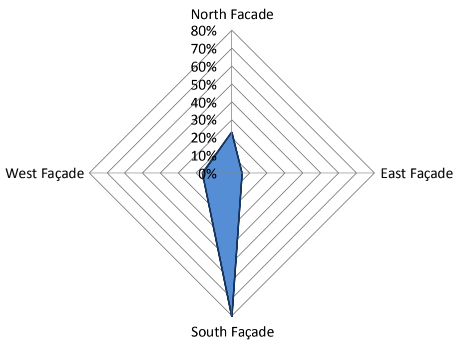
Large windows

Large windows facing south allow to use natural daylight as much as possible.

Window Distribution Information

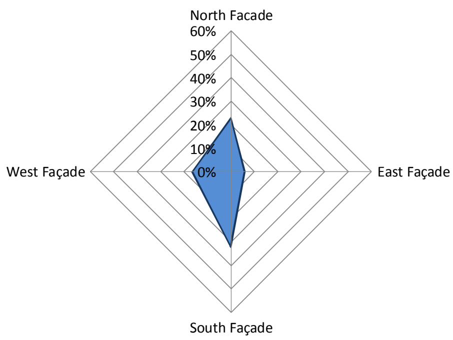
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
 H, L,		 H, C, L,	 H, C, L,	 H,		 H, C,			

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.12

Solar Absorptivity

18 mm wood, 30 mm air, 15 mm kronotec, 80mm mineral wool, 260mm mineral wool, 35 mm 3-S plates

East

U-value (W/m² ºC) 0.12

Solar Absorptivity

18 mm wood, 30 mm air, 15 mm kronotec, 80mm mineral wool, 260mm mineral wool, 35 mm 3-S plates

Facing Polar Direction

U-value (W/m² ºC) 0.12

Solar Absorptivity

18 mm wood, 30 mm air, 15 mm kronotec, 80mm mineral wool, 260mm mineral wool, 35 mm 3-S plates

West

U-value (W/m² ºC) 0.12

Solar Absorptivity

18 mm wood, 30 mm air, 15 mm kronotec, 80mm mineral wool, 260mm mineral wool, 35 mm 3-S plates

Roofs

U-value (W/m² ºC) 0.09

Solar Absorptivity

Timber construction

Ground floor

U-value (W/m² ºC) 0.11

Timber construction

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.73

g-value 0.49

triple glazing

East

U-value (W/m² ºC) 0.71

g-value 0.47

triple glazing

Polar direction

U-value (W/m² ºC) 0.68

g-value 0.37

triple glazing

West

U-value (W/m² ºC) 0.75

g-value 0.28

triple glazing

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.6 1/h@50 Pa

Compactness (m-1)

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
max. 14

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ?

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
The ground source heat pump could be used for cooling. A ground tube could pre-cool the fresh air for the mechanical ventilation system.

Heating

Central Plant	No
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
Space heating (floor heating) and domestic hot water demands are covered by an electric heat pump.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Unknown
Local Air Recirc plus Central Fresh Air	Unknown

Description
Counter flow and ground tubes

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	No

Description
Heat pump

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage
Latent Storage?
Fuel Cell?
Compressed Air?

User Interactions
User Manual Provided? No

Description
No

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
A++ rated appliances

Energy Storage

Other

HVAC Systems
Ground source heat pump (2*180m tubes), PV, mech. ventilation

Artificial Lighting
Efficient artificial lighting

Computer Management

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,									H, C, DHW,	

Design Team

Engineer Civil

Name

Address

Email

Web Address

Engineer MEP

Name

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Web Address

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Engineer Structural

Name

Address

Email

Web Address

Architect

Name

kämpfen für architektur ag

Address

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Email

info@kaempfen.com

Web Address

www.kaempfen.com

Builder/Contractor

Name

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Address

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Email

jean-pierre.gigaud@marche-int.com

Web Address

Funding

Source and Type of Funding

Principal Actors

The owner wanted an energy sufficient and ecological building.

Authors

Monika Hall

Email

monika.hall@fhnw.ch

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Roof
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	12°
Azimuth	south
Technology	thin film
Nominal Power (kWp)	45
Area (m²)	485
Yield (kWh/m².year)	82
Expected generation (kWh)	40000
Measured generation (kWh)	39500

Wind Turbine

Position

Number of Turbine

Technology

Nominal Power (kWp)

Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal

Technology

Position

Area (m²)

Production (kWh/m².year)

Annual % of Hot Water

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type

Fuel

Efficiency (%)

Electricity

Water Heating

Space Heating

Cooling

Production (kWh/m².year)

Electricity

Water Heating

Space Heating

Cooling

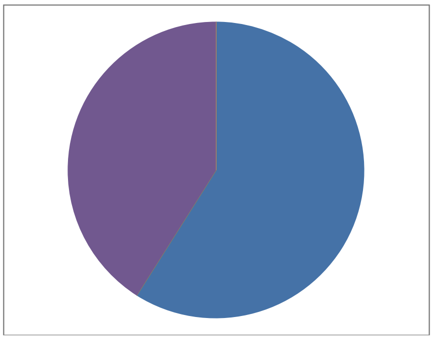
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Heat Pump	**Ground / Water Source Heat Pump**
Technology		CTA 18e
Power		16.3 kW
Efficiency (%)		
Production (kWh/m².yr)		22
Annual % of Heating - (Produced by renewables)	100	

Cooling Equipment - Final Energy

	Heat Pump
Technology	Ground Source
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.

**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	 E,					 I,		

References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Kraftwerk B

Net Zero Energy Building Overview

A well-insulated building makes an extensive use of renewable energy, in particular photovoltaic production and thermal solar collector integrated into the large façade. Heat reconvert from hot waste water, a heat pump, individual wood ovens and a mechanical ventilation system incorporating heat recovery complete the building's equipment.

Completion Date
2009

Location
Burgerenstrasse 1
8836 Bennau
Schwyz
Switzerland

Latitude	Longitude
North	West
47°8'54"	8°43'47"

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
1403

Conditioned Floor Area (m²)
1380

Occupancy (m² per Person)
60.0

Number of Storeys

Cost US$/(Net) m² Floor Area

Cost US$/(Net) m² typical similar building

Web Address

For more information:
http://tinyurl.com/Kraftwerk

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

This building uses facade integrated thermal solar systems and a roof integrated PV-system for its renewable energy generation.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

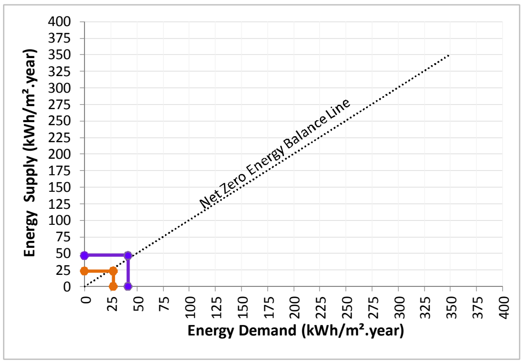
	Electricity	Biofuel
Final:	17	10
Primary:	35	7

Energy Supply (kWh/m².year)
Renewable Energy

Final:	24
Primary:	47

Source to Site Conversion Factor (Electricity): 2

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

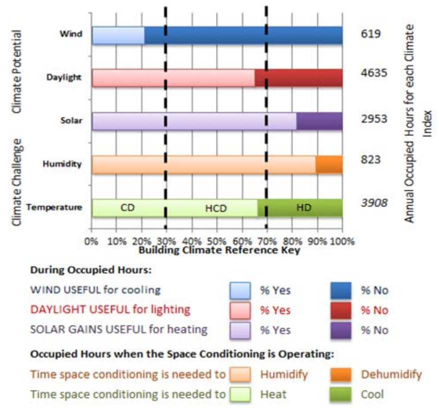
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H - Heating	*P - Plug Loads*
C - Cooling	*E - Electricity*
L - Lighting	*I - Integration*
DHW - Domestic Hot Water	

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.11

Solar Absorptivity

East

U-value (W/m² ºC) 0.11

Solar Absorptivity

Facing Polar Direction

U-value (W/m² ºC) 0.11

Solar Absorptivity

West

U-value (W/m² ºC) 0.11

Solar Absorptivity

Roofs

U-value (W/m² ºC) 0.11

Solar Absorptivity

Oriented Strand Board (OSB), insulation OSB

Ground floor

U-value (W/m² ºC) 0.18

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.64

g-value 0.48

East

U-value (W/m² ºC) 0.64

g-value 0.48

Polar direction

U-value (W/m² ºC) 0.64

g-value 0.48

West

U-value (W/m² ºC) 0.64

g-value 0.48

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.6 ach

Compactness (m-1)

Passive Approaches:

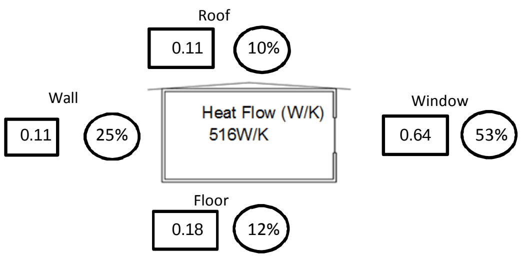
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Sunspaces

Large windows facing south west

Thermal Mass

The concrete core stores the heat.

Heat Recovery

The ground tubes pre-warm the fresh air.

Daylight Systems

Cooling

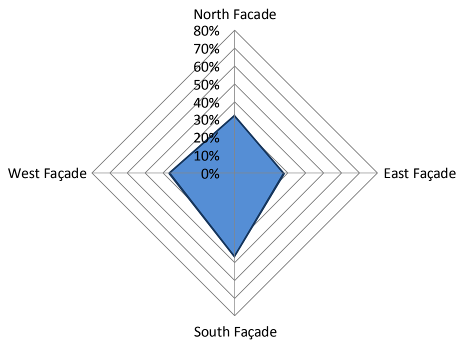
Ground Cooling

The ground tubes pre-cool the fresh air.

Window Distribution Information

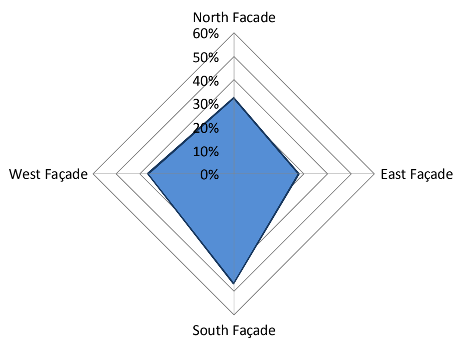
Distribution of Window Areas per Façade

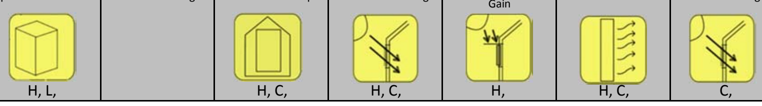
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, L,		H, C,	H, C,	H,	H, C,	C,			

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage
4000 l tank for hot water + 24000l for heating + 3000 l pre heating tank for the neighbour

Other

HVAC Systems
Heat pump and mechanical ventilation

Artificial Lighting

Computer Management

Control of Systems

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ?

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description

Heating

Central Plant	No
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
Space heating (floor heating) and domestic hot water demands are covered by thermal solar, air/water heat pump and decentralise wood ovens.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description
Counterflow with pre-heating/cooling the fresh air in an earth tube.

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	

Description
Solar collector with large storage tank. 24'000 l storage for heating (40°C), 3'000 l for hot water (60°C), 3'000 l pre heat hot water (30°C) for the neighbour.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided?	No

Description
Although there are energy displays in the apartments, the occupiers do not control them. They do however operate the wood ovens in their apartments, and in this way interact with the buildings energy concept.

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
	P,			kWh P,	AIR H,	E,					

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Design Team

Engineer Civil

Name

Address

Email

Web Address

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amena ag

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Web Address
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Address

Email

Web Address

Architect

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Web Address
www.grabarchtitekten.ch

Builder/Contractor

Name

Address

Email

Web Address

Funding

Source and Type of Funding
The monitoring was founded for 2 years.

Principal Actors
Architect and owner

Authors
Monika Hall

Email
monika.hall@fhnw.ch

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Yes
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	43°
Azimuth	South-west
Technology	
Nominal Power (kWp)	32
Area (m²)	220
Yield (kWh/m².year)	
Expected generation (kWh)	32000
Measured generation (kWh)	32980

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Solar panels
Position	South-west
Area (m²)	146
Production (kWh/m².year)	21
Annual % of Hot Water	5800%

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

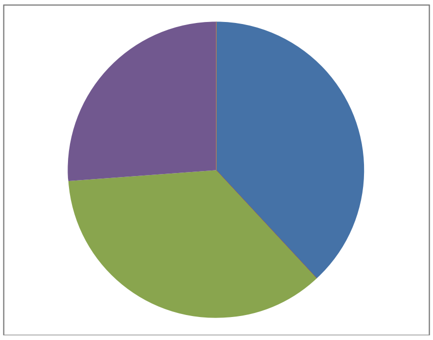
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Heat Pump	Wood Oven
Technology	Air/water heat pump	
Power		
Efficiency (%)		
Production (kWh/m².yr)	4.28	11.40
Annual % of Heating - (Produced by renewables)	12	30

Cooling Equipment - Final Energy

	Heat Pump
Technology	
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
DHW, E,	E,				H, C, P,	I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

RESIDENTIAL NET ZEBs

Heating and cooling dominated climate

EnergyFlexHouse
Denmark
Arch. : Henning Larsens Architects

"Le Charpak" IESC
Cargèse, France
Arch. : Villa & Battesti

Leaf House
Italy
Arch. : MEP

Casa Zero Energy
Italy
Arch. : Arnaldo Savorelli

Lima
Spain
Arch. : Joan Sabate, Christoph Peters, Horacio Espe

EnergyFlexHouse (family house)

Net Zero Energy Building Overview

Low energy building with solar heating, heat pumps and photovoltaics. Photovoltaic energy production makes the building energy neutral. Strategically positioned windows give daylight and passive solar energy. Controlled natural ventilation and solar shading increase comfort.

Completion Date
In operation from fall 2009

Location
Gregersensvej 14
Taastrup

Denmark

Latitude	Longitude
North	West
55° 39' 35" N	12° 16' 34" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Open Site

Gross Floor Area (m²)
216

Conditioned Floor Area (m²)
216

Occupancy (m² per Person)
0.0

Number of Storeys

Cost US$/(Net) m² Floor Area
Being experimental buildings, the cost is very high. No similar houses on the commercial market

Cost US$/(Net) m² typical similar building

Web Address
http://www.dti.dk/inspiration/25348

For more information:
http://maps.google.co.nz/maps?hl=en&ta b=il

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

EnergyFlexHouse consists of 2 two-storeyed, single-family houses each with 216 m² heated gross area. The two buildings are in principle identical, but while the one building acts as a technical laboratory (EnergyFlexLab), the other is occupied by typical families (EnergyFlexFamily). Each family lives in EnergyFlexFamily for 3-5 months at a time. In EnergyFlexLab focus is on short-term tests where the interaction between installations and building can be tested under realistic weather conditions. EnergyFlexFamily makes it possible to test user behaviour, influence and acceptance of and interaction with the components and systems – i.e. EnergyFlexFamily is a living lab. EnergyFlexHouse is built to resemble an attractive, Danish, detached; single-family house, designed so most people would think: "I could live in this building". Focus has been on obtaining energy neutrality on an annual basis, good indoor comfort and utilization of daylight.

Measured Energy Production and Consumption:

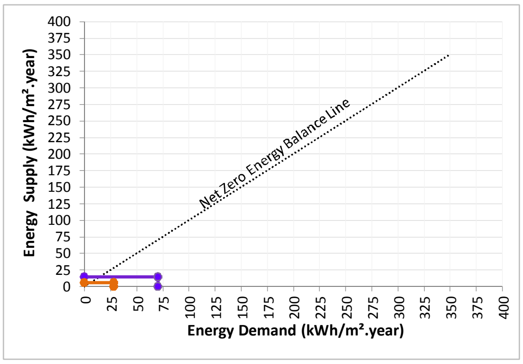
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 28
Primary: 70

Energy Supply (kWh/m².year)
Renewable Energy
Final: 6
Primary: 15

Source to Site Conversion Factor (Electricity): 2.5

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

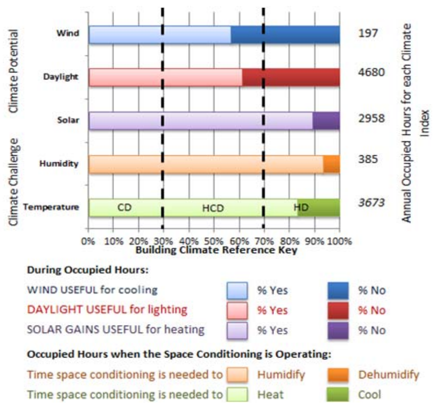
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L	 L		

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 0.08
Solar Absorptivity

A core insulated wooden frame structure (Kerto). 350 mm mineral wool/Kerot, 30 mm mineral wool, air gaps , external and internal finish

East
U- 0.08
Solar Absorptivity

A core insulated wooden frame structure (Kerto). 350 mm mineral wool/Kerot, 30 mm mineral wool, air gaps , external and internal finish

Facing Polar Direction
U-value (W/m² ºC) 0.08
Solar Absorptivity

A core insulated wooden frame structure (Kerto). 350 mm mineral wool/Kerot, 30 mm mineral wool, air gaps , external and internal finish

West
U-value (W/m² ºC) 0.08
Solar Absorptivity

A core insulated wooden frame structure (Kerto). 350 mm mineral wool/Kerot, 30 mm mineral wool, air gaps , external and internal finish

Roofs
U-value (W/m² ºC) 0.09
Solar Absorptivity

A core insulated wooden frame structure (Kerto). 350 mm mineral wool/Kerot, 30 mm mineral wool, air gaps , external and internal finish

Ground floor
U-value (W/m² ºC) 0.11

400 mm polystyrene (Sundolit S150), 100 mm concrete, 10 mm hard polystyrene, 30 mm polystyrene with floor heating tubes, vapor barrier, 16 mm parquet

Windows - Construction Elements

Solar noon - South
U-value (W/m² ºC) 0.79
g-value 0.47

8 Velfac Helo-36 windows

East
U-value (W/m² ºC) 0.74
g-value 0.47

1 door + 3 windows - Velfac Helo-36

Polar direction - North
U-value (W/m² ºC) 0.75
g-value 0.47

4 Velfac Helo-36 windows

West
U-value (W/m² ºC) 0.74
g-value 0.47

1 door + 3 windows - Velfac Helo-36

Air permeability (m³/m²h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built
0.42 l/s/m² at 50 Pa

Compactness (m-1)

Passive Approaches:

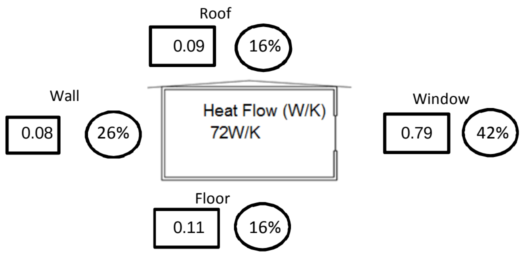
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Increased Glazing in the South

The South façade has approximatly double the window area compared to the other façades.

