# L’ENERGIA
# NEGLI EDIFICI

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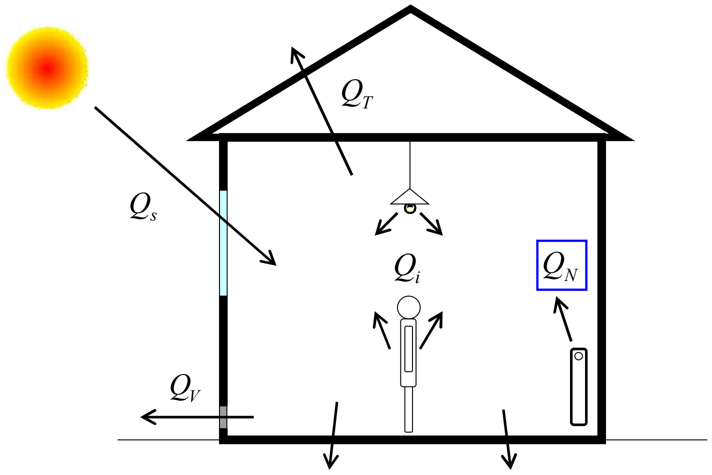
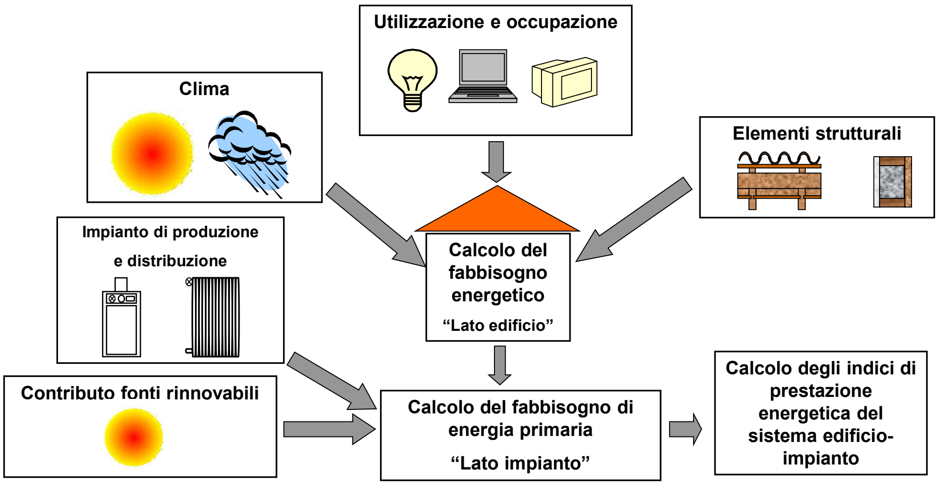
## Schema dei flussi termici



# Principali protagonisti del bilancio energetico



**Fabbisogni energetici tipici in riscaldamento in edifici residenziali:**

| | kWh/(m$^2$a) |
|---|---|
| **Edifici convenzionali non corrispondenti alle normative sul risparmio energetico** | **220-250** |
| **Edifici convenzionali corrispondenti alle più recenti normative** | **80-100** |
| **Edifici a basso consumo energetico** | **30-50** |
| **Edifici passivi** | **< 15** |
| **Edifici a consumo energetico zero** | **0** |

### 2.1.2 Definition of the Passive House standard

The term "Passive House" refers to a construction standard. The standard can be met using a variety of technologies, designs and materials. It is a refinement of the low-energy house (LEH) standard.

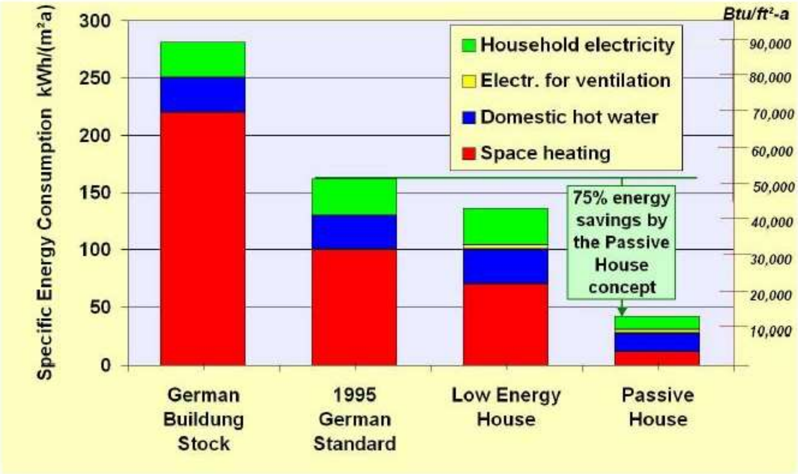
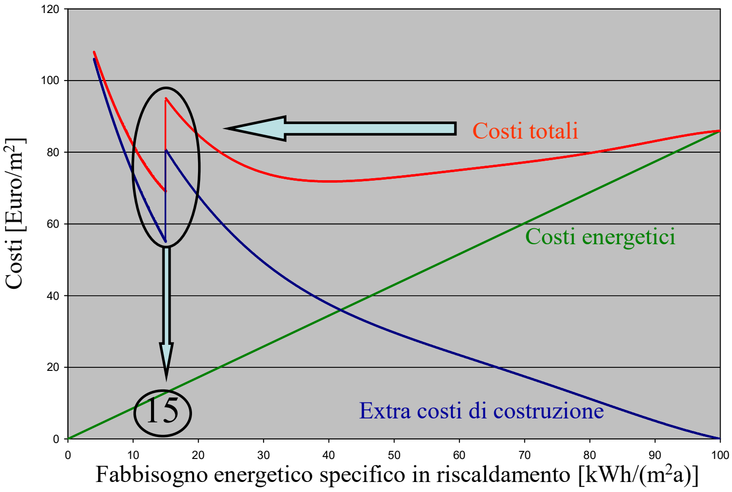