Glazing U-value

The windows and door all Velfac Helo-36 but U-values differ according to window size. The U-value shown in the side panel (left) are therefore area-weighted mean values for each façade.

Thermal Mass

The thermal mass of the building consists of 100 mm concrete floor slab at the ground floor with imbedded pipes for under floor heating. This thermal mass is especially useful for peak saving in connection with Smart Grid.

Cooling

Sunshading

Sunshading has been used on South facing windows to prevent overheating due to solar radiation.

Natural Ventilation

To prevent overheating during the day, and decrease the electricity consumption of the fans - see also below under Thermal Chimney.

Thermal Chimney

There is an automatically operable window of 0.21 m² at each end of the aisle at the ground floor and two operable windows at the north facing top of the roof with a total opening area of 0.57 m² (not in the figure below). The chimney effect reduces overheating and replaces mechanical ventilation with natural ventilation outside the heating season.

Daylight Systems

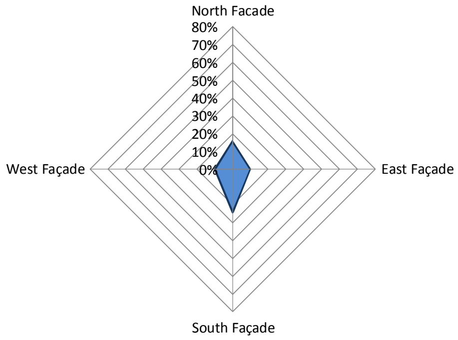
Strategic Openings

There are roof lights, strategic window placing and openings in partition floor to allow for light to funnel from upper level down to lower level. Roof windows at the top of the north facing roof have a total transparent area of 2 m² - not included in the below figure.

Window Distribution Information

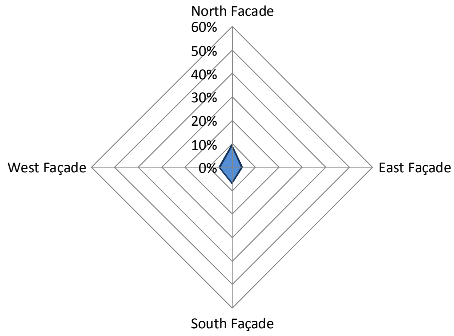
Distribution of Window Areas per Façade

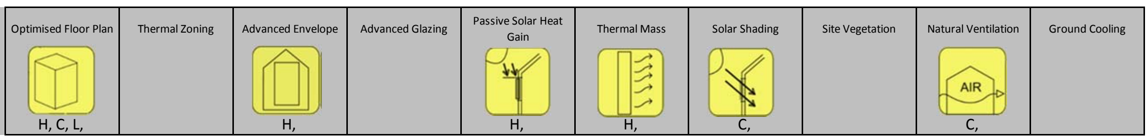
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
Demand controlled- based on temperature, CO_2 and humidity.

Appliances / Plug Loads
Power Density Installed (W/m²) : Unknown

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	Yes
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
No cooling plant

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	Yes

Description
Ground source heat pump connected to underfloor heating, a heat recovery heat pump for heating fresh air and DHW and solar heating

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description
Passive heat recovery unit (efficiency approx. 85%) combined with air to water/air heat pump

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	Yes
Electrical?	No
Other?	

Description
Combination of solar heating (4.8 m²) and heat recovery heat pump in the ventilation system. The two system share one 180 litre DHW tank

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
Manual

HVAC
The control of the space heating system, the ventilation system, the natural ventilation systems and the shading system is combined in order to achieve a good indoor climate while decreasing the energy use

Energy Storage

Latent Storage?	Yes
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description
Users may change the set points for space heating (via individual room thermostats) and DHW and the combined control of solar shading/natural ventilation

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
Weekly reports on used energy

Energy Storage
In EnergyFlexLab: PCM in the concrete floor of one room

Other
Electrical vehicle

HVAC Systems
Small ground source heat pump + air to air ventilation/DHW heat pump + solar thermal

Artificial Lighting
Some LED lights

Computer Management

Control of Systems
Combined control of hybrid ventilation, solar shading, heating- installed summer 2011

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,				AIR H, DHW,			H,			

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Danish Technological Institute

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	No
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	55°
Azimuth	0°
Technology	Sunpower 225 mono crystalline
Nominal Power (kWp)	11
Area (m²)	60
Yield (kWh/m².year)	55
Expected generation (kWh)	7258
Measured generation (kWh)	7278

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Flat plate collectors
Position	South facing (55°)
Area (m²)	5
Production (kWh/m².year)	6
Annual % of Hot Water	55

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

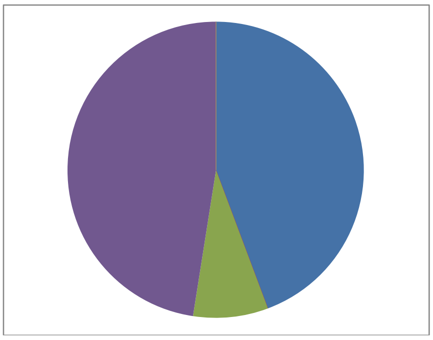
Renewable Production of Heating and Cooling

Heating Equipment - Final En

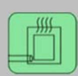
	Heat Pump	Heat Pump
Technology	Nilan VP18 Compact - ground source heat pump	Nilan VP18 air to water/air heat pump
Power Capacity heat	1-3.5 kWh heat	1-2 kWh heat
Efficiency (%)	COP 3.5 at 3.5 kWh heat	COP 2.9 at 2 kWh heat (EN 14511)
Production (kWh/m².yr)	28.60	7.50
Annual % of Heating - (Produced by renewables)	1	

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,	 H, L, DHW, E,				 H,	 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

"Le Charpak", IESC Cargèse

Completion Date
Completed in 2011

Location
Menasina
CARGÈSE
Corsica
France

Latitude	Longitude
North	West
42.135 N	8.61 E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Open Site

Net Floor Area (m²)
713

Conditioned Floor Area (m²)
647

Occupancy (m² per Person)
20.0

Number of Storeys
2

Cost US$/(Net) m² Floor Area
4,550

Cost US$/(Net) m² typical similar building
4,000

Web Address
www.iesc.univ-corse.fr/index.php?id=1&L=1

For more information:
http://tinyurl.com/IESC-Cargese-FR

Net Zero Energy Building Overview

Le Charpak has been designed to meet an ambitious energy performance criteria. For this reason, the external conditions, energy consumption and internal environmental conditions are monitored. A solar water system is used for space heating (radiant floors) and domestic hot water heating. The primary structure of this building is concrete, however the facades to the East and West are constructed from cellulose wadding with wood fibre panels on either side.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

This building is orientated to take advantage of sea breezes, allowing for natural ventilation. Extensive shading protects the building from the sun and this is enhanced by natural night ventilation NNV - an innovative system controlled by the building management system which allows for automatized window openings at night. This is further enhanced by high mass thermal mass walls, floors and ceilings.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

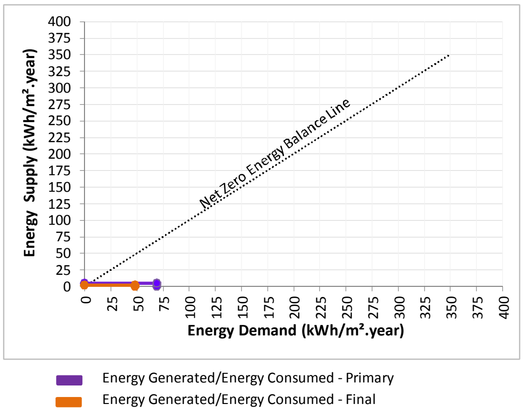
Energy Demand (kWh/m².year)

	Electricity	Natural Gas
Final:	11	37
Primary:	29	40

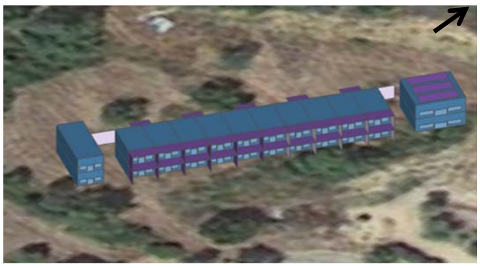
Energy Supply (kWh/m².year)
Renewable Energy
Final: 2
Primary: 5

Source to Site Conversion Factor (Electricity): 2.58

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



EnergyPlus Model

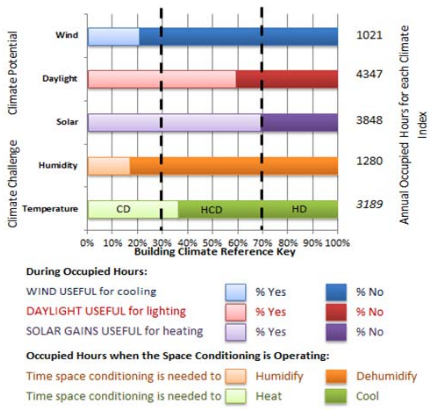


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference non-residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

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C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

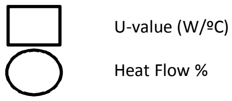
Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

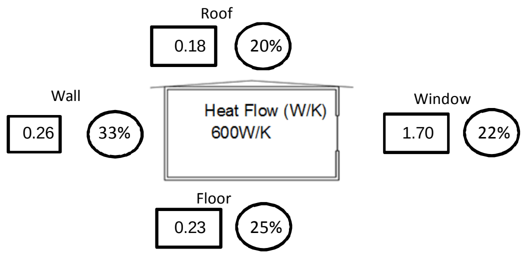
Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





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Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Solar Thermal System

80% of heating and domestic hot water needs covered by solar thermal system provided by SOLISART.

Thermal Mass

Storage of the heat provided by solar thermal panels in both solar system water tanks (capacity of 5m3) and 70 m3 of concrete in floors.

Cooling

Natural Ventilation

Openings motorized and controlled by BMS for passive cooling, thanks to dominant sea breezes.

Sun shading

Huge solar shadings designed to stop most of solar gains during summer period.

Night Cooling

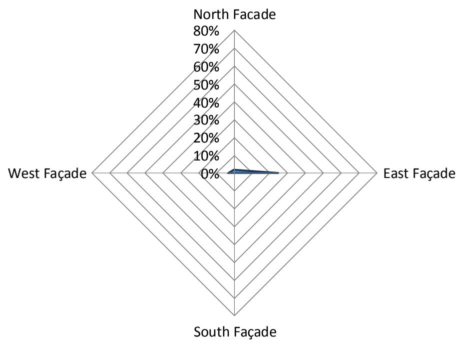
Openings motorized and controlled by BMS for passive cooling during night, in order to cool inner inertial concrete walls, storing night "cold" air for next day.

Daylight Systems

Window Distribution Information

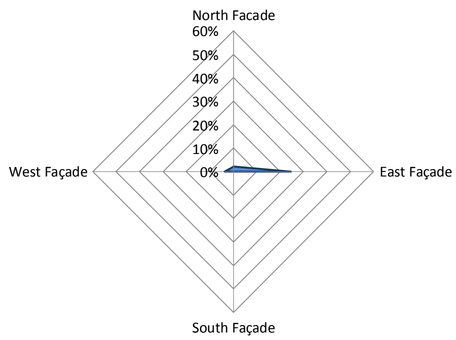
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C, L,		H, C,	H, C,		H, C,	C,		C,	

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.26
Solar Absorptivity 0.80

180mm of high density concrete with interior insulation (wool of wood 120mm).

East

U-value (W/m² ºC) 0.21
Solar Absorptivity 0.70

Wood facades insulated by 120mm of absorbent cotton of cellulose & 50mm of wood fibre panels.

Facing Polar Direction

U-value (W/m² ºC) 0.26
Solar Absorptivity 0.80

180mm of high density concrete with interior insulation (wool of wood 120mm).

West

U-value (W/m² ºC) 0.21
Solar Absorptivity 0.70

Wood facades insulated by 120mm of absorbent cotton of cellulose & 50mm of wood fibre panels.

Roofs

U-value (W/m² ºC) 0.18
Solar Absorptivity 0.85

180mm of high density concrete, with exterior insulation (180mm of absorbent cotton of cellulose) with waterproofing membranes.

Ground floor

U-value (W/m² ºC) 0.23

Radiant floor, then 100mm of high density concrete and exterior insulation (100mm of polystyrene).

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 1.70
g-value

None

East

U-value (W/m² ºC) 1.70
g-value 0.53

Saint Gobain 4-16-4 double glazing with argon.

Polar direction

U-value (W/m² ºC) 1.70
g-value 0.53

Saint Gobain 4-16-4 double glazing with argon.

West

U-value (W/m² ºC) 1.70
g-value 0.53

Saint Gobain 4-16-4 double glazing with argon.

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

Compactness (m-1)

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
8

Appliances / Plug Loads
Power Density Installed (W/m²) : 8 W/m²

Artificial Lighting
Power Density Installed (W/m²) : 5

Computer Network
Power Density Installed (W/m²) : 1.0
Datacentre ? Yes

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	Yes
Hydronic distribution	No
Air distribution	No

Description

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	No

Description
80% of space heating (radiant floors) and domestic hot water demands are covered by solar thermal water system. A 24kW gas backup system is also installed.

Ventilation System

Heat Recovery Type	No
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	Yes
Other?	

Description
Energy comes mainly from solar thermal panels and also from gas backup boiler.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
None

HVAC
Natural ventilation controlled by BMS, heating strategies controlled by solar system itself.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? Yes

Description
User controls of the ceiling fans include choosing between three fan speeds or switching them off. User can also change natural ventilation control setpoints, but cannot control heating.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
Outdoor lighting with motion sensors.

Energy Storage
Solar energy stored in both water tanks ($5m^3$) and concrete slabs ($70m^3$)

Ceiling Fans
Ceiling fans in case of overheating during hot periods (no active cooling system).

HVAC Systems
Solar thermal for both DHW and heating. Cross ventilation for night cooling, motored and controlled by BMS.

Artificial Lighting

Computer Management
All sensors linked to BMS. Measurements of consumptions by end-uses. Openings for natural ventilation controlled by BMS.

Control of Systems
Heating and DHW solar water system, openings for natural ventilatoin and ceiling fan can be controlled through internet.

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,		P,		P,				H,	C,		C,

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Funding
Source and Type of Funding
CNRS: 320000€ ; CPER: 1500000€ ; CTC: 400000€ ; ADEME: 300000€

Principal Actors
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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV)

Building Integrated PV?	Yes
Ground mounted	No
Roof mounted	yes
Position	Fixed
Tilt (angle)	3°
Azimuth	287° (North 0°/East 90°)
Technology	Amorpheus sillicium
Nominal Power (kWp)	15
Area (m²)	245
Yield (kWh/m².year)	150
Expected generation (kWh)	36750
Measured generation (kWh)	

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal	Yes
Technology	Evacuated tubes
Position	On roofs
Area (m²)	47
Production (kWh/m².year)	13
Annual % of Hot Water	80

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

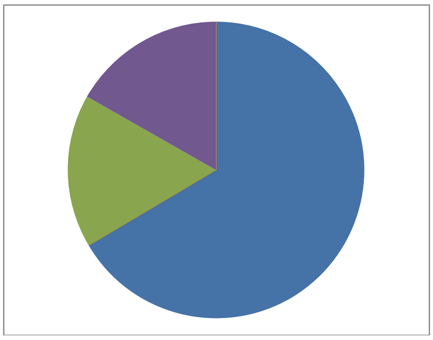
Renewable Production of Heating and Cooling

Heating Equipment

	Radiant Floors
Technology	Evacuated tubes for radiant floors
Power	24 KW backup gas boiler
Efficiency (%)	97
Production (kWh/m².yr)	13.00
Annual % of Heating - (Produced by renewables)	80

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 H, C, DHW,	 E,					 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Leaf House

Completion Date
2008

Location
Petrarca (via F. Petrarca)
Rosora
Ancona
Italy

Latitude	Longitude
North	West
43° 28' 43" N	13° 04' 03" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
477

Conditioned Floor Area (m²)
477

Occupancy (m² per Person)
40.0

Number of Storeys

Cost US$/(Net) m² Floor Area
943,600

Cost US$/(Net) m² typical similar building

704,200

Web Address
http://www.leafcommunity.com/?page_id=5&lang=en

For more information:
http://tinyurl.com/LeafHouseAlbum

Net Zero Energy Building Overview

The Leaf House inspiration is the Italian rural house - an autonomous and sustainable microcosm where every resource is exploited and nothing wasted. Its main features include North South orientation, high thermal mass boundary walls, and glazed surfaces on the South facade.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

The Leaf House is North/South oriented and presents a compact shape; to increase its thermal performance. The North facade is set into a bank, enhancing thermal exchange with the ground. On the South facade, the glazed surfaces allow for good daylight in the building, and for enhancing the useful solar gains useful in Winter. During the hotter season a large photovoltaic roof, integrated into the envelope protects the building from the sun. It overhangs on the South facade to shade the upper level of the building. The second level is shadowed by a canopy made out of 7 thermal modules; the overhang of the balcony at the second level, provides shadow to the first level. These overhangs have been designed using dynamic simulations which have been used to design the optimised control of the building services through the building automation system, reducing not only the energy consumption of the building but its impact on the grid.

Measured Energy Production and Consumption:

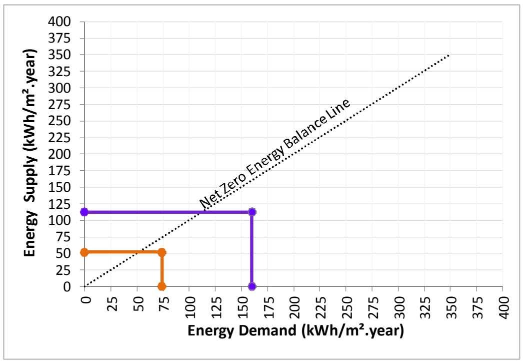
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 74
Primary: 160

Energy Supply (kWh/m².year)
Renewable Energy
Final: 52
Primary: 113

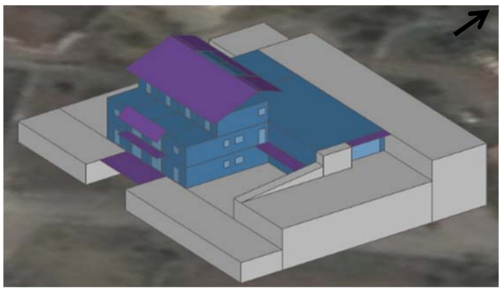
Source to Site Conversion Factor (Electricity): 2.17

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model

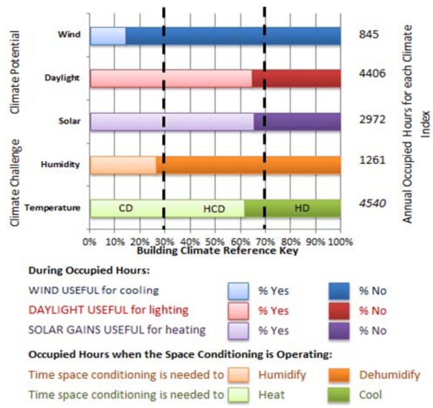


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

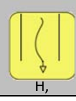
The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
		 H,	

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.15

Solar Absorptivity

2cm Plaster, 30cm Poroton Brick, 18cm Polystyrene Rofix EPS 100, 2cm Plaster

East

U-value (W/m² ºC) 0.15

Solar Absorptivity

Facing Polar Direction

U-value (W/m² ºC) 0.15

Solar Absorptivity

124 of them below grade

West

U-value (W/m² ºC) 0.15

Solar Absorptivity

Roofs

U-value (W/m² ºC) 0.25

Solar Absorptivity

3x1cm Plasterboard Pregyplac, 10cm wood fibre, 10 cm rockwool, 4cm airspace, 2cm Pinewood

Ground floor

U-value (W/m² ºC) 0.41

2cm ceramic tile, 5cm concrete, 4cm polyurethane, 5cm concrete, 0.5cm bitumen, 20cm concrete, 19cm air, 11.80cm gravel

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.86

g-value 0.61

Internorm, edition, double glazing filled with argon

East

U-value (W/m² ºC) 0.86

g-value 0.61

Polar direction

U-value (W/m² ºC) 0.86

g-value 0.61

West

U-value (W/m² ºC) 0.86

g-value 0.61

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

1.91

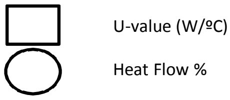
Compactness (m-1)

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

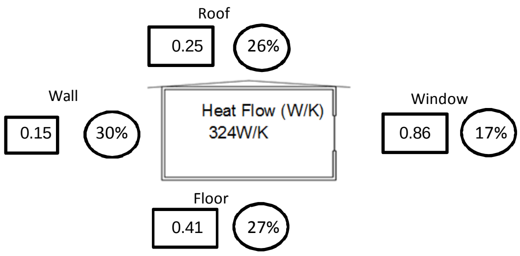
High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*



Heating

Thermal Mass

Walls and floors have high thermal mass.

Sunspaces

Wide windows on the southern facade allow solar radiation to heat the building.

Heat Recovery

Preconditioning in an underground duct of the fresh air.

Cooling

Sun shading

The roof, solar thermal panels and the balcony behave like solar shields.

Green Roof/Façade

Ventilated roof reduces the solar loads during summer.

Ground Cooling

Preconditioning in an underground duct of the fresh air.

Daylight Systems

Solar tubes

The two apartments on the ground floor and the two apartments on the first floor have a bathroom not provided with windows: solar tubes allows natural light to light these rooms.

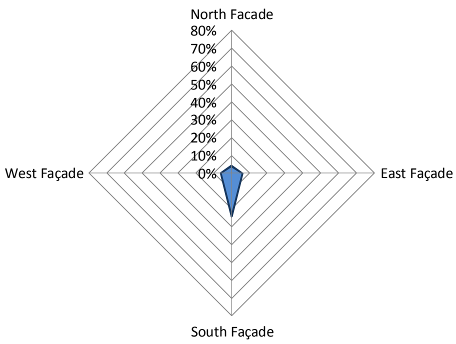
Window Distribution Information

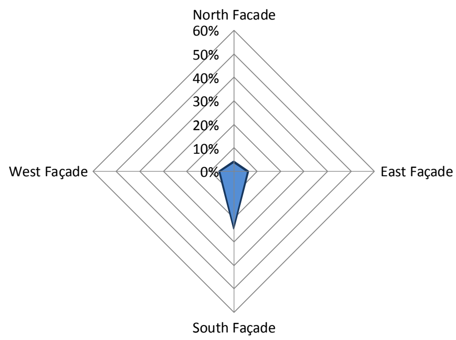
Distribution of Window Areas per Façade

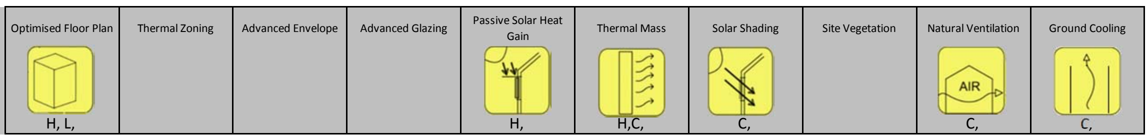
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.

Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.







Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	Yes
Air distribution	No

Description
Cooling provided by the radiant floor, cooling demand covered by an heat pump. An electric dehumidifier is switched on if the UR becomes critical (a few hours a year)

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	No

Description
Space heating (radiant floors) and domestic hot water demands are covered by an electric heat pump operating with three ground probes and by the heat produced from flat plate solar thermal collectors in the facade at first floor.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description
Entalpic

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	

Description
DHW is produced completely or partially (depending on the season) from seven flat solar thermal collectors.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
High efficiency appliances, stand by button

Energy Storage

Other

HVAC Systems
Geothermal Heat Pump

Artificial Lighting
Fluorescent

Computer Management
Building Automation, remote monitoring

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,				H,	DHW,		H,	C,		

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Funding
Source and Type of Funding
Project completely financed by Loccioni Group

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Integrated roof
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	22°
Azimuth	0°
Technology	Monocrystalline silicon
Nominal Power (kWp)	20
Area (m²)	150 (0.31 m2/m2)
Yield (kWh/m².year)	167
Expected generation (kWh)	25000
Measured generation (kWh)	24750

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Flat plate collectors
Position	Solar Shading
Area (m²)	19
Production (kWh/m².year)	9
Annual % of Hot Water	6300%

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type	
Fuel	
Efficiency (%)	
Electricity	
Water Heating	
Space Heating	
Cooling	
Production (kWh/m².year)	
Electricity	
Water Heating	
Space Heating	
Cooling	

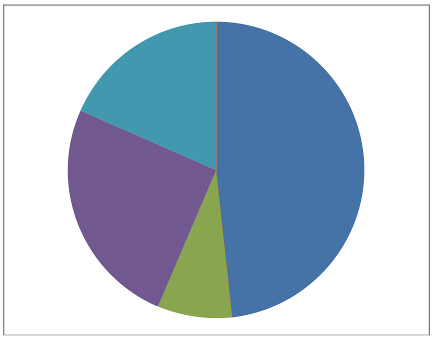
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Heat Pump
Technology	Geothermal Heat Pump
Power	16.6
Efficiency (%)	4.6
Production (kWh/m².yr)	27.40
Annual % of Heating - (Produced by renewables)	78.26086957

Cooling Equipment - Final Energy

	Heat Pump
Technology	Geothermal
Power	
Efficiency (%)	4
Production (kWh/m².year)	20
Annual % of Cooling - (Produced by renewables)	100



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,					 H, C,			

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Casa Zero Energy House

Net Zero Energy Building Overview

Bioclimatic house with low energy consumption. Renewable energy provides most of the energy demands.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
In operation from 2010

Location
Felettano
Tricesimo
Udine
Italy

Latitude	Longitude
North	West
46° 9' 36" N	13° 12' 60" E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Open Site

Gross Floor Area (m²)
378

Conditioned Floor Area (m²)
378

Occupancy (m² per Person)
100

Number of Storeys

Cost US$/(Net) m² Floor Area
As being experimental buildings the cost is very high. No similar houses on the commercial market

Cost US$/(Net) m² typical similar building

Web Address
http://www.casazeroenergy.net/

For more information:
http://tinyurl.com/CasaEnergyAlbum

Architectural Design Concept

The building is a detached house with a surface to volume ratio of 1:0.73. Its shape and orientation have been optimised to maximise the solar heat gains and natural ventilation. Several natural elements, such as plants and trees, were used for allowing or permitting the sunlight to enter into the house and for mitigating the breeze from north side. There are openings are on all facades to allow for views of the Alps.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

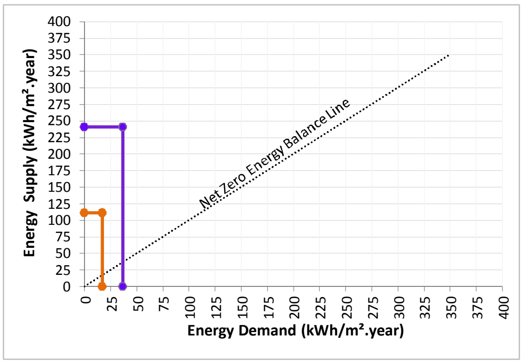
Electricity		**Natural Gas**
Final:	17	
Primary:	37	

Energy Supply (kWh/m².year)

Renewable Energy
Final: 111
Primary: 241

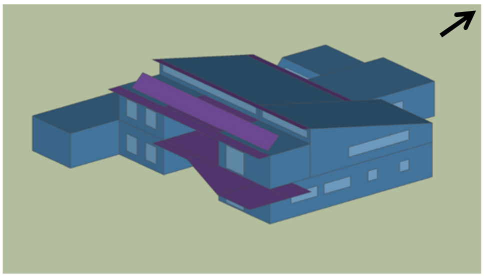
Source to Site Conversion Factor (Electricity): 2.17

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model



This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
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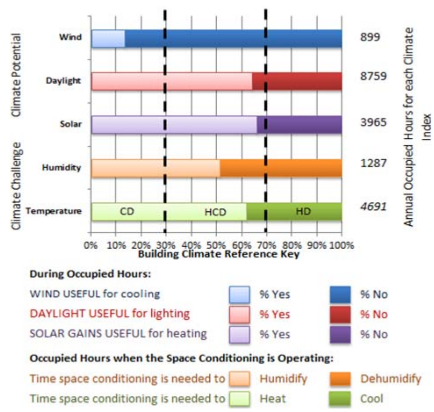
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,			

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Construction

Walls - Construction Elements

Facing Solar Noon
U-value (W/m² ºC) 0.20
Solar Absorptivity

Plasterboard, non-ventilated airgap, wood fibre insulation, plywood, wood fibre insulation, plywood, cork insulation, wind barrier, ventilated airgap, wood laths.

East
U-value (W/m² ºC) 0.20
Solar Absorptivity

Plasterboard, non-ventilated airgap, wood fibre insulation, plywood, wood fibre insulation, plywood, cork insulation, wind barrier, ventilated airgap, wood laths.

Facing Polar Direction
U-value (W/m² ºC) 0.20
Solar Absorptivity

Plasterboard, non-ventilated airgap, wood fibre insulation, plywood, wood fibre insulation, plywood, cork insulation, wind barrier, ventilated airgap, wood laths.

West
U-value (W/m² ºC) 0.20
Solar Absorptivity

Plasterboard, non-ventilated airgap, wood fibre insulation, plywood, wood fibre insulation, plywood, cork insulation, wind barrier, ventilated airgap, wood laths.

Roofs
U-value (W/m² ºC) 0.20
Solar Absorptivity

Wooden plank 20mm, vapour break, wood fibre insulation 180mm, wooden plank 20mm, waterproof barrier, laths sec.40x60 mm, tiles or structure for green roof.

Ground floor
U-value (W/m² ºC) 0.37

Resin floor 3mm, concrete screed 50mm, insulating light concrete layer with EPS 90mm, reinforced concrete 30mm, aerated basement.

Windows - Construction Elements

Solar noon - South
U-value (W/m² ºC) 0.90
g-value 0.67

Wooden fixtures with double panes and low emitting glass on the external side and Argon airgap

East
U-value (W/m² ºC) 0.90
g-value 0.67

Wooden fixtures with double panes and low emitting glass on the external side and Argon airgap

Polar direction - North
U-value (W/m² ºC) 0.90
g-value 0.67

Wooden fixtures with double panes and low emitting glass on the external side and Argon airgap

West
U-value (W/m² ºC) 0.90
g-value 0.67

Wooden fixtures with double panes and low emitting glass on the external side and Argon airgap

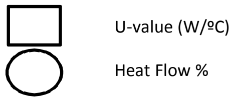
Air permeability (m^3/m^2h@50pa)
Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

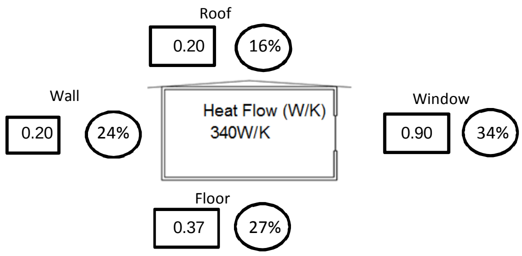
As Built

Compactness (m-1)

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

***Building Challenge Solution Set** - The set of solutions used to lower the energy needed by a particular building challenge.*

***Whole Building Solution Set** - The set of solutions used to lower the energy consumption of the whole building.*

Heating

Sunspaces

Located on the south facade, on two levels, in order to optimize the use of the solar energy during the winter season. Furthermore the south facade has wide openings that allow the sun to heat the internal environment during the cold season.

Building Envelope Properties

Building envelope properties (good insulation, high thermal capacity and high thermal shift) minimalise the effect of variations in external temperature.

Thermal Mass

Ground floor and intermediate floor have a high thermal mass to store the heat and moderate the internal temperature.

Cooling

Natural Ventilation

There are windows on all facades to allow for natural ventilation from the North. Furthermore the double height in the centre of the house acts like a chimney, with the warm air rising up and going out through the windows at the top of the house.

Green Roof/Façade

The green roof moderates the internal environment due to its thermal mass.

Sunshading

The shading system reduces the passive solar heat gains during summer.

Daylight Systems

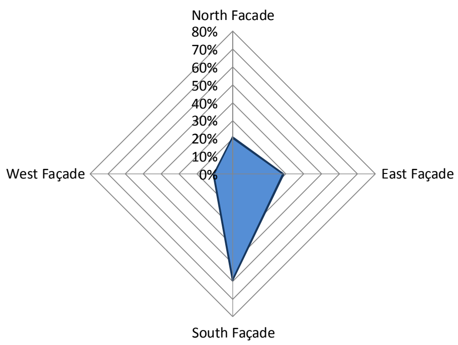
Strategic Openings

Wide windows on all facades decrease the need for artificial lighting.