Figure 1: Comparison of specific energy consumption levels of dwellings

# Edifici passivi “PassivHaus” (2/2)



# A comparative analysis

Let’s consider a 100 m$^2$ apartment. Typical consumptions:

- Stock building: natural gas used for heating, DHW, cooking. Electricity for cooling (split-system), lighting and appliances
- Building ‘90ies: natural gas used for heating, DHW, cooking. Electricity for cooling (split-system), lighting and appliances
- Low Energy Building (LEB): all consumptions with electricity. Heat pump for heating, cooling & DHW. Cooking (induction), lighting and appliances as the other cases.
- Passive House (PH): all consumptions with electricity. Solar collectors (50%) + el. Resistance. Heating with el. Resistance. Cooling (split-system). Cooking (induction). Lighting and appliances as the other cases.

| | Energy Demand [kWh/(m$^2$ y)] | | | | | |
|---|---|---|---|---|---|---|
| | **heating** | **DHW** | **cooling** | **cooking** | **electricity** | **overall** |
| **Stock** | 200 | 20 | 25 | 10 | 35 | 290 |
| **Buildings '90ies** | 100 | 20 | 25 | 10 | 35 | 190 |
| **LEB** | 40 | 20 | 25 | 10 | 35 | 130 |
| **PH** | 15 | 10 | 25 | 10 | 35 | 95 |

Boiler: $\eta$ = 100% = 1
Split-system: SPF cooling: 3.0
Electric resistance: SPF (heating & DHW: 1.0)
Cooking: 1 kWh gas = 0.6 kWhe induction

Heat pump: SPF heating: 3.5
SPF DHW: 2.5
SPF cooling: 3.0

| | Energy Demand [kWh/(m$^2$ y)] | | | | | |
|---|---|---|---|---|---|---|
| | **heating** | **DHW** | **cooling** | **cooking** | **electricity** | **overall** |
| **Stock** | 200 / 1 | 20 / 1 | 25 / 3 | 10 / 1 | 35 | 290 |
| **Buildings '90ies** | 100 / 1 | 20 / 1 | 25 / 3 | 10 / 1 | 35 | 190 |
| **LEB** | 40 / 3.5 | 20 / 1 | 25 / 3 | 10 * 0.6 | 35 | 130 |
| **PH** | 15 / 1 | 10 / 1 | 25 / 3 | 10 * 0.6 | 35 | 95 |

Based on the above mentioned efficiencies, the following table resumes the specific final energy per energy carrier:

| | Final energy per energy carrier [kWh/(m$^2$ y)] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **heating** | | **DHW** | | **cooking** | | **cooling** | | |
| | **gas** | **electr.** | **gas** | **electr.** | **gas** | **electr.** | **electr.** | **electr.** | **overall** |
| **Stock** | 200 | - | 20 | - | 10 | - | 8 | 35 | 273 |
| **Buildings '90ies** | 100 | - | 20 | - | 10 | - | 8 | 35 | 173 |
| **LEB** | - | 11 | - | 8 | - | 6 | 8 | 35 | 68 |
| **PH** | - | 15 | - | 10 | - | 6 | 8 | 35 | 74 |

**Costs in 2020**

Costs
Electricity: 0.22 €/kWhe
Natural gas: 0.08 €/kWht

| | Final energy per energy carrier [kWh/($m^2$ y)] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | heating | | DHW | | cooking | | cooling | | |
| | gas | electr. | gas | electr. | gas | electr. | electr. | electr. | overall |
| **Stock** | 200 | - | 20 | - | 10 | - | 8 | 35 | 273 |
| **Buildings '90ies** | 100 | - | 20 | - | 10 | - | 8 | 35 | 173 |
| **LEB** | - | 11 | - | 8 | - | 6 | 8 | 35 | 68 |
| **PH** | - | 15 | - | 10 | - | 6 | 8 | 35 | 74 |

Based on the above mentioned efficiencies, the following table resumes the specific final energy per energy carrier:

| | Final energy per energy carrier [kWh/($m^2$ y)] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | heating | | DHW | | cooking | | cooling | | |
| | gas | electr. | gas | electr. | gas | electr. | electr. | electr. | overall |
| **Stock** | 1600 | - | 160 | - | 80 | - | 176 | 770 | 2790 |
| **Buildings '90ies** | 800 | - | 160 | - | 80 | - | 176 | 770 | 1990 |
| **LEB** | - | 242 | - | 176 | - | 132 | 176 | 770 | 1500 |
| **PH** | - | 330 | - | 220 | - | 132 | 176 | 770 | 1630 |