Window Distribution Information

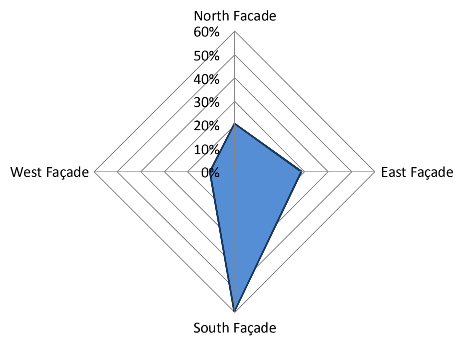
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C, L,		H, C,		H,	H, C,	C,	C,	C,	

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
33

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description
A heat pump is used for space cooling (radiant floor).

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description
Space heating (radiant floors) and domestic hot water demands are covered by a geothermal heat pump and by the heat produced from flat solar thermal collectors on the roof.

Ventilation System

Heat Recovery Type	No
Central Air supply	No
Local Air Recirc plus Central Fresh Air	No

Description

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	Yes
Electrical?	No
Other?	

Description
The heat production of solar thermal collectors can basically cover the monthly heat demand for DHW. When their production is not enough for covering the DHW demand an electric boiler supplies the heat necessary to produce it.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided?

Description
The users can manage all the systems thanks to a control panel for the domotic management of the house.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
High efficiency appliances

Energy Storage

Others
The building is provided of several technologies: PV panels, solar collectors, biomass heating, radiant floors, phytodepuration, rainwater storage.

HVAC Systems
Geothermal heat pump for heating and cooling

Artificial Lighting
Fluorescent and LED

Computer Management
Building automation, remote monitoring

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	H, C, P,								C,		

Design Team

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Email
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Web Address
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Funding

Source and Type of Funding
The building was built by a private construction company with the partial contribution of the Friuli Venezia Giulia Region.

Principal Actors
The research project was carried out by the Laboratory of Building Design of the University of Trento directed by Prof. Antonio Frattari. The research protype was financed and built by Polo Group - Le ville Plus (Cassacco -UD - Italy).

Authors
Antonio Frattari

Email
antonio.frattari@unitn.it

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Roof integrated
Ground mounted	Yes
Roof mounted	Yes
Position	Fixed
Tilt (angle)	30°
Azimuth	25°
Technology	Polycrystalline silicium
Nominal Power (kWp)	16
Area (m²)	110
Yield (kWh/m².year)	147
Expected generation (kWh)	Approx. as measured
Measured generation (kWh)	41981

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water

Solar Thermal	Yes
Technology	Flat plate collectors/PV
Position	Roof- South
Area (m²)	19
Production (kWh/m².year)	
Annual % of Hot Water	

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type	
Fuel	
Efficiency (%)	
Electricity	
Water Heating	
Space Heating	
Cooling	
Production (kWh/m².year)	
Electricity	
Water Heating	
Space Heating	
Cooling	

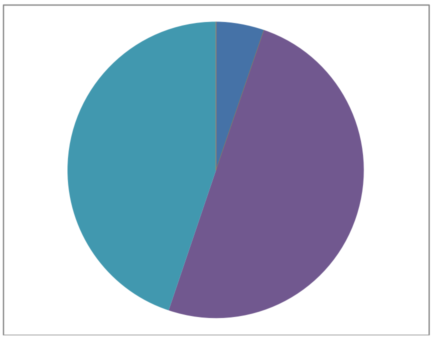
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Heat Pump	**Flat Plate Collectors**
Technology	Geothermal heat pump with horizontal probes (radiant floors)	
Power Capacity heat	151W	
Efficiency (%)	360	75
Production (kWh/m².yr)	1049.81	
Annual % of Heating - (Produced by renewables)	100	

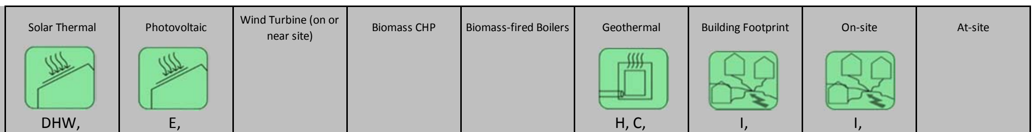
Cooling Equipment - Final En

	Heat Pump
Technology	Geothermal
Power	
Efficiency (%)	300
Production (kWh/m².year)	945
Annual % of Cooling - (Produced by renewables)	100 (948 kWh/m².year cool from the ground)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production



References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

LIMA

Completion Date
Under test

Location
C/St. Joan de la Salle 42
Barcelona
Barcelona
Spain

Latitude North	Longitude East
41°24'29.14"N	2° 7'47.36"E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
45

Conditioned Floor Area (m²)
45

Occupancy (m² per Person)
22.5

Number of Storeys

Cost US$/(Net) m² Floor Area

Cost US$/(Net) m² typical similar building

Web Address
http://www.lima.cat/

For more information:
https://maps.google.es/maps/ms?msid=207261427881350543522.0004ca0f1e5c676

Net Zero Energy Building Overview

The project aims to show the economic and technological viability of drastically reducing the environmental impact of buildings in the Mediterranean Area. This includes the whole life cycle, of both construction and operation. The objective is to have a high standard of low-impact construction. The test building- a house, is the first prototype of the LIMA initiative.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

Designed to minimize heating and cooling loads: (relatively) compact design, high insulation levels, thermal mass (green roof), ventilated façade, and solar protections (Venetian blinds with automatic control).

Measured Energy Production and Consumption:

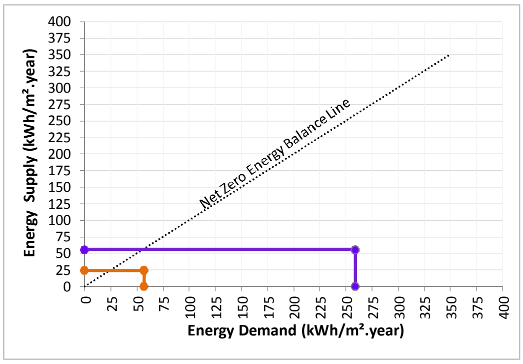
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 57
Primary: 130

Energy Supply (kWh/m².year)
Renewable Energy
Final: 24
Primary: 56

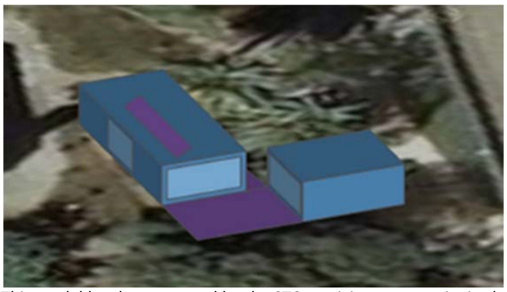
Source to Site Conversion Factor (Electricity): 2.28

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model



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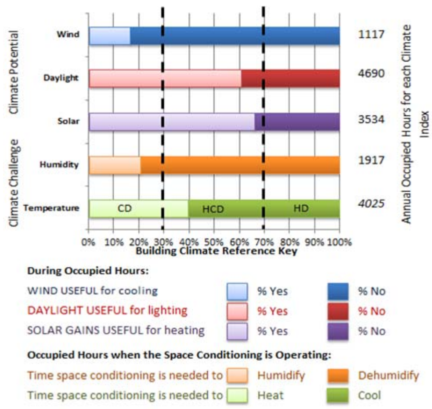

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H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.19

Solar Absorptivity

Horizontal timber cladding, ventilated cavity, semi-permeable polypropylene membrane, wood fibre insulation, cross laminated timber panels, cavity, plasterboard.

East

U-value (W/m² ºC) 0.19

Solar Absorptivity

Horizontal timber cladding, ventilated cavity, semi-permeable polypropylene membrane, wood fibre insulation, cross laminated timber panels, cavity, plasterboard.

Facing Polar Direction

U-value (W/m² ºC) 0.19

Solar Absorptivity

Horizontal timber cladding, ventilated cavity, semi-permeable polypropylene membrane, wood fibre insulation, cross laminated timber panels, cavity, plasterboard.

West

U-value (W/m² ºC) 0.19

Solar Absorptivity

Horizontal timber cladding, ventilated cavity, semi-permeable polypropylene membrane, wood fibre insulation, cross laminated timber panels, cavity, plasterboard.

Roofs

U-value (W/m² ºC) 0.17

Solar Absorptivity

Ground floor

U-value (W/m² ºC) 0.18

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 1.35

g-value 0.42

Frames Fustiland. Glazing Saint-Gobain Climalit Plus

East

U-value (W/m² ºC) 1.35

g-value 0.42

Frames Fustiland. Glazing Saint-Gobain Climalit Plus

Polar direction

U-value (W/m² ºC)

g-value

Frames Fustiland. Glazing Saint-Gobain Climalit Plus

West

U-value (W/m² ºC) 1.57

g-value 0.42

Frames Fustiland. Glazing Saint-Gobain Climalit Plus

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

Compactness (m-1)

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

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U-value (W/ºC)

Heat Flow %

Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

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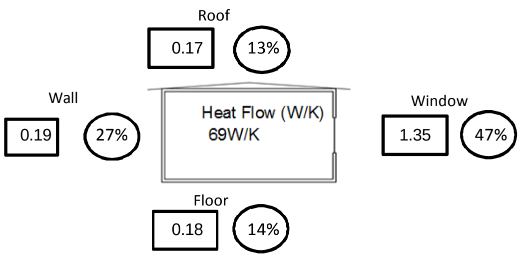


Heating

Heat Recovery

The current Spanish building code requires large amounts of fresh air. A heat recovery unit largely reduces the energy use for heating the ventilation air.

Cooling

Natural Ventilation

Ventilated façade - to reduce heat transfer through the wall in summer.

Green Roof/Façade

To increase the thermal inertia - reduce the peak load.

Sunshading

Automatically controlled Venetian blinds.

Daylight Systems

Daylight tube (espacio solar)

A light tube lets daylight into the bathroom, reducing the need to turn on the light in a windowless space.

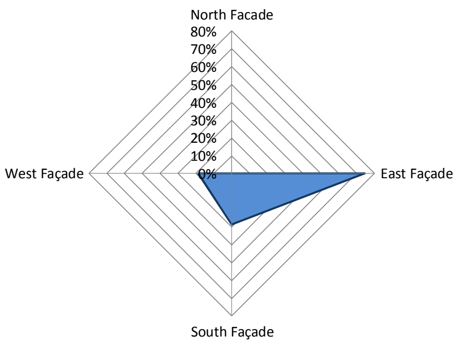
Window Distribution Information

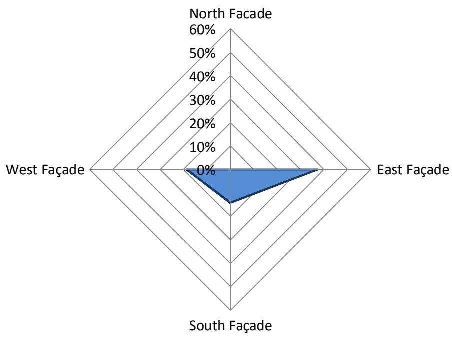
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.

Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
 H, C, L,						 C,		 AIR C,	

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances
High efficiency appliances

Energy Storage

Tubes

HVAC Systems
Heat recovery, radiant ceiling

Artificial Lighting
High efficiency lighting

Computer Management

Control of Systems
For blinds, lighting, and HVAC

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) : 3

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	Yes
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	Yes
Air distribution	Yes

Description
Heat pump and radiant panels.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	Yes

Description
Heat pump and radiant panels.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	No
Local Air Recirc plus Central Fresh Air	Yes

Description
Mitsubishi LOSSNAY 3kW

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	Heat pump

Description
The solar thermal production basically covers the monthly DHW demand

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting
Manual

HVAC
Scheduled room air temperature setpoints

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,				H, C			H,	C,	H, C,	

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Funding
Source and Type of Funding
Private. It is a research project funded by the companies within the LIMA association

Principal Actors
The Architect firm (SaAS) leads the project both in terms of workforce and funding

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	No
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	30º
Azimuth	0
Technology	Polycrystalline
Nominal Power (kWp)	1
Area (m²)	
Yield (kWh/m².year)	
Expected generation (kWh)	1100
Measured generation (kWh)	

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Flat plate collectors
Position	On the roof
Area (m²)	4
Production (kWh/m².year)	49
Annual % of Hot Water	100

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

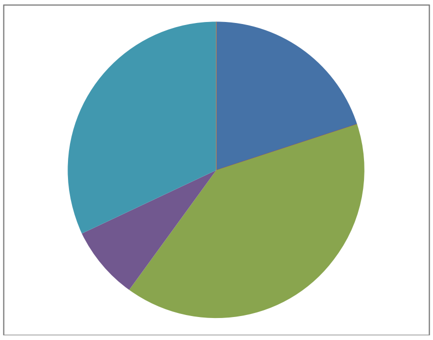
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Heat Pump
Technology	
Power	
Efficiency (%)	140
Production (kWh/m².yr)	9.80
Annual % of Heating - (Produced by renewables)	28% (2.8 kWh/m².year heat from the ground)

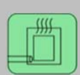
Cooling Equipment

	Heat Pump
Technology	
Power	
Efficiency (%)	140
Production (kWh/m².year)	39
Annual % of Cooling - (Produced by renewables)	101% (39.5 kWh/m².year cool from the ground)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,	 E,				 H, C,	 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

International Energy Agency

RESIDENTIAL NET ZEBs

Heating dominated climate

Plus Energy Houses Weiz
Austria
Arch. : Arch. ° Buero Kaltenneger

Ecoterra
Canada
Arch. : Masa Noguchi

Riverdale
Canada
Arch. : Habitat Studio & Workshop Ltd

Solarsiedlung am Schlierberg
Germany
Arch. : Rolf Disch SolarArchitektur, Freiburg

Kleehauser
Germany
Arch. : Common & Gies Architekten, Freiburg

Riehen
Switzerland
Arch. : Setz Archtektur

Plus Energy Houses Weiz

Net Zero Energy Building Overview

On average this passive house community with its twenty-two row houses creates surplus energy. Its photovoltaic systems produce more energy than is required to operate the decentralised heat-pumps and other electric loads in these all-electric buildings.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2006

Location
Weiz
Styria
Austria

Latitude	Longitude
North	West
47°21'67" N	15°61'7"

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
855.9

Conditioned Floor Area (m²)
855,90

Occupancy (m² per Person)
33.3

Number of Storeys

Cost US$/(Net) m² Floor Area

1.420€/m2 Net Floor Area

Cost US$/(Net) m² typical similar building

1.200€/m2 - 1.600€/m2 Net Floor Area

Web Address
www.tanno.at

For more information:
http://tinyurl.com/Plus-Energy-House

Architectural Design Concept

Each of the six house rows consists of three, four, or five connected row houses with two different floor plans (93m2 or 105m2). The rows are not strictly orientated towards the south. Instead the architecture is integrated into the landscape in order to create a desired state of harmony between both. The southern orientation of the individual rows varies by 12° to 34°.

Measured Energy Production and Consumption:

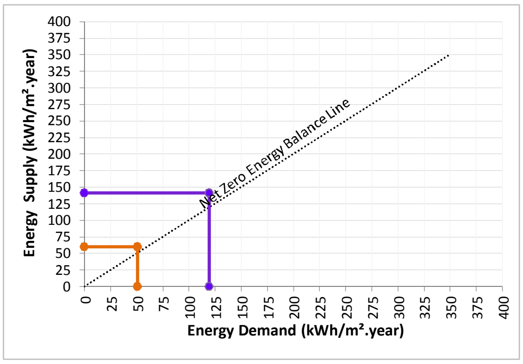
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 51
Primary: 120

Energy Supply (kWh/m².year)
Renewable Energy
Final: 60
Primary: 142

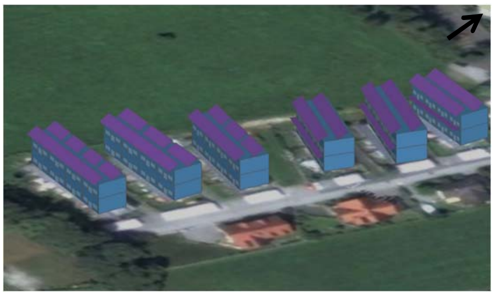
Source to Site Conversion Factor (Electricity): 2.35

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model

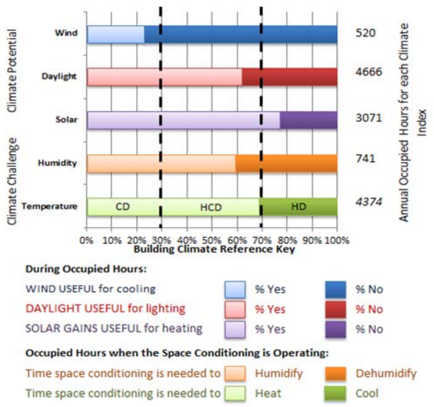


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating* ***P*** *- Plug Loads*
C *- Cooling* ***E*** *- Electricity*
L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

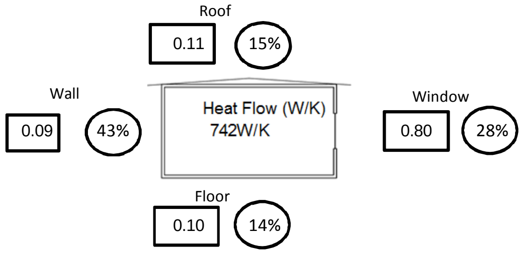
U-value (W/ºC)

Heat Flow %

Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*



Heating

Heat Recovery

Decentralized Ventilation System with heat recovery

Passive Solar Heat Gain

Passive Solar Heat Gain through South Facades

Heating from air-to-air heat pump

Heating demand covered by the ventilation system and an air-to-air heat pump

Cooling

Sunshading

Shading of the south facade - Brise Soleil Metal Construction

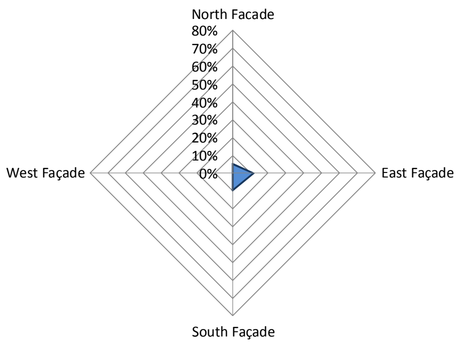
Daylight Systems

none (adequate Window Area)

Window Distribution Information

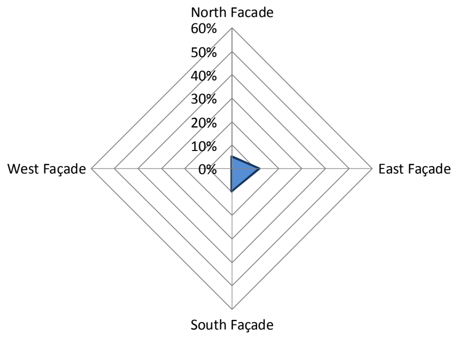
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
H, C, L,	H,	H, C,		H,	H, C,	C,			C,

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.09

Solar Absorptivity

Plasterboard(1.25 cm); OSB slab(1.6 cm); Cellulose(35.0 cm);Wood fibre board (1.6 cm);Ventilated wood façade (5.0 cm); Windows: Triple Glazed

East

U-value (W/m² ºC) 0.09

Solar Absorptivity

Plasterboard(1.25 cm); OSB slab(1.6 cm); Cellulose(35.0 cm);Wood fibre board (1.6 cm);Ventilated wood façade (5.0 cm); Windows: Triple Glazed

Facing Polar Direction

U-value (W/m² ºC) 0.09

Solar Absorptivity

Plasterboard(1.25 cm); OSB slab(1.6 cm); Cellulose(35.0 cm);Wood fibre board (1.6 cm);Ventilated wood façade (5.0 cm); Windows: Triple Glazed

West

U-value (W/m² ºC) 0.09

Solar Absorptivity

Plasterboard(1.25 cm); OSB slab(1.6 cm); Cellulose(35.0 cm);Wood fibre board (1.6 cm);Ventilated wood façade (5.0 cm); Windows: Triple Glazed

Roofs

U-value (W/m² ºC) 0.11

Solar Absorptivity

The flat roof is insulated with 30 cm of expanded polystyrene (EPS).

Ground floor

U-value (W/m² ºC) 0.10

Floor Construction, 30cm Concrete insulated with rigid foam boards.

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.80

g-value 0.55

East

U-value (W/m² ºC)

g-value -

Polar direction

U-value (W/m² ºC) 0.80

g-value 0.55

West

U-value (W/m² ºC) 0.80

g-value 0.55

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.37-0.50/h at 50 Pa mea:

Compactness (m-1)

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
0.5/h

Appliances / Plug Loads
Power Density Installed (W/m²) : 18

Artificial Lighting
Power Density Installed (W/m²) : Depending on inhabitant - no special measures.

Computer Network
Power Density Installed (W/m²) : Housing
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	Yes

Description
No cooling plant

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	Yes

Description
Heating Demand covered by the ventilation system and an air-to air heat pump. 185 litre Hot Water tank integrated into the ventilation system, supplementary heating coil 1.05kW to cover peak loads.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description
85% heat recovery efficiency Ventilation system Inc. DHW (Air-to-air- heat pump) COMBI 185 EC (GENVEX) Earth source heat exchanger for pre-warming supply air, laying depth ~ 1.60 m

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	

Description
185 litre Hot Water tank integrated into the ventilation system driven by air-to air heat pump, supplementary heating coil 1.05kW to cover peak loads.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	Yes
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description
Depending on inhabitant - no special measures.

Innovative Technologies
The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage
185 litre Hot Water tank integrated into the ventilation system, supplementary heating coil 1.05kW to cover peak loads

Other
Extremely well insulated, airtight building envelope (0.37-0.50h at 50 Pa). As well as decentralized ventilation system with heat recovery and extremely compact size.

HVAC Systems
Air to Air Heat Pump, Earth tube heat exchanger, combination of domestic hot water heat pump and ventilation system as heat source

Artificial Lighting

Computer Management

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,			kWh P,	AIR H,					HP H,	

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Funding

Source and Type of Funding

Funding for Photovoltaic - OEM-AG

Principal Actors

Architect (Arch. Kaltenegger) and Investor (Siedlungsgenossenschaft Elin)

Authors

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Photovoltaic roof
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	25
Azimuth	16-34°
Technology	Polycrystalline
Nominal Power (kWp)	5 kWp x p houses
Area (m²)	40m2 x 9 houses = 360m^2
Yield (kWh/m².year)	53,80Wp/m^2
Expected generation (kWh)	
Measured generation (kWh)	54572

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal
Technology
Position
Area (m²)
Production (kWh/m².year)
Annual % of Hot Water

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

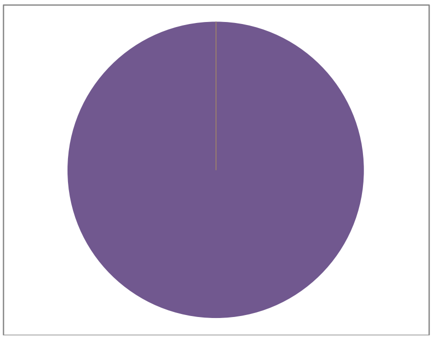
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Heat Pump
Technology	Air to air heat pump
Power	Driven by PV on roof
Efficiency (%)	
Production (kWh/m².yr)	
Annual % of Heating - (Produced by renewables)	100% yearly balance

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	E,				H, C,	I,		

References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

ÉcoTerra Home

Net Zero Energy Building Overview

The EcoTerra house is a prefabricated detached house built in a wooded area in Eastman, Quebec. The house aims at fulfilling the objectives of the EQuilibrium initiative led by Canada's Housing and Mortgage Corporation (CMHC): to provide a healthy, affordable and comfortable living space, while reaching the goal of annual net-zero energy consumption.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
Winter 2008

Location
9, de la Héronnière
Eastman
Quebec
Canada

Latitude	Longitude
North	West
45.3 N	72.3 W

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating Dominated

Building Type
Residential

Site Context
Open Site

Net Floor Area (m²)
230

Conditioned Floor Area (m²)
230

Occupancy (m² per Person)
100.0

Number of Storeys

Cost US$/(Net) m² Floor Area
1,500

Cost US$/(Net)m² typical similar building

1,000

Web Address (publicly available info)
http://www.cmhc-schl.gc.ca

For more information:

Architectural Design Concept

The house is oriented due South. The footprint is roughly a rectangle with an aspect ratio of about 1.4. The South façade of the house is longer to receive more direct solar radiation. A family room with large glazing area is located in the south portion of the ground floor. It is the main direct gain zone for passive solar heating. A skylight window with an area of about 1 square meter located above the stairways brings in daylight for the kitchen and dining area. All rooms are equipped with windows except the north portion of the basement, where the mechanical room is located. Large south facing windows and open space architectural layout help improve daylight distribution. The length of the overhangs on the South facade was optimised to block most of the direct solar radiation in the summer, but to allow the window to be fully exposed to direct solar radiation in the winter. All the windows are operable. This enables cross ventilation for passive cooling.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

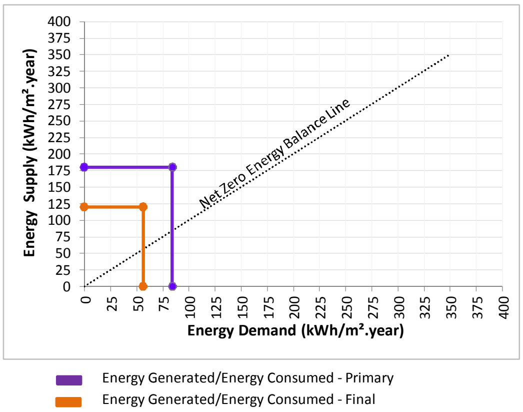
Electricity		**Natural Gas**
Final:	56	
Primary:	84	

Energy Supply (kWh/m².year)
Renewable Energy

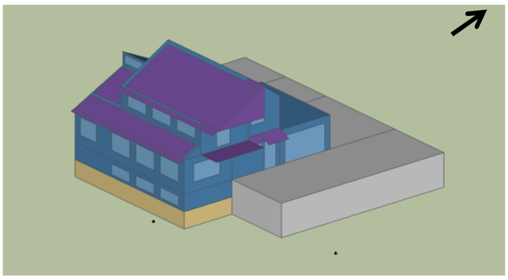
Final:	120
Primary:	180

Source to Site Conversion Factor (Electricity): 1.5

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



EnergyPlus Model

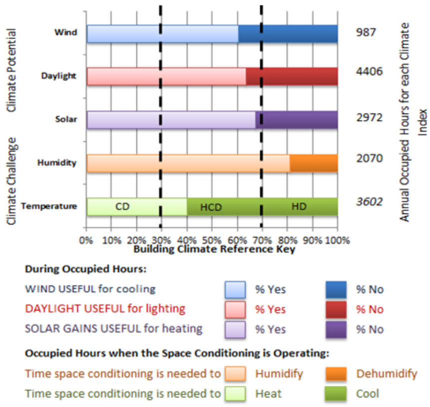


This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating*
C *- Cooling*
L *- Lighting*
DHW *- Domestic Hot Water*
P *- Plug Loads*
E *- Electricity*
I *- Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
 L,	 C,		

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.30

Wood siding, BASF Walltite, Neopor and Enertite insulation

East

U- 0.16

Solar Absorptivity 0.30

Wood siding, BASF Walltite, Neopor and Enertite insulation

Facing Polar Direction

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.30

Wood siding, BASF Walltite, Neopor and Enertite insulation

West

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.30

Wood siding, BASF Walltite, Neopor and Enertite insulation

Roofs

U-value (W/m² ºC) 0.16

Solar Absorptivity 0.20

Cathedral ceiling and attic type of roof

Ground floor

U-value (W/m² ºC) 0.68

Floor is below-grade

Windows - Construction Elements

Solar Noon

U-value (W/m² ºC) 1.18

g-value 0.53

Argon-filled, triple-glazed, low-e coating

East

U-value (W/m² ºC) 1.18

g-value 0.53

Argon-filled, triple-glazed, low-e coating

Polar Direction

U-value (W/m² ºC) 1.18

g-value 0.53

Argon-filled, triple-glazed, low-e coating

West

U-value (W/m² ºC) 1.18

g-value 0.53

Argon-filled, triple-glazed, low-e coating

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

1.611

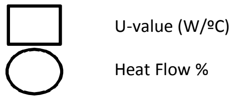
Compactness (m-1)

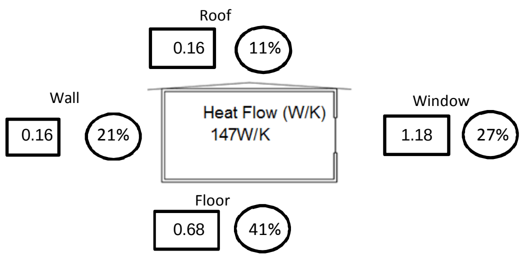
Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.





Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Thermal Mass

A concrete floor and half-wall in the south facing zone store solar energy passively.

Thermal Mass

The hollow-core concrete slab of the basement is actively charged with the thermal energy coming from the BIPV/T roof, but discharges its energy passively.

Heat Recovery

There is a drain water heat recovery system to recover heat from the shower water.

Cooling

Sunshading

There are overhangs over the south facing windows that block most of the direct solar radiation in the summer season.

Natural Ventilation

Passive cooling is promoted with all the windows being operable to allow cross ventilation.

Daylight Systems

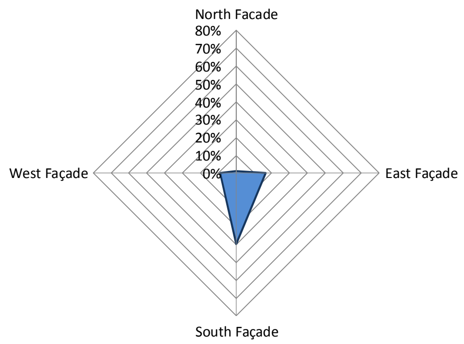
Skylight and south-facing windows

A skylight window located above the stairways brings in daylight for the kitchen and dining area. All rooms are equipped with windows except the North portion of the basement where the mechanical room is located. Large South facing windows and open space architectural layout help to improve daylight distribution.

Window Distribution Information

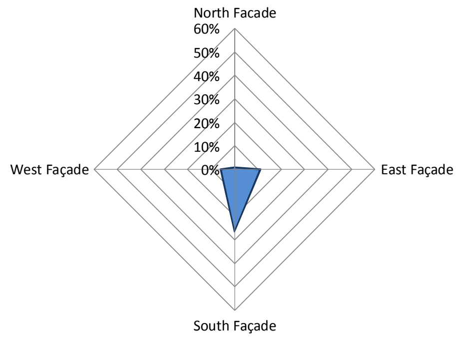
Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.

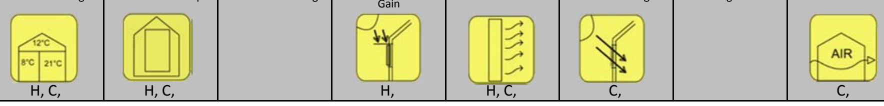


Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.



Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
	H, C,	H, C,		H,	H, C,	C,		C,	



Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)
13

Appliances / Plug Loads
Power Density Installed (W/m²) :

Artificial Lighting
Power Density Installed (W/m²) :

Computer Network
Power Density Installed (W/m²) :
Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	Yes
Hydronic distribution	No
Air distribution	Yes

Description
Cooling is achieved with a geothermal heat pump and pre-cooling of the hollow-core slab in the basement. There is also automatic control of the awnings.

Heating

Central Plant	No
Distributed Plant	No
Hydronic distribution	No
Air distribution	Yes

Description
Heating is provided by the BIPV/T roof and a geothermal heat pump with back-up electrical element. The BIPV/T roof is coupled with a hollow-core ventilated concrete slab in the basement for space heating, an air-to-water heat exchanger for DHW and the clothes dryer.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description
The house has a heat recovery ventilator (HRV).

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	Yes
Gas?	Yes
Electrical?	No
Other? (Less than 200 words:)	No

Description
DHW is supplied by the BIPV/T roof (through an air-to-water heat exchanger), the heat pump desuperheater, a drain water heat recovery unit and back-up electricity.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC
The user interface is located a the entrance. The heating/cooling schedules and setpoints can be adjusted by the user.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions
User Manual Provided? No

Description
There is a user interface in the house to indicate weather and the PV system energy production.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Most plug loads and appliances are energy-efficient.

Energy Storage
The basement hollow-core slab stores the heat from the BIPV/T roof preheated air (heating season) and the coolness from the night outdoor air (cooling season). Concrete floor and half-wall in the south facing zone ensure passive storage of solar gains.

BIPV/T Roof
The BIPV/T roof consists of amorphous silicon PV laminates directly attached to a metal roof, with air passing under the metal to recover heat. This heat is used for both space or water heating.

HVAC Systems
Space heating is provided by geothermal heat pump and a BIPV/T roof. This BIPV/T system is coupled with a hollow-core ventilated concrete slab located in the basement and an air-to-water heat exchanger to provide domestic hot water.

Artificial Lighting

Computer Management

Control of Systems
A commercial system based on the BACNet protocol is used to manage the BIPV/T collector, exterior motorized awnings and heat pump.

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,			P,	H,	DHW,					

Design Team

Engineer Civil

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Web Address
www.bcee/index.php/Dr._A._Athienitis.html

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Email

Web Address

Engineer Structural

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Address

Email

Web Address

Architect

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Web Address

Builder/Contractor

Name
Maison Alouette

Address

Email

Web Address
http://www.maisonalouette.com

Funding

Source and Type of Funding
The house was built by Alouette Homes with support from the Canadian Solar Buildings Research Network, Canada's Mortgage and Housing Corporation (CMHC), Natural Resources Canada (NRCan), Hydro-Quebec and Regular.

Principal Actors
This house was developed by Alouette Homes and a Concordia University team as part of Canada's Mortgage and Housing Corporation (CMHC) EQuilibrium initiative.