**Costs in 2023**

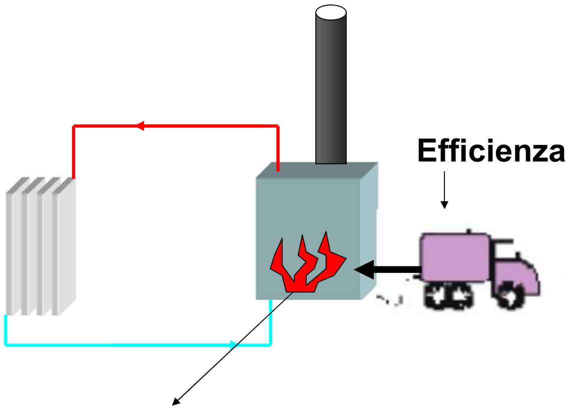
Costs
Electricity: 0.25 €/kWhe
Natural gas: 0.12 €/kWht

| | Final energy per energy carrier [kWh/($m^2$ y)] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | heating | | DHW | | cooking | | cooling | | |
| | gas | electr. | gas | electr. | gas | electr. | electr. | electr. | overall |
| **Stock** | 200 | - | 20 | - | 10 | - | 8 | 35 | 273 |
| **Buildings '90ies** | 100 | - | 20 | - | 10 | - | 8 | 35 | 173 |
| **LEB** | - | 11 | - | 8 | - | 6 | 8 | 35 | 68 |
| **PH** | - | 15 | - | 10 | - | 6 | 8 | 35 | 74 |

Based on the above mentioned efficiencies, the following table resumes the specific final energy per energy carrier:

| | Final costs per energy carrier [€] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | heating | | DHW | | cooking | | cooling | | |
| | gas | electr. | gas | electr. | gas | electr. | electr. | electr. | overall |
| **Stock** | 2400 | - | 240 | - | 120 | - | 210 | 875 | 3845 |
| **Buildings '90ies** | 1200 | - | 240 | - | 120 | - | 210 | 875 | 2645 |
| **LEB** | - | 285 | - | 206 | - | 140 | 210 | 875 | 1715 |
| **PH** | - | 375 | - | 250 | - | 140 | 210 | 875 | 1850 |

# Energia primaria da fonti fossili



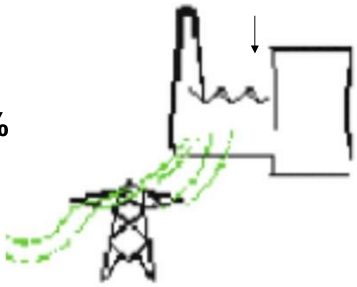
**Efficienza: 90%**

**1.1 kWh$_P$**

**1kWh$_T$ bruciato = 1/0.9 = 1.1 kWh$_P$ (Energia primaria)**

**(Nel resto d'Europa si usa 1.1 kWh$_P$/kWh$_T$)**

# Energia primaria da energia elettrica



**2.5 kWh$_P$**

**Efficienza della**
**rete elettrica: 40%**

**1kWh$_E$**

**1kWh$_E$ energia elettrica =**
**= 1/0.40 = 2.5 kWh$_P$ (Energia primaria)**

**(Nel resto d'Europa si usa 2.7 kWh$_P$/kWh$_T$)**

Considering agauin the specific final energy per energy carrier:

| | Final energy per energy carrier [kWh/(m² y)] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | heating | | DHW | | cooking | | cooling | | |
| | gas | electr. | gas | electr. | gas | electr. | electr. | electr. | overall |
| **Stock** | 200 | - | 20 | - | 10 | - | 8 | 35 | 273 |
| **Buildings '90ies** | 100 | - | 20 | - | 10 | - | 8 | 35 | 173 |
| **LEB** | - | 11 | - | 8 | - | 6 | 8 | 35 | 68 |
| **PH** | - | 15 | - | 10 | - | 6 | 8 | 35 | 74 |

Considering for the conversion factors for primary energy 1.04 $kWh_p/kWh_f$ for natural gas and 2.42 $kWh_p/kWh_f$ for electrical energy:

| | Primary energy per energy carrier [kWh/(m² y)] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | heating | | DHW | | cooking | | cooling | | |
| | gas | electr. | gas | electr. | gas | electr. | electr. | electr. | overall |
| **Stock** | 210 | - | 21 | - | 11 | - | 20 | 85 | 346 |
| **Buildings '90ies** | 105 | - | 21 | - | 11 | - | 20 | 85 | 241 |
| **LEB** | - | 28 | - | 19 | - | 13 | 20 | 85 | 165 |
| **PH** | - | 36 | - | 24 | - | 13 | 20 | 85 | 179 |

Let's suppose to install 3 kW (3600 kWh electricity produced) and 6 kW (7200 kWh electricity produced), i.e. 36 kWhe/(m² year) and 72 kWhe/(m² year) respectively.