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Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Yes
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	30
Azimuth	0
Technology	Amorphous silicone
Nominal Power (kWp)	3
Area (m²)	45
Yield (kWh/m².year)	11
Expected generation (kWh)	3465
Measured generation (kWh)	2570

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Heat recovery from BIPV
Position	30 deg Tilt, 0 deg azimuth
Area (m²)	45
Production (kWh/m².year)	
Annual % of Hot Water	

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

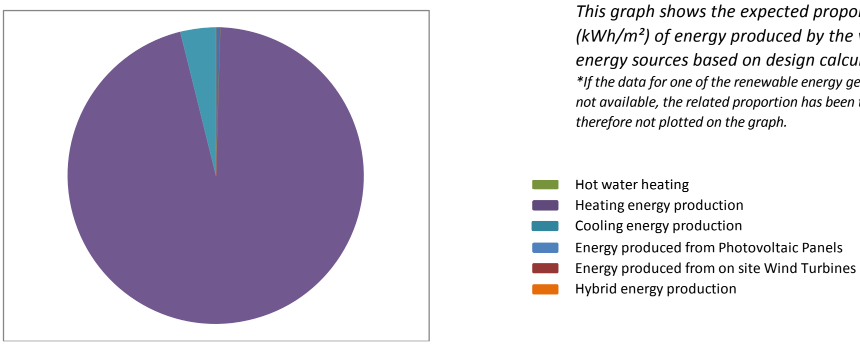
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

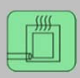
	BIPV/T air	Ground / Water Source Heat Pump
Technology		Two-stage
Power		10.5 kW
Efficiency (%)		COP of 4.2 at full load
Production (kWh/m².yr)	329	2530
Annual % of Heating - (Produced by renewables)		

Cooling Equipment - Final En

	Heat Pump
Technology	Ground-source, two-stage
Power	
Efficiency (%)	ER of 19.8 at full load
Production (kWh/m².year)	115
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 H, DHW, E,	 E,				 H, C,	 I,		

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Riverdale

Net Zero Energy Building Overview

Net-zero demonstration house. A double family building with high insulation levels, active solar thermal heating system, and a building-integrated photovoltaic array electricity sources.

Completion Date
Operational

Location
9924 - 87 Street
Edmonton
Alberta
Canada

Latitude	Longitude
North	West
53.34	113.31

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating Dominated

Building Type
Residential

Site Context
Open Site

Net Floor Area (m²)
234

Conditioned Floor Area (m²)
234

Occupancy (m^2 per Person)
0.0

Number of Storeys

Cost US$/(Net) m² Floor Area

2,282
Cost US$/(Net)m² typical similar building

Web Address

For more information:
http://tinyurl.com/Riverdale-CA

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

The goal of the Riverdale NetZero Project is to prove that it is possible to build housing that offers an exceptional quality of life for the homeowners while also dramatically reducing greenhouse gas emissions, energy consumption and the overall impact on the environment.

The duplex uses an electricity producing photovoltaic array, a solar hot water heating system, and passive solar gains to produce as much renewable energy as it needs to heat, light and operate each of the homes. The units are very well insulated with R-values at least double the building code minimums. The building envelope is also very tightly air sealed, allowing the project to achieve very low air leakages in the range of 0.5 air changes per hour at 50 Pascals.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

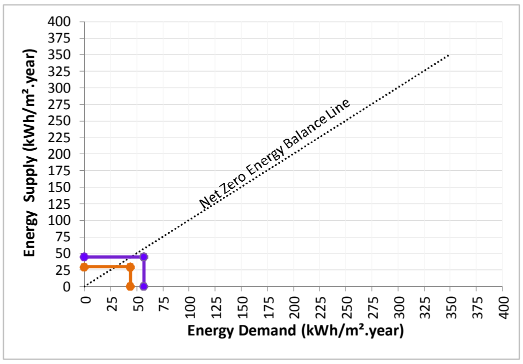
Energy Demand (kWh/m².year)

	Electricity	**Other**
Final:	25	19
Primary:	38	19

Energy Supply (kWh/m².year)
Renewable Energy
Final: 30
Primary: 44

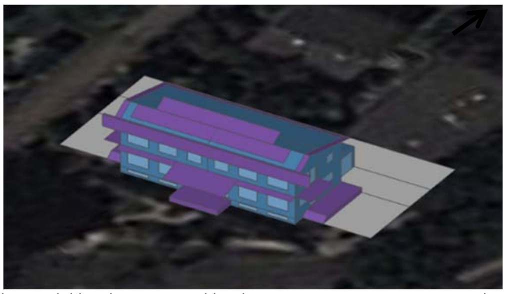
Source to Site Conversion Factor (Electricity): 1.5

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model



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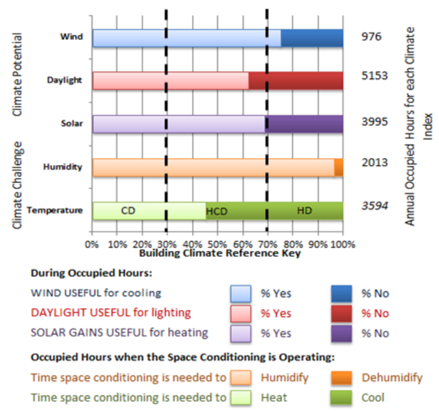

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L *- Lighting* ***I*** *- Integration*
DHW *- Domestic Hot Water*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.10

Solar Absorptivity

Exterior cladding, spun-bonded building sheathing wrap, 10mm strand board sheathing, 406 mm cellulose fibre 150 micrometers of polyethylene vapour barrier, 12mm drywall finish

East

U-value (W/m² ºC)

Solar Absorptivity

Facing Polar Direction

U-value (W/m² ºC)

Solar Absorptivity

West

U-value (W/m² ºC)

Solar Absorptivity

Roofs

U-value (W/m² ºC)

Solar Absorptivity

Ground floor

U-value (W/m² ºC)

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.56

g-value

Quadruple-glazed with three soft, low-e coatings and argon gas in the spaces between the glass.

East

U-value (W/m² ºC) 0.71

g-value

Triple-glazed with two soft, low-e coatings and argon gas in the spaces between the glass.

Polar direction

U-value (W/m² ºC) 0.83

g-value

Triple-glazed with two soft, low-e coatings and argon gas in the spaces between the glass.

West

U-value (W/m² ºC) 0.71

g-value

Triple-glazed with two soft, low-e coatings and argon gas in the spaces between the glass.

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.5 ACH @ 50

Compactness (m-1)

Passive Approaches:

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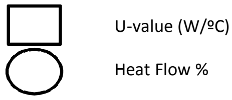

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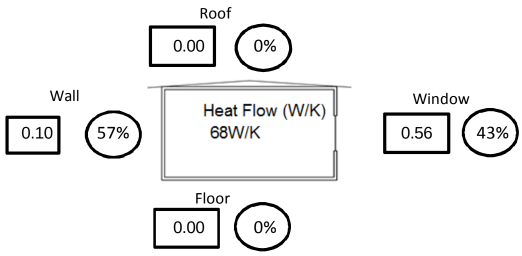


Heating

Heat Recovery

Heated water is circulated from the large storage tank to a fan coil for distribution to the house via the forced-air heat distribution system.

Trombe Wall

To minimize the space-heating load, the building has an airtight, highly insulated thermal envelope. The 410 mm deep wall system is designed to reduce the heat loss by about 70 per cent from a typical 140 mm wall. The windows are exceptionally energy efficient.

Thermal Mass

Large masonry wall was installed on main and basement floor levels. Concrete decorative feature was added to the living room.

Cooling

Natural Ventilation

Green Roof/Façade

Ground Cooling

Daylight Systems

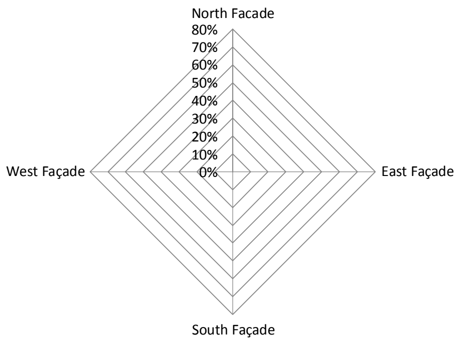
Natural sunlight through various windows, with passive solar gains.

Main living spaces are adjacent to larger windows. House plan is elongated east and west. No part of floor is more than 8m from a window. Most living spaces receive light from two sides, reducing glare

Window Distribution Information

Distribution of Window Areas per Façade

In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

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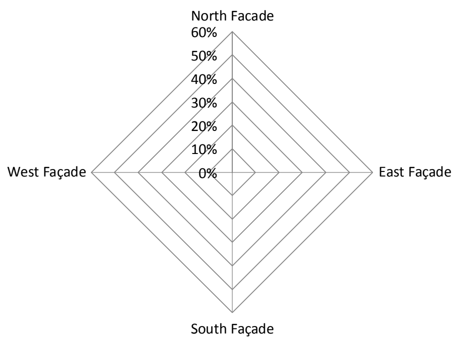

Optimised Floor Plan	Thermal Zoning	Advanced Envelope	Advanced Glazing	Passive Solar Heat Gain	Thermal Mass	Solar Shading	Site Vegetation	Natural Ventilation	Ground Cooling
 H, C,			 H, C,		 H, C,	 C,			

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Energy Storage

Other

HVAC Systems

Approximately 40% of heating will be provided by passive solar gain, 28 per cent by internal sources, 21 per cent by active solar, and 11 per cent by solar photovoltaics. A water-based, drain back, active solar thermal heating system is the main heat source

Artificial Lighting

Computer Management

Control of Systems

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

8

Appliances / Plug Loads

Power Density Installed (W/m²) : 14

Artificial Lighting

Power Density Installed (W/m²) : 3

Computer Network

Power Density Installed (W/m²) :

Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	Unknown
Hydronic distribution	Yes
Air distribution	No

Description

Overhangs above windows reduce summer solar heat gains. Operable windows placed to take advantage of natural cross ventilation. When this is not sufficient, cold water is supplied to fan coil.

Heating

Central Plant	No
Distributed Plant	No
Hydronic distribution	Yes
Air distribution	No

Description

Solar heating. To minimize the space-heating load, the building has an airtight, highly insulated thermal envelope. Windows have multiple glazing, argon gas filled, and have multiple soft, low-e coatings.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	No
Local Air Recirc plus Central Fresh Air	Unknown

Description

The home incorporates fully ducted mechanical ventilation with a heat recovery ventilator as the energy saving heart of it. Incoming fresh air from the
HRV is ducted to each room in quantities prescribed by the Canadian Standards Association (CSA) Standard F326.

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	Yes
Gas?	Yes
Electrical?	No
Other? (Less than 200 words:)	Grey water

Description

A grey water heat recovery device will be installed on the main grey water lines. The performance of these devices is difficult to model and will vary with occupant behaviour.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

Normal light switches are used for lighting control.

HVAC

A programmable logic controller is used to control the solar thermal space heating system. A normal thermostat is used to control the PLC. A humidistat is used to control the HRV.

Energy Storage

Latent Storage?	Yes
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided? Unknown

Description

HVAC is controlled via standard thermostat, standard HRV humidistat, normal on/off light switches. Advanced PLC control for solar thermal system.

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,				H,	H,					

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Funding
Source and Type of Funding
Normal house construction financing. Community, Sponsors, CMHC-EQuillibruim.

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	
Ground mounted	
Roof mounted	28 solar PV modules
Position	
Tilt (angle)	53
Azimuth	22 degrees east of South
Technology	Sanyo
Nominal Power (kW rated)	6
Area (m²)	33
Yield (kWh/m².year)	27
Expected generation (kWh)	6224
Measured generation (kWh)	6652

Wind Turbine

Position	
Number of Turbine	
Technology	
Nominal Power (kWp)	
Energy Production (kWh/m².year)	

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes (solar collectors)
Technology	Solar thermal drain back
Position	
Area (m²)	19
Production (kWh/m².year)	8
Annual % of Hot Water	83

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

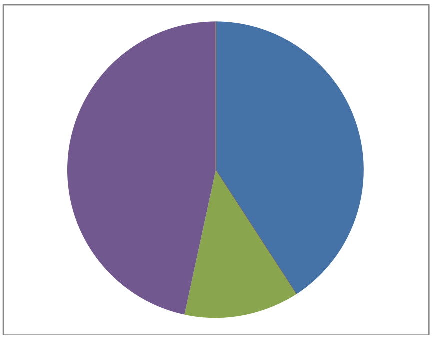
Renewable Production of Heating and Cooling

Heating Equipment - Final Energy

	Active Solar Thermal Heating System	Passive Solar Gain
Technology	-Water-based, drain back (space and Water	
Power		7kW
Efficiency (%)		
Production (kWh/m².yr)	28.25	2.14
Annual % of Heating - (Produced by renewables)	21	

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 H,	 E,					 I,		

References
American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.
Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Solarsiedlung am Schlierberg

Net Zero Energy Building Overview

The Plus-Energy Settlement exemplifies the use of regenerative energy and provides its inhabitants with the social benefits of a housing community offering a high, ecologically conscious standard. Natural resources are a primary consideration in the overall construction concept, the choice of materials, and the water and energy systems.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2006

Location
Elly Heuss Knapp Str.
79100 Freiburg
Baden Wüthemberg
Germany

Latitude	Longitude
North	West
47°58'29.73"N	7°49'46.88"E

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Village, Urban Edge - 2-5 storey buildings with at most narrow lanes between adjacent buildings and street widths of 20 - 40m

Net Floor Area (m²)
7890

Conditioned Floor Area (m²)
7890

Occupancy (m² per Person)
46.4

Number of Storeys

Cost US$/(Net) m² Floor Area
1,940

Cost US$/(Net) m² typical similar building

Web Address
www.solarsiedlung.de

For more information:
http://tinyurl.com/Plus-Energy-Settlement-DE

Architectural Design Concept

The fundamental principle of the planning concept was to maximize active and passive utilization of solar energy. The open spaces between the rows of houses, their height, and roof shapes contributed to creating shade-free southern elevations in winter, while aiming at maximising the floor space index of the very expensive properties as part of economic concerns. The result was the characteristic image of the community with its densely arranged row houses and asymmetrical pitched roof structures with clear southern orientation. The layouts follow classic solar house design concepts: living areas are on the southern side, hallways in the centre, and service areas, including kitchen, bathroom, and utilities are in the north. Due to their row house design, building volumes are very compact. Since there are no basements, exterior sheds offer storage space.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)

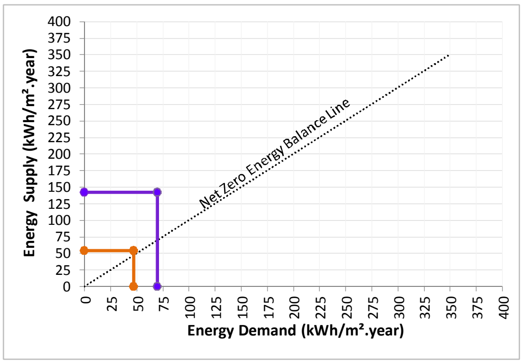
	Electricity	Others
Final:	21	26
Primary:	54	16

Energy Supply (kWh/m².year)
Renewable Energy

Final:	55
Primary:	142

Source to Site Conversion Factor (Electricity): 2.6

In the graph ***Final Energy Demand*** *is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers.* ***Final Energy Supply*** *is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

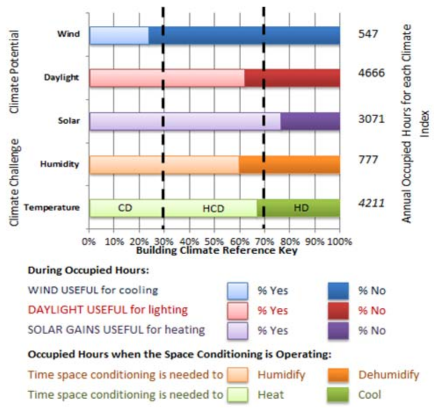
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

H *- Heating*	***P*** *- Plug Loads*
C - *Cooling*	***E -*** *Electricity*
L *- Lighting*	***I -*** *Integration*
DHW - *Domestic Hot Water*	

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
L,			

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

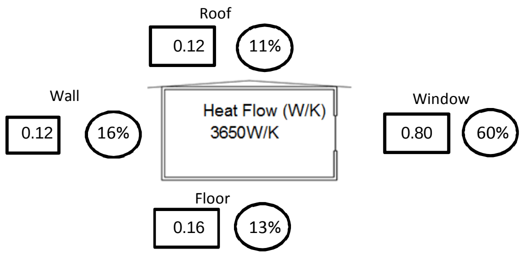
U-value (W/ºC)

Heat Flow %

Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*



Heating

Heat Recovery

Decentralise ventilation system with heat recovery (65%).

Cooling

Sunshading

Static exterior sunshading by roof overhangs (up to 2.70m).

Solar heat gain

Maximising passive solar energy gains via the envelope, form, and orientation of the building (large windows), small window areas facing south.

Natural Ventilation

Possible but not necessary.

Daylight Systems

Windows

No daylight "system" is used but the windows to the main rooms are very large and offer good natural light.

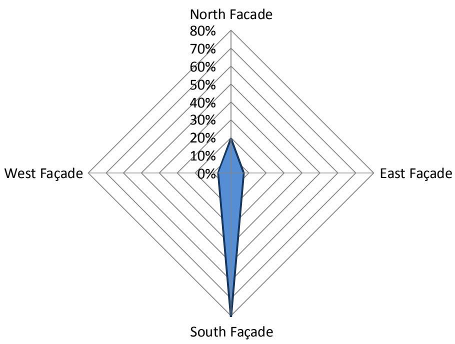
Window Distribution Information

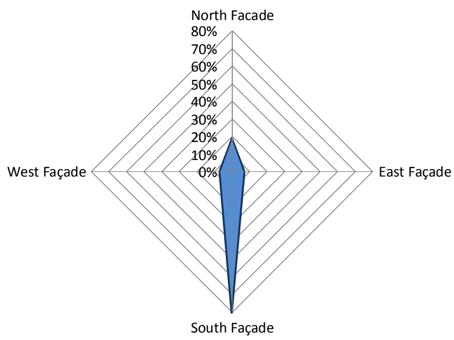
Distribution of Window Areas per Façade

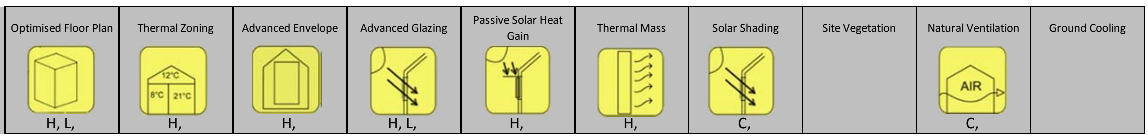
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.

Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.







Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.12

Solar Absorptivity

Exterior walls are comprised of prefabricated, slender wood I-joists as studs and insulated with 30 cm of mineral insulation.

East

U-value (W/m² ºC) 0.12

Solar Absorptivity

Exterior walls are comprised of prefabricated, slender wood I-joists as studs and insulated with 30 cm of mineral insulation.

Facing Polar Direction

U-value (W/m² ºC) 0.12

Solar Absorptivity

Exterior walls are comprised of prefabricated, slender wood I-joists as studs and insulated with 30 cm of mineral insulation.

West

U-value (W/m² ºC) 0.12

Solar Absorptivity

Exterior walls are comprised of prefabricated, slender wood I-joists as studs and insulated with 30 cm of mineral insulation.

Roofs

U-value (W/m² ºC) 0.12

Solar Absorptivity

Prefabricated wood beam roof construction in filled with 36 cm of mineral wool insulation.

Ground floor

U-value (W/m² ºC) 0.16

30 cm polystyrol insulation above 30 cm concrete floor slab.

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.80

g-value 0.48

Triple-glazed windows with insulated wood frames

East

U-value (W/m² ºC) 0.80

g-value 0.48

Triple-glazed windows with insulated wood frames.

Polar direction

U-value (W/m² ºC) 0.80

g-value 0.48

Triple-glazed windows with insulated wood frames.

West

U-value (W/m² ºC) 0.80

g-value 0.48

Triple-glazed windows with insulated wood frames.

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.4

Compactness (m-1)

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Indoor air changed 1/2 per hour

Appliances / Plug Loads

Power Density Installed (W/m²) :	Very efficient appliances

Artificial Lighting

Power Density Installed (W/m²) :	Not documented

Computer Network

Power Density Installed (W/m²) :	Not documented
Datacentre ?	No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	Yes
Ceiling Fans	No
Hydronic distribution	No
Air distribution	Yes

Description

Heating

Central Plant	No
Distributed Plant	Yes
Hydronic distribution	No
Air distribution	No

Description

A district heating grid supplies heat for space heating and hot water. This grid is fed by a combined heat and power plant fired by wood chips and natural gas, located in the adjacent city district. Transfer stations in each building supply heating circuits and decentralized hot water storage tanks. Thus, the need for continuously operating the district heating grid in summer is avoided and corresponding losses are reduced. There are no solar thermal collectors.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	No
Local Air Recirc plus Central Fresh Air	No

Description

Decentralised, compact ventilation systems with integrated heat recovery are used. No air ducts are required but compromises have been made in terms of energy efficiency. The installed ventilation systems both vent exhaust air and provide fresh air by reversing the fan direction. Air passes through a heat sink, which is less efficient than a central system with a cross-flow heat exchanger. The decentralise ventilation systems are interconnected in each row house and operate in push-pull mode.

DHW - Domestic Hot Water

Solar?	No
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	See heating system

Description

See heating system

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Heat is not let through the district heating grid continuously in warmer times in order to reduce heat losses. For this, the heat storage is loaded discontinuously two to three times a day. This is controlled centrally in the heating centre

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided?	Yes

Description

No control system

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Not possible because the single row houses are rented and sold.

Energy Storage

Decentralise storage tanks coupled with local heating grid.

Other

HVAC Systems

CHP in heating grid

Artificial Lighting

Computer Management

not necessary because of Typology

Control of Systems

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,			H, P, E,	H,						

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Web Address
www.rolfdisch.de

Funding

Source and Type of Funding
Privately funded. Several "solar funds" were established. The purpose of this financing concept was to facilitate roof-mount solar units throughout the development, even if the buyers of some houses couldn't cover the cost.

Principal Actors
Architect as planner and developer

Authors
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emusall@uni-wuppertal.de

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	Yes
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	22°
Azimuth	0°
Technology	Multi-crystalline cells
Nominal Power (kWp)	404
Area (m²)	3205 m²
Yield (kWh/m².year)	55
Expected generation (kWh)	404000
Measured generation (kWh)	431031

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water

Solar Thermal
Technology
Position
Area (m²)
Production (kWh/m².year)
Annual % of Hot Water

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power - Final Energy

Type	See heating system
Fuel	Natural gas / wood chips
Efficiency (%)	0.9
Electricity	Yes
Water Heating	Yes
Space Heating	Yes
Cooling	No
Production (kWh/m².year)	
Electricity	
Water Heating	
Space Heating	
Cooling	

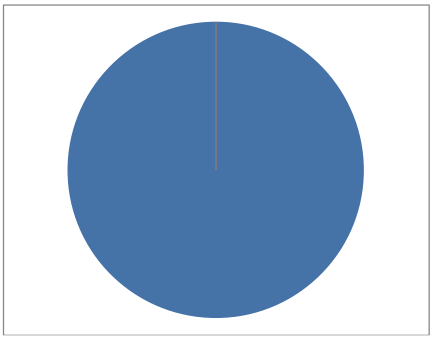
Renewable Production of Heating and Cooling

Heating Equipment

	Biomass CHP
Technology	Coupled to heating grid which is based on biomass CHP
Power	
Efficiency (%)	
Production (kWh/m².yr)	
Annual % of Heating - (Produced by renewables)	

Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
	 E,					 I,		

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Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Kleehäuser

Net Zero Energy Building Overview

Passive house with very low heat demand following the idea of the 2000 Watt society. Intensive use of different renewables energy sources have been used, as well as using a combined heat and power system.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Completion Date
2006

Location
Paul-Klee Str. 6
79100 Freiburg
Baden-Württemberg
Germany

Latitude	Longitude
North	West
47°58'36.47"	7°49'18.93"

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
2520

Conditioned Floor Area (m²)
2520

Occupancy (m² per Person)
33.6

Number of Storeys

Cost US$/(Net) m² Floor Area
1,923

Cost US$/(Net) m² typical similar building

Web Address
www.kleehaeuser.de

For more information:
http://tinyurl.com/Kleehauser

Architectural Design Concept

The two buildings have a compact structure to lower the volume requiring to be heated. To save space the stairs are outside (access via balconies). All walls are well insulated and the windows are triple glazed. The passive solar design is supported by an asymmetric arrangement of the windows. Extensively glazed South-facing facades optimise passive solar energy gains in winter. Cantilevered balconies orientated towards the South and extending up to two metres provide shade and prevent overheating in the summer. There are fewer windows on the remaining facades. The layout follows the same principle: Living spaces are generally orientated towards the South and other areas are on the Northern side of the building.

Measured Energy Production and Consumption:

These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

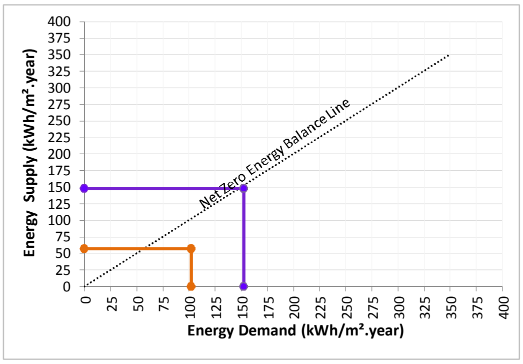
Energy Demand (kWh/m².year)

	Electricity	Natural Gas
Final:	27	75
Primary:	69	83

Energy Supply (kWh/m².year)
Renewable Energy
Final: 57
Primary: 148

Source to Site Conversion Factor (Electricity): 2.6

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

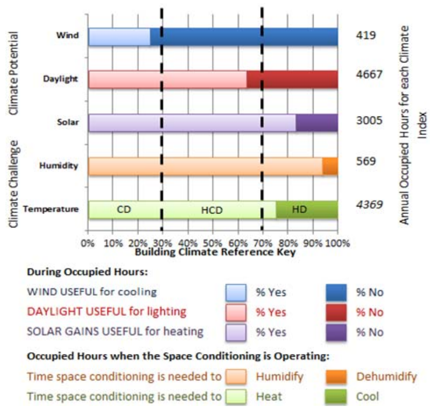
EnergyPlus Model

This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
Blue = Outside (sun and wind exposed)
Yellow = Ground (floors and basement walls)
Purple = Building shading
Grey = Site shading (ground surfaces)

Climate Analysis

The building climate method uses a reference residential building built to the local building code minimum insulation requirements to test the interaction between a building built in a location and the external climatic conditions in that location.



The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

The icons at the end of each section provide a visual key for the reader who wants to quickly organize all the case studies. They symbolically summarize the individual technology solution sets used in each building. Please see the key to the right for more information

***H** - Heating* · ***C** - Cooling* · ***L** - Lighting* · ***DHW** - Domestic Hot Water* · ***P** - Plug Loads* · ***E** - Electricity* · ***I** - Integration*

Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control
H, L,			

Construction

Walls - Construction Elements

Facing Solar Noon

U-value (W/m² ºC) 0.17

Solar Absorptivity

On the balcony and porch fronts white fibre cement panels alternate with triple-glazed timber frame windows.

East

U- 0.17

Solar Absorptivity

Externally reinforced concrete walls or in filled wood stud walls insulated with 30 cm mineral wool. Wood planks or untreated steel plates dress the gables.

Facing Polar Direction

U-value (W/m² ºC) 0.17

Solar Absorptivity

On the balcony and porch fronts white fibre cement panels alternate with triple-glazed timber frame windows.

West

U-value (W/m² ºC) 0.17

Solar Absorptivity

Externally reinforced concrete walls or in filled wood stud walls insulated with 30 cm mineral wool. Wood planks or untreated steel plates dress the gables.

Roofs

U-value (W/m² ºC) 0.11

Solar Absorptivity

Reinforced concrete of flat roof is insulated with 30 cm of expanded polystyrene (EPS).

Ground floor

U-value (W/m² ºC) 0.18

Thermal envelope of basement is insulated with rigid foam boards.

Windows - Construction Elements

Solar noon

U-value (W/m² ºC) 0.98

g-value 0.60

triple glazed windows

East

U-value (W/m² ºC) 0.98

g-value 0.60

triple glazed windows

Polar direction

U-value (W/m² ºC) 0.98

g-value 0.60

triple glazed windows

West

U-value (W/m² ºC) 0.98

g-value 0.60

triple glazed windows

Air permeability (m³/m²h@50pa)

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

0.6

Compactness (m-1)

Passive Approaches:

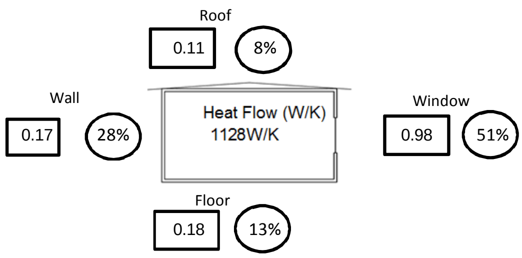
Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.

U-value (W/ºC)

Heat Flow %



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*

Heating

Thermal Mass

In some apartments loam buffers moisture.

Heat Recovery

A comfortable indoor climate is achieved through an individually controlled ventilation system. Each apartment has a switch by the front door.

The ventilation system's piping system is thermally insulated to reduce heat loss.

Cooling

Sunshading

South facades are solar protected with balconies and/or blinds.

Natural Ventilation

Normal option to open the windows.

Daylight Systems

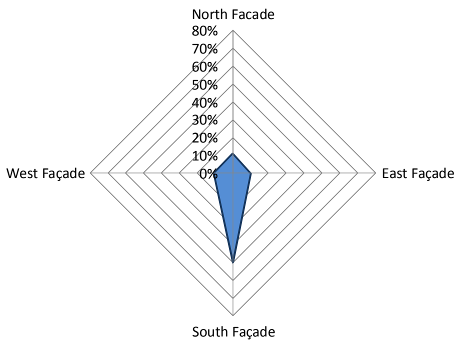
Windows

High value of porosity combined with solar shadings.

Window Distribution Information

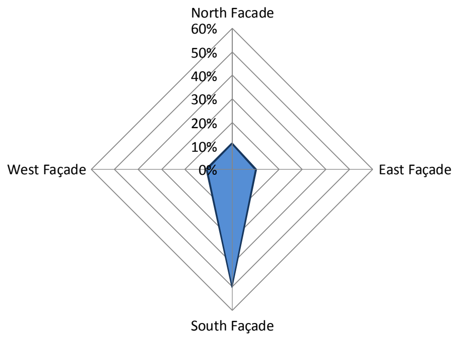
Distribution of Window Areas per Façade

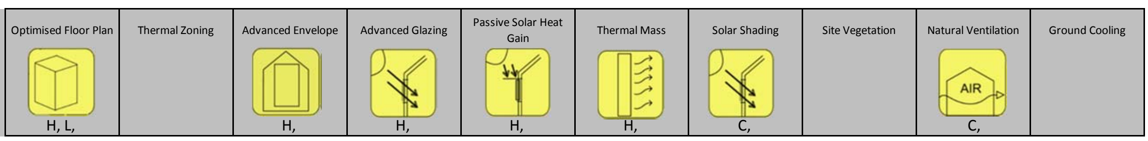
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



Façade Porosity - Percentage of Openings per Façade

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

Partly efficient appliances, efficient elevator, switcher for the ventilation system in each apartment

Energy Storage

Thermal buffer storage (3900 l)

Other

Common used refrigerators and washing machines with hot water tab in cellar rooms

HVAC Systems

Small scale CHP

Artificial Lighting

LEDs and very efficient light bulbs

Computer Management

Control of Systems

Building Management System

System Design Parameters

Outside Air Requirements per Person (L/s-p)

Indoor air changed 1/2 per hour

Appliances / Plug Loads

Power Density Installed (W/m²) : No information available

Artificial Lighting

Power Density Installed (W/m²) : Not documented

Computer Network

Power Density Installed (W/m²) : No information available

Datacentre ? No

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	Yes
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description

No cooling plant

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description

A natural gas-powered cogeneration plant (capacity 14 kWel / 30 kWth) generates electricity for the small electricity grid and covers the heat demand of the two houses. 61.2 m² of flat plate collectors feed heat into a small heat grid between the two houses. A solar heat storage has a total volume of 3900 litres.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	Yes

Description

Ventilation with 85% heat recovery.

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	Yes
Other?	Yes

Description

Solar thermal system and a CHPP

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

No information available because of residential use

HVAC

HVAC is controlled using standard systems (related to the CHPP). To conserve moisture, the airflow in each apartment can be controlled by a switch.

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided? Yes

Description

User related by efficient appliances

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
L,	P,			kWh H, L, DHW, E,	AIR H,						

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www.kleehaeuser.de/

Funding

Source and Type of Funding
The two buildings were built by a assembly and hence funded completely private.

Principal Actors
Main actor was a building assembly. Engineers forced the project to a zeroHaus-certificate (consumptions are equalized by renewables)

Authors
Eike Musall

email
emusall@uni-wuppertal.de

This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	No
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	30°
Azimuth	0° South
Technology	Polycrystalline cells
Nominal Power (kWp)	23 kWp
Area (m²)	202 m²
Yield (kWh/m².year)	9
Expected generation (kWh)	23000
Measured generation (kWh)	22529

Wind Turbine - Final Energy

Position	Off-site
Number of Turbine	One
Technology	
Nominal Power (kWp)	6300 kW
Energy Production (kWh/m².year)	26.52

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Flat plate collectors
Position	On the roof
Area (m²)	56
Production (kWh/m².year)	Efficiency measure
Annual % of Hot Water	ca. 70 %

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power - Final Energy

Type	Natural gas-powered CHP
Fuel	Gas
Efficiency (%)	ca. 90 %
Electricity	0.3
Water Heating	0.3
Space Heating	0.3
Cooling	0
Production (kWh/m².year)	21.48
Electricity	21,48 kWh/m²y
Water Heating	71,51 kWh/m²y
Space Heating	See above
Cooling	No

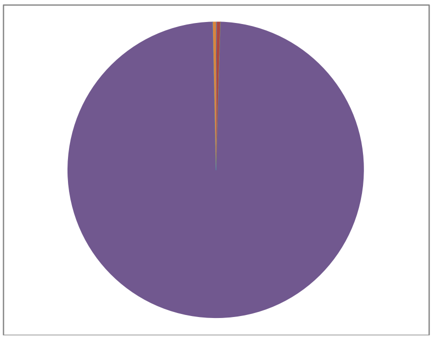
Renewable Production of Heating and Cooling

Heating Equipment - Final En

	CHP
Technology	Natural gas-powered CHP
Power	Capacity 14 kWel / heat output 30 kWth
Efficiency (%)	ca. 90 %
Production (kWh/m².yr)	7151
Annual % of Heating - (Produced by renewables)	0 (natural gas)

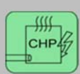
Cooling Equipment There is no active cooling system installed in the building.