The following table resumes the final energy consumptions (on yearly base)

| | Final energy [kWh/(m² y)] | | | Percentage of sharing | |
|---|---|---|---|---|---|
| | No RES | PV (3 kW) | PV (6 kW) | PV (3 kW) | PV (6 kW) |
| **Stock** | 273 | 237 | 201 | 13% | 26% |
| **Buildings '90ies** | 173 | 137 | 101 | 21% | 42% |
| **LEB** | 68 | 32 | -4 | 53% | 105% |
| **PH** | 74 | 38 | 2 | 49% | 97% |

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The following table resumes the primary energy consumptions (on yearly base), considering the primary energy produced by the PV, i.e. 87 kWhp/(m² year) and 174 kWhp/(m² year) respectively

| | Primary energy [kWh/(m² y)] | | | Percentage of sharing | |
|---|---|---|---|---|---|
| | No RES | PV (3 kW) | PV (6 kW) | PV (3 kW) | PV (6 kW) |
| **Stock** | 346 | 259 | 172 | 25% | 50% |
| **Buildings '90ies** | 241 | 154 | 67 | 36% | 72% |
| **LEB** | 165 | 78 | -9 | 53% | 105% |
| **PH** | 179 | 92 | 5 | 49% | 97% |

# Costs 2020

Natural gas costs 0.08 €/kWht and electricity costs 0.22 €/kWhe.
The costs assume that 50% of electricity produced is self-consumed and 50% is sold, leading to an average value of 0.15 €/kWhe as cost value of the electricity produced with PVs

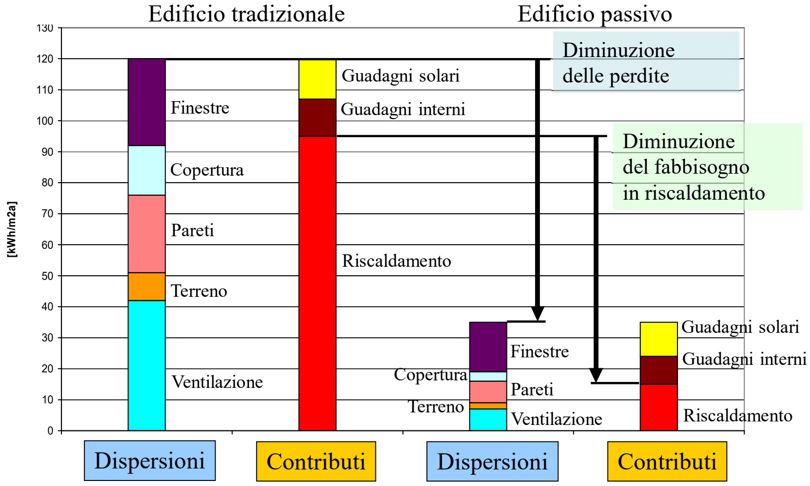
| | Overall costs | | |
|---|---|---|---|
| | Without PV | With 3 kW PV | With 6 kW PV |
| Stock | 2,790 € | 2,250 € | 1,710 € |
| Buildings '90ies | 1,990 € | 1,450 € | 910 € |
| LEB | 1,500 € | 960 € | 420 € |
| PH | 1,630 € | 1,090 € | 550 € |

# Costs 2023

Natural gas costs 0.12 €/kWht and electricity costs 0.25 €/kWhe.
The costs assume that 50% of electricity produced is self-consumed and 50% is sold, leading to an average value of 0.10 €/kWhe as cost value of the electricity produced with PVs

| | Overall costs | | |
|---|---|---|---|
| | Without PV | With 3 kW PV | With 6 kW PV |
| Stock | 3,845 € | 3,300 € | 2,765 € |
| Buildings '90ies | 2,645 € | 2,100 € | 1,565 € |
| LEB | 1,715 € | 1,170 € | 630 € |
| PH | 1,850 € | 1,310 € | 765 € |

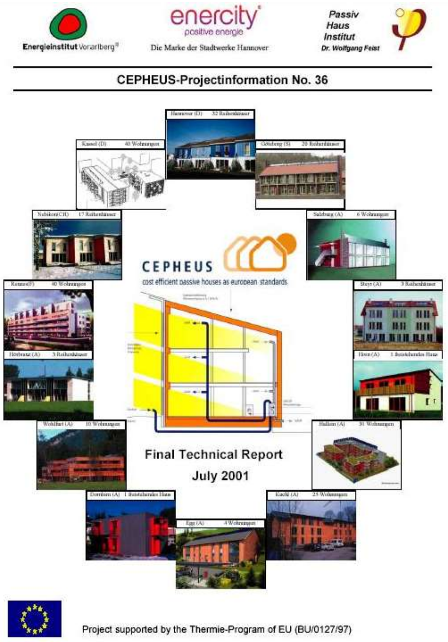
## Esempio di confronto del bilancio termico tra un edificio tradizionale ed un edificio passivo



## Criteri per aumentare l’efficienza energetica di un edificio

1. Aumento dell’isolamento termico globale dell’involucro e limitazione delle infiltrazioni d’aria non necessarie
2. Controllo dei guadagni gratuiti di calore
3. Aumento dell’efficienza degli impianti tecnici
4. Utilizzo delle enrgie rinnovabili

# PROGETTO CEPHEUS



Energieinstitut Vorarlberg
enercity positive energie
Die Marke der Stadtwerke Hannover
Passiv Haus Institut
Dr. Wolfgang Feist

CEPHEUS-Projectinformation No. 36

CEPHEUS
cost efficient passive houses as european standards

Final Technical Report
July 2001

Project supported by the Thermie-Program of EU (BU/0127/97)

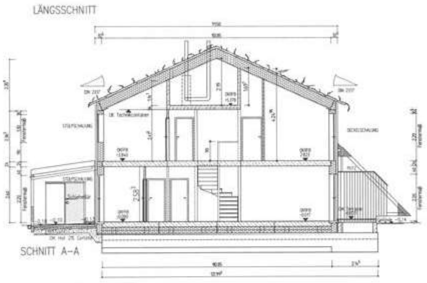
**"Passive Houses" are buildings which assure a comfortable indoor climate in summer and in winter without needing a conventional heat distribution system. To permit this, it is essential that, under climatic conditions prevailing in Central Europe, the building's annual space heating requirement does not exceed 15 kWh/(m$^2$a).** This small space heat requirement can be met by heating the supply air in the ventilation system – a system which is necessary in any case. Passive Houses need about **80% less space heat** than new buildings designed to the standards of the 1995 German Thermal Insulation Ordinance (Wärmeschutzverordnung).

The standard has been named "Passive House" because the 'passive' use of free heat gains – delivered externally by solar irradiation through the windows and provided internally by the heat emissions of appliances and occupants – essentially suffices to keep the building at comfortable indoor temperatures throughout the heating period.

It is a part of the Passive House philosophy that efficient technologies are also used to minimize the other sources of energy consumption in the building, notably electricity for household appliances. The target of the CEPHEUS project is to keep the **total primary energy requirement** for space heating, domestic hot water and household appliances below 120 kWh/(m$^2$a). This is **lower by a factor of 2 to 4** than the specific consumption levels of new buildings designed to the standards presently applicable across Europe.

## CEPHEUS 01 Germany, Hannover-Kronsberg

Southeast elevation



Longitudinal section

| Project brief | |
|---|---|
| Location | D-30539 Hannover (Lower Saxony, Germany) |
| Developer/client | Rasch & Partner GmbH, Dipl.-Ing. F. Rasch, Darmstadt |
| Architect | Dipl.-Ing. Arch. P. Grenz, Dipl.-Ing. F. Rasch |
| Engineers | Building services: inPlan GmbH, Dipl.-Ing. N. Stärz , Pfungstadt |
| Construction period | Commencement: 01.09.1998, completion: Dec. 1998 |
| Building type | Terrace |
| Use | Owner-occupied |
| Number of dwelling units | 32 (4 rows with 8 houses each) |
| Living floor space | 3805 m² |

| | |
|---|---|
| Type of construction | Load-bearing structure and gable walls: prefab. concrete elements; external walls and roofs: prefab. lightweight timber elements |
| Windows and glazing | Triple low-emissivity glazing, TSET: 60%, insulated wood-aluminium frames |
| U-values (W/(m²K)) | Lightweight timber wall: 0.13; solid gable wall: 0.10; end-of-terrace basement ceiling: 0.10; mid-terrace basement ceiling: 0.13; roof: 0.10; glazing: 0.75; window frame: 0.57; whole window: 0.83 |
| Building services | |
| Heating | Supplementary supply air heating and bathroom radiator, district heat supply |
| Ventilation | Distributed controlled ventilation with heat recovery from extract air |
| Hot water | Solar collector (4 m²) with 300 l storage; solar contribution ca. 50% |
| Electric appliances | Provision of advice on electric household appliances and grants for high-efficiency appliances; equipment of each dwelling unit with an energy-saving laundry drying cabinet integrated within the extract air flow |
| Energy parameters | |
| **Total Floor Area (TFA)** | Jangster de Lüx house type (mid- and end-terrace): 119.5 m²,<br>Jangster house type: 97 m², "123"house type: 75 m² |
| Annual space heat consumption (measured) | 15.3* kWh/(m²a)<br>*The measured values were normalized to 20°C indoor temperature and extrapolated across a full year. |
| **Space heat requirement (calculated by PHPP)** | 11.8 kWh/(m²a) |

## CEPHEUS 02 Germany, Kassel


Lot 1: HHS/ASP project


Lot 2: Schneider project

| Project brief | |
|---|---|
| Location | D-34131 Kassel (Hesse, Germany) |
| General contractor | HOCHTIEF AG, Fuldabrück |
| Client | Gemeinnützige Wohnungsbaugesellschaft der Stadt Kassel (GWG) |
| Architect | Lot 1: Hegger/Hegger/Schleif (HHS), Kassel and<br>ASP Planungs- und Bauleitungs-GmbH, Kassel<br>Lot 2: Prof. Dr. Schneider, Detmold |
| Engineers | Statics: Klute & Klute, Kassel<br>Building services: InnovaTec Energiesysteme GmbH, Kassel |
| Construction period | Commencement: 28.4.99, occupied in May/June 2000 |
| Building type | Apartment building |