Technology	
Power	
Efficiency (%)	
Production (kWh/m².year)	
Annual % of Cooling - (Produced by renewables)	



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

Hot water heating
Heating energy production
Cooling energy production
Energy produced from Photovoltaic Panels
Energy produced from on site Wind Turbines
Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 H, DHW,	 E,		 H, DHW, E,			 I,		

References

American Society of Heating, Refrigerating and Ait-Conditioning Engineers. Ashrae Green Guide: The Design, Construction, and Operating of Sustainable Buildings USA: Elsevier 2006.

Belleri, Annamaria, Assunta Napolitano, and Roberto Lollini. "Net Zeb Evaluation Tool - User Guide " (2012).

Single Family Building (Riehen)

Completion Date
2007

Location
Leimgrubenweg 90
4125 Riehen
Basel-Stadt
Switzerland

Latitude	Longitude
North	West
47.58	7.668

Climate Challenge Definition
Buildings are either cooling dominated, heating dominated or mixed heating and cooling dominated. A building is climate dominated if one of a reference buildings space conditioning processes is 70% or greater of the total space conditioning load.

Climate Challenge
Heating & Cooling Dominated

Building Type
Residential

Site Context
Suburban Site - single family houses 1-2 storey spaced 3-5m apart

Net Floor Area (m²)
315

Conditioned Floor Area (m²)
315

Occupancy (m² per Person)
45.0

Number of Storeys

Cost US$/(Net) m² Floor Area

Cost US$/(Net) m² typical similar building

Web Address

For more information:
http://tinyurl.com/Riehen-CH

Net Zero Energy Building Overview

Intensive use of renewable energy with in particular an expected photovoltaic production 1.3 times higher then the yearly electricity demand. Additional equipment is a solar thermal collector, a ground source heat pump and a mechanical ventilation with heat recovery. The building is compact, well insulated and the main facade is facing South with large windows.

This is one of thirty case study factsheets collected by participants in Subtask C of the IEA 'Net Zero Energy Buildings' (NZEBs) research project. Subtask C focuses on documenting and analysing current NZEBs design and technologies. The case studies form the basis of a proposed Source Book describing NZEB Solution Sets and guidelines and documenting monitored performance and lessons learned.

Architectural Design Concept

The well insulated building envelope and the compact shape reflect the design approach of maximising efficiency. External concrete elements stand in contrast to the wooden façade. Large windows on the South façade for passive solar heat gains. External blinds provide the required shading in summertime. The building needs only electricity and solar power. The technique is simple and well known: heat pump, thermal solar collector, photovoltaic system and a mechanical ventilation system with heat recovery. The solar system covers the whole roof, but is nearly invisible. In 2008 the building got the Solar Swiss Award in the new construction category.

Measured Energy Production and Consumption:

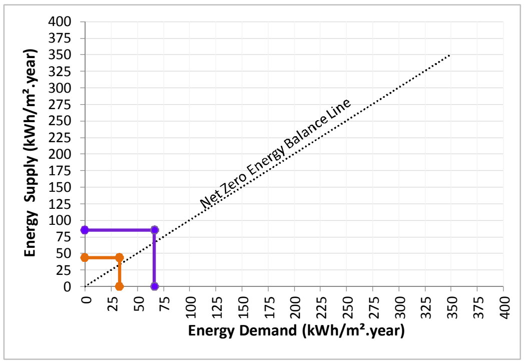
These data compare the overall energy consumption with the total energy generated though renewable energy onsite.

Energy Demand (kWh/m².year)
Electricity
Final: 33
Primary: 66

Energy Supply (kWh/m².year)
Renewable Energy
Final: 44
Primary: 85

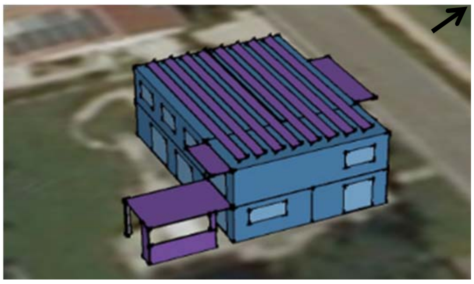
Source to Site Conversion Factor (Electricity): 2

*In the graph **Final Energy Demand** is the sum of all delivered energy (kWk/m².year) obtained by summing all energy carriers. **Final Energy Supply** is the sum of all energy generated on site from renewable sources. The Primary Energy Demand and Primary Energy Credit have been calculated based upon the Primary Energy Conversion Factors for each energy carrier for this location.*



Energy Generated/Energy Consumed - Primary
Energy Generated/Energy Consumed - Final

EnergyPlus Model



This model has been created by the STC participants to assist in the standardised analysis of the performance of this building. It calculates internal temperatures and energy consumption and production.

Key to colours:
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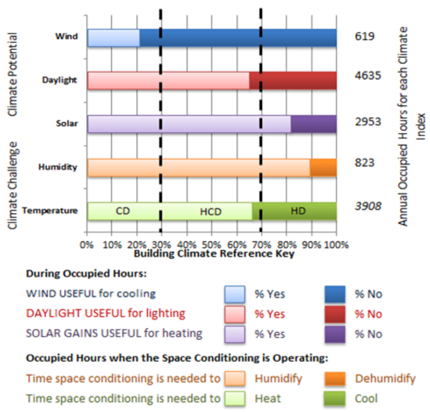

The Climate Challenge for the building designer is HEATING DOMINATED (HD) if the green bars meet between 70 and 100%; it is COOLING DOMINATED (CD) if they meet between 0 and 30%; it is MIXED HEATING AND COOLING (HCD) if they meet between 30 and 70%.

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H *- Heating*
C *- Cooling*
L *- Lighting*
DHW *- Domestic Hot Water*
P *- Plug Loads*
E *- Electricity*
I *- Integration*

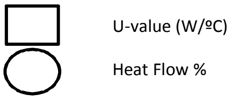
Window to Wall Ratio	Skylights	Solar Tubes	Blinds for Glare Control

Passive Approaches:

Passive design techniques or solutions are design measures that require no direct purchased energy input. These design measures include optimisation of solar energy collection, storage and shading, plus natural ventilation and advanced day lighting measures. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of passive measures for this climate did not need to include this particular measure.

Heat Flow (W/ºC)

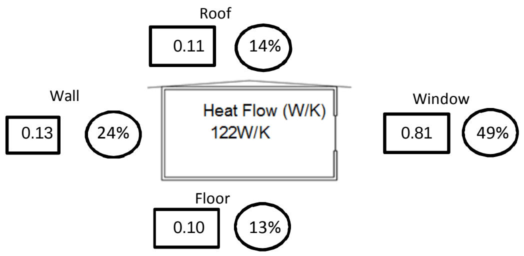
High resistance to heat flow (high R-value, low U-value) is important in climate where energy using services are used to maintain a large temperatures difference between indoors and outdoors.



Solution Sets are: A set of passive, energy efficiency, and/or renewable energy solutions used to mitigate or lessen the building challenges and achieve the design goal.

Building Challenge Solution Set *- The set of solutions used to lower the energy needed by a particular building challenge.*

Whole Building Solution Set - *The set of solutions used to lower the energy consumption of the whole building.*



<u>Heating</u>

Sunspaces

Large windows facing south to optimise solar heat gains.

<u>Cooling</u>

<u>Daylight Systems</u>

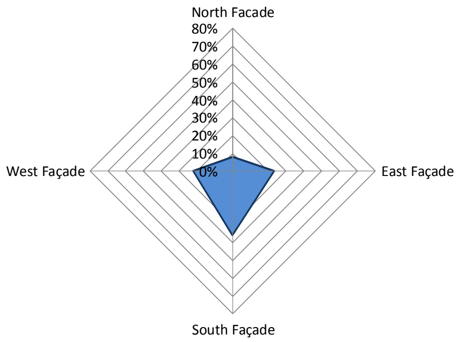
Large windows

The large windows in the building increase the natural lighting.

Window Distribution Information

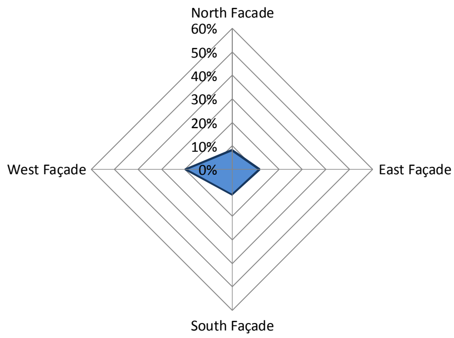
<u>Distribution of Window Areas per Façade</u>

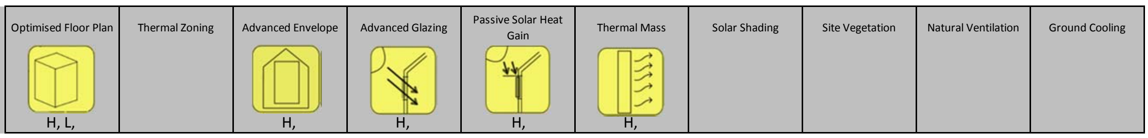
In Passive Design, the orientation of the windows and their size has an extreme effect on the heating, cooling and the daylight harvesting potential of the building. This graph enables simple comparison of these properties for each climate and building type.



<u>Façade Porosity - Percentage of Openings per Façade</u>

In Passive Design, the orientation of the openings for Natural Ventilation is a response to the wind and the site. This graph enables a simple comparison of the porosity of each façade for each climate and building type.





<u>Construction</u>

<u>Walls - Construction Elements</u>

Facing Solar Noon

U-value (W/m² ºC) 0.13

Solar Absorptivity

Wood construction with 38cm mineral wool insulation

East

U-value (W/m² ºC) 0.12

Solar Absorptivity

Wood construction with 38cm mineral wool insulation

Facing Polar Direction

U-value (W/m² ºC) 0.11

Solar Absorptivity

Wood construction with 38cm mineral wool insulation

West

U-value (W/m² ºC) 0.12

Solar Absorptivity

Wood construction with 38cm mineral wool insulation

<u>Roofs</u>

U-value (W/m² ºC) 0.11

Solar Absorptivity

Wood construction with 38cm mineral wool insulation

<u>Ground floor</u>

U-value (W/m² ºC) 0.10

Steel baton, insulation,

<u>Windows - Construction Elements</u>

Solar noon

U-value (W/m² ºC) 0.81

g-value 0.52

Triple glazing

East

U-value (W/m² ºC) 0.83

g-value 0.52

Triple glazing

Polar direction

U-value (W/m² ºC) 0.91

g-value 0.52

Triple glazing

West

U-value (W/m² ºC) 0.88

g-value 0.52

Triple glazing

<u>Air permeability (m³/m²h@50pa)</u>

Air permeability is the total building air leakage (m3.h-1) per m2 of building envelope at a reference pressure difference of 50 Pa.

As Built

2.03 (0.46 1/h@50Pa)

<u>Compactness (m-1)</u>

Energy Efficiency Systems:

Energy efficient technologies are specific equipment and appliances that focus on reducing the use of energy, in the building, through more efficient means. These energy efficient technologies are used in harmony with the passive design to lower the overall energy consumption of the building. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular system.

Innovative Technologies

The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy efficient Systems for this climate did not need to include this particular technology.

Energy Reduction Measures for Plug Loads and Appliances

A++ rated appliances, only

Energy Storage

Other

HVAC Systems

heat pump, thermal collector, PV, mech. ventilation

Artificial Lighting

Computer Management

Control of Systems

System Design Parameters

Outside Air Requirements per Person (L/s-p)

7

Appliances / Plug Loads

Power Density Installed (W/m²) :

Artificial Lighting

Power Density Installed (W/m²) :

Computer Network

Power Density Installed (W/m²) :

Datacentre ?

Internal Environmental Systems and Domestic Hot Water

This section describes how the design team has provided for the internal space conditioning. Central systems place the heating, cooling and ventilation equipment in a separate space from the occupied rooms. The heating or cooling of the rooms requires a distribution system taking heat to or away from the occupied rooms using water (hydronic) or air. Distributed systems have separate heating, cooling and possibly ventilation equipment installed for each space.

Cooling

Central Plant	No
Distributed Plant	No
Openable Windows	See Passive Systems
Ceiling Fans	No
Hydronic distribution	No
Air distribution	No

Description

The heat pump could be used for cooling in summertime. The earth tube for pre-cooling the fresh air for mechanical ventilation system.

Heating

Central Plant	Yes
Distributed Plant	No
Hydronic distribution	No
Air distribution	No

Description

Space heating (floor heating) and domestic hot water demands are covered by an electric heat pump operating with one ground probe and by the heat produced from flat plate solar thermal collectors on the roof.

Ventilation System

Heat Recovery Type	Yes
Central Air supply	Yes
Local Air Recirc plus Central Fresh Air	No

Description

Counterflow

DHW - Domestic Hot Water

Solar?	Yes
Waste Water Heat Recovery?	No
Gas?	No
Electrical?	No
Other?	No

Description

The heat production of solar thermal collectors can cover 60% of DHW.

Control Systems

The critical feature of a successful ultra low energy building is the user interaction. Without control systems that are responsive to user needs and easily understood successful operation is extremely difficult.

Lighting

HVAC

Energy Storage

Latent Storage?	No
Fuel Cell?	No
Compressed Air?	No

User Interactions

User Manual Provided?	No

Description

No

Energy Efficient Lighting	Efficient Appliances	Efficient Office Equipment	Advanced Lighting Controls	Load Management	Mechanical Air Heat Recovery	Hot Water Heat Recovery	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Ceiling Fans/ Evaporative Cooling
	P,				H,						

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Funding

Source and Type of Funding
40% of the PV-System is sponsored by a foundation program of the City of Basel, the other 60% will be paid back after 20 years with money from the state.

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Architect and Owner

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This project has been organised under the framework of two International Energy Agency implementing agreements: Solar Heating and Cooling and Energy Conservation in Buildings and Community Systems. For more information please visit: www.iea-shc.org/task40

Energy Supply and Integration of Renewable Energy:

"By definition, a renewable energy source is a fuel source that can be replenished in a short amount of time. (American Society Of Heating, Refrigerating and Air-Conditioning Engineers, 2006)" Through the use of these replenishing energy sources, the annual energy demand of an already low-energy building can be offset through the renewable energy generation. Renewable energy sources are converted to energy using renewable energy generation technologies or solutions. The information below is organised under headings in the case study database. Where a field is blank it is because the building design team decided that the NZEB design solution set of energy supply and integration of renewable energy for this climate did not need to include this particular measure.

Electricity Production

Photovoltaic (PV) - Final Energy

Building Integrated PV?	No
Ground mounted	No
Roof mounted	Yes
Position	Fixed
Tilt (angle)	10°
Azimuth	South
Technology	
Nominal Power (kWp)	14
Area (m²)	84
Yield (kWh/m².year)	160
Expected generation (kWh)	15600
Measured generation (kWh)	13400

Wind Turbine

Position
Number of Turbine
Technology
Nominal Power (kWp)
Energy Production (kWh/m².year)

Solar Water Heating

Hot Water - Final Energy

Solar Thermal	Yes
Technology	Flat plate collectors
Position	Roof
Area (m²)	8
Production (kWh/m².year)	8
Annual % of Hot Water	60

Combined (Cooling) Heat and Power

Combined (Cooling) Heat and Power

Type
Fuel
Efficiency (%)
Electricity
Water Heating
Space Heating
Cooling
Production (kWh/m².year)
Electricity
Water Heating
Space Heating
Cooling

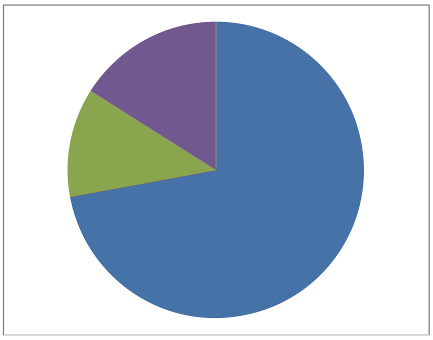
Renewable Production of Heating and Cooling

Heating Equipment

	Ground / Water Source Heat Pump
Technology	Calmotherm SWC 60H, 1 x 120 m earth tube
Power	5.7 kW
Efficiency (%)	
Production (kWh/m².yr)	11.00
Annual % of Heating - (Produced by renewables)	100

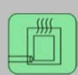
Cooling Equipment There is no active cooling system installed in the building.

Technology
Power
Efficiency (%)
Production (kWh/m².year)
Annual % of Cooling - (Produced by renewables)



This graph shows the expected proportion of generation (kWh/m²) of energy produced by the various renewable energy sources based on design calculations.
**If the data for one of the renewable energy generation technologies is not available, the related proportion has been taken as null and is therefore not plotted on the graph.*

- Hot water heating
- Heating energy production
- Cooling energy production
- Energy produced from Photovoltaic Panels
- Energy produced from on site Wind Turbines
- Hybrid energy production

Solar Thermal	Photovoltaic	Wind Turbine (on or near site)	Biomass CHP	Biomass-fired Boilers	Geothermal	Building Footprint	On-site	At-site
 DHW,	 E,				 H, DHW,	 I,		

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