| | |
|---|---|
| Use | Publicly-assisted housing |
| Number of dwelling units | 40 (Lot 1: 23, Lot 2: 17) |
| Living floor space | 3164 $m^2$ |
| Construction | |
| Type of construction | Solid (sand-lime with external thermal insulation compound system) |
| Windows and glazing | Triple low-emissivity glazing, TSET: 42%, window frame: PVC profile with additional internal and external insulating moulding |
| U-values (W/($m^2$K)) | External wall: 0.13; ground/basement ceiling: 0.11; roof: 0.11; glazing: 0.6; window frame: 0.8; whole window: 0.82 |
| Building services | |
| Heating | Distributed supplementary heating of supply air through heating registers; bathroom radiators, heat supply by district heat |
| Ventilation | Semi-centralized ventilation with heat recovery from extract air (centralized heat interchanger, distributed ventilators) |
| Hot water | Centralized hot water heating, 800 l hot service water storage in building services room, heat supply through district heat |
| Electric appliances | Energy conservation advice for occupants |
| Energy parameters | |
| **Total Floor Area (TFA)** | Lot 1: 1802 $m^2$ / Lot 2: 1253 $m^2$ |
| Annual space heat consumption (measured) | Lot 1: 15.1* kWh/($m^2$a), Lot 2: not within measurement programme<br>*The measured values were normalized to 20°C indoor temperature and extrapolated across a full year. |
| **Space heat requirement (calculated by PHPP)** | Lot 1: 13.4 kWh/($m^2$a)<br>Lot 2: 15.0 kWh/($m^2$a) |

## CEPHEUS 03 Sweden, Gothenburg

South elevation

| | |
|---|---|
| Project brief | |
| Location | S-427 42 Bildal |
| Developer/client | Egnahemsbolaget, Gothenburg |
| Architect | EFEM arkitektkontor, Arch. Hans Eek, Gothenburg |
| Engineers | Building services: Bengt Dahlgren AB, Gothenburg |

| | |
|---|---|
| Construction period | Commencement: 31.12.1999, completion: 01.05.2001 |
| Building type | Terrace |
| Use | Owner-occupied |
| Number of dwelling units | 20 (two rows, one with 4 and one with 6 houses) |
| Living floor space | ca. 2704 m² |
| Construction | |
| Type of construction | Timber |
| Windows and glazing | Double low-emissivity glazing with coated glass, TSET: 40%, wooden window frames |
| U-values (W/(m²K)) | External wall: 0.08; ground: 0.09; roof: 0.07; glazing:0.7; window frame: no information; whole window. 0.88 |
| Building services | |
| Heating | Direct electric supplementary heating of supply air |
| Ventilation | Balanced supply and extract air flows with heat recovery from extract air |
| Hot water | Solar collectors (5 m²) and 500 l storage per dwelling unit |
| Electric appliances | Normal Swedish standard, but with energy-efficient household appliances |
| Energy parameters | |
| **Total Floor Area (TFA)** | 2635 m² |
| Annual space heat consumption (measured) | No complete set of measured data is yet available for this project. |
| **Space heat requirement (calculated by PHPP)** | 12.4 kWh/(m²a) |

## CEPHEUS 04 Austria, Egg


Southeast elevation


North elevation

| | |
|---|---|
| Project brief | |
| Location | A-6863 Egg (Vorarlberg, Austria) |
| Developer/client | Kohler Wohnbau GmbH, Andelsbuch |
| Architect | Fink & Thurnher, Bregenz |
| Engineers | Building services: Michael Gutbrunner, Dornbirn |
| Construction period | Commencement: Dec. 1999, completion: Sept. 2000 |
| Building type | Multifamily building |
| Use | Owner-occupied |
| Number of dwelling units | 4 |
| Living floor space | 400 m² |

| | |
|---|---|
| Construction | |
| Type of construction | Solid (brickwork with external thermal insulation compound system) |
| Windows and glazing | Triple low-emissivity glazing, TSET: 53%,<br>standard wooden window frames |
| U-values (W/(m²K)) | External wall: 0.12; ground: 0.14; uppermost ceiling: 0.10; glazing: 0.7; window frame: 1.25; whole window: 0.85 |
| Building services | |
| Heating | Preheating of fresh air by subsoil heat exchanger,<br>floor heating using heat pump (subsoil absorber) |
| Ventilation | Distributed controlled ventilation supply and extraction with heat recovery from extracted air |
| Hot water | Solar collector (35 m²), two 1000 l storage tanks |
| Electric appliances | Provision of advice for occupants, energy-efficient appliances only partly used |
| Energy parameters | |
| **Total Floor Area (TFA)** | 310 m² |
| Annual space heat consumption (measured) | 24.5* kWh/(m²a)<br>*The measured values were normalized to 20°C indoor temperature and extrapolated across a full year. |
| **Space heat requirement (calculated by PHPP)** | 15.7 kWh/(m²a) |

## CEPHEUS 05 Austria, Hörbranz

South elevation

East elevation

| | |
|---|---|
| Project brief | |
| Location | A- 6912 Hörbranz (Vorarlberg, Austria) |
| Client group | Hofer/Österle/Amann |
| Architect | Ing. Richard Caldonazzi, Frastanz |
| Engineers | Building services: Ing. Christof Drexel, Bregenz |
| Construction period | Commencement: Oct. 1998, completion: June 1999 |
| Building type | Terrace |
| Use | Owner-occupied |
| Number of dwelling units | 3 |
| Living floor space | 394 m² |

| Construction | |
|---|---|
| Type of construction | Solid (brickwork with external thermal insulation compound system using cork) |
| Windows and glazing | Triple low-emissivity glazing, TSET: 47%, wooden window frames |
| U-values (W/(m²K)) | External wall: 0.10; basement ceiling: 0.11; roof: 0.09; glazing: 0.6; window frame: 1.12; whole window: 0.83 |
| Building services | |
| Heating | Preheating of fresh air by subsoil heat exchanger,<br>supplementary heating of supply air by a water/air heat exchanger,<br>heat pump or gas boiler as emergency heating |
| Ventilation | Controlled ventilation supply and extraction with heat recovery from extract air |
| Hot water | Façade-integrated solar collector (18 m² per house) with ca. 3000 l buffer storage |
| Electric appliances | High-efficiency appliances are used predominantly |
| Energy parameters | |
| **Total Floor Area (TFA)** | 381 m² |
| Annual space heat consumption (measured) | 7.5* kWh/(m²a)<br>*The measured values were normalized to 20°C indoor temperature and extrapolated across a full year. |
| **Space heat requirement (calculated by PHPP)** | 13.8 kWh/(m²a) |

## CEPHEUS 06 Austria, Wolfurt


South elevation


East elevation

| Project brief | |
|---|---|
| Location | A-6922 Wolfurt (Vorarlberg, Austria) |
| Developer/client | Errichtergemeinschaft Passivhaus Wolfurt-Oberfeld |
| Architect | Dipl.-Ing. Gerhard Zweier, Wolfurt |
| Engineers | Building services: GMI Gasser&Messner-Ingenieure, Dornbirn and Christof Drexel, Bregenz<br>Building physics: Architecturbüro Dr. Lothar Künz, Hard |
| Construction period | Commencement: Feb. 1999, completion: Dec. 1999 |
| Building type | Multifamily building (2 identical buildings) |
| Use | Owner-occupied: 8 dwelling units, one office, one atelier |
| Number of dwelling units | 10 |

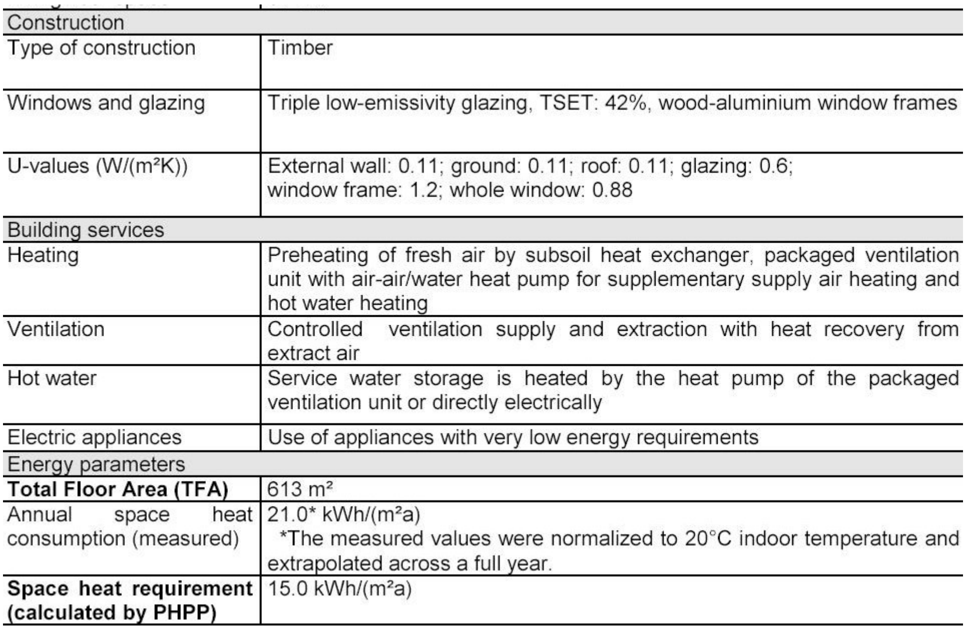
| | |
|---|---|
| Living floor space | 1300 m² |
| Construction | |
| Type of construction | Mixed construction: Steel skeleton with reinforced concrete ceilings and stiffening concrete slabs; external walls are prefabricated timber elements |
| Windows and glazing | Triple low-emissivity glazing, TSET: 53%, wooden window frames with core insulation made of recycled PU material |
| U-values (W/(m²K)) | External wall 1: 0.12; external wall 2: 0.16; basement ceiling: 0.10; roof: 0.09; glazing: 0.70; window frame: 1.0; whole window: 0.82 |
| Building services | |
| Heating | Supplementary heating through hot water register from the centralized buffer storage, the latter heated by a pellet boiler and a solar installation |
| Ventilation | Distributed controlled ventilation supply and extraction with subsoil heat exchanger and heat recovery from extract air |
| Hot water | Solar collector (total: 62 m²), 2500 l joint storage per building |
| Electric appliances | Provision is made for high-efficiency appliances |
| Energy parameters | |
| **Total Floor Area (TFA)** | 1296 m² |
| Annual space heat consumption (measured) | 15.7* kWh/(m²a)<br>*The measured values were normalized to 20°C indoor temperature and extrapolated across a full year. |
| **Space heat requirement (calculated by PHPP)** | 13.5 kWh/(m²a) |

## CEPHEUS 13 Switzerland, Nebikon

South elevation

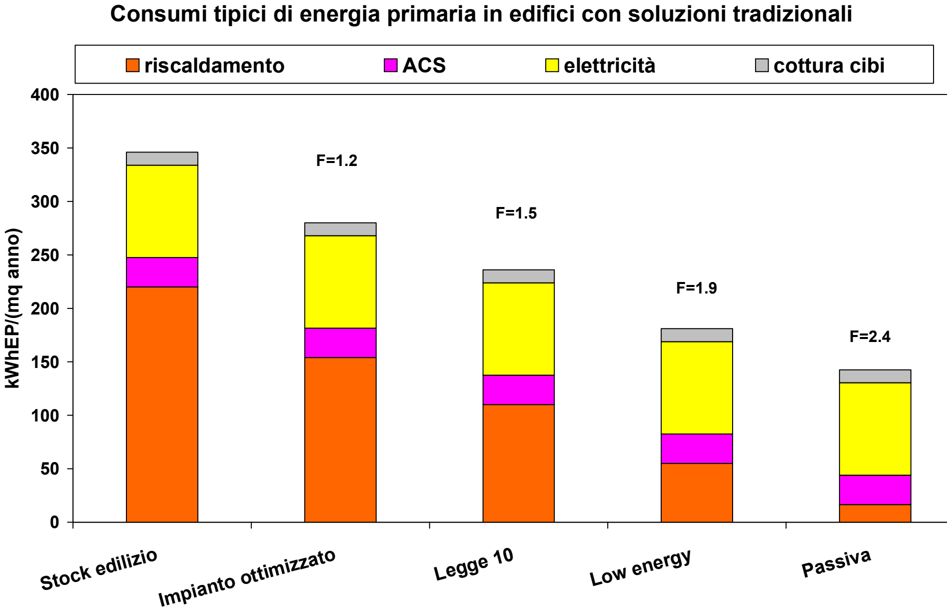
Bird's eye perspective

| | |
|---|---|
| Project brief | |
| Location | CH-6244 Nebikon (Lucerne, Switzerland) |
| Client | Renggli AG, Schötz |
| Architect | Susan Amrhein, Renggli AG, Schötz<br>ASP Architectur und Bauleitungs GmbH, Kassel<br>Lot 2: Prof. Dr. Schneider, Detmold |
| Engineers | Building services: bw Building services AG, Prof. W. Betschart, Hünenberg |
| Construction period | Commencement: May 1999; completion: Nov. 1999 |
| Building type | Terrace |
| Use | Owner-occupied |
| Number of dwelling units | 5 |
| Living floor space | 641 m² |

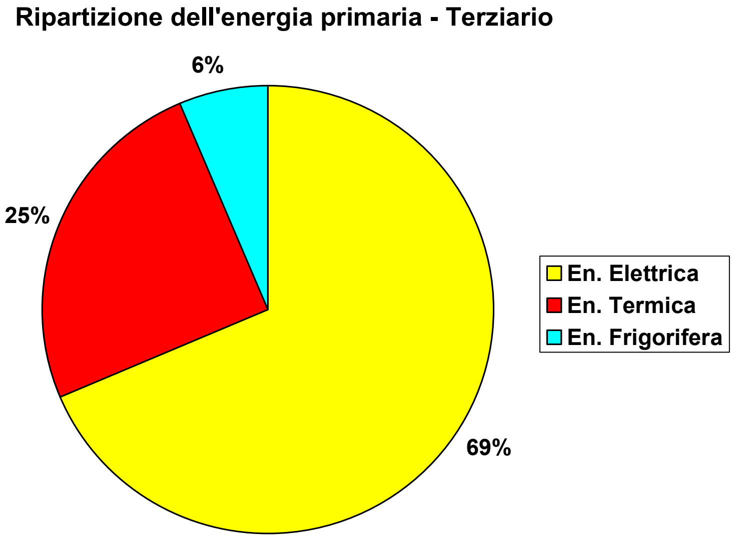


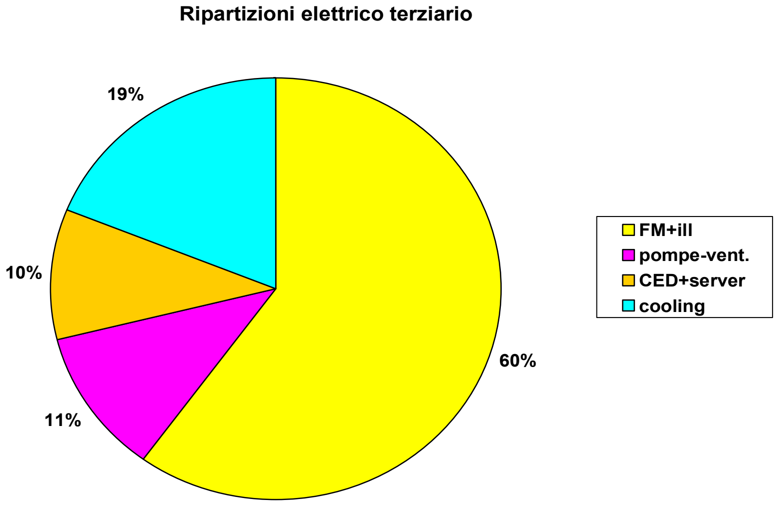
| | |
|---|---|
| Construction | |
| Type of construction | Timber |
| Windows and glazing | Triple low-emissivity glazing, TSET: 42%, wood-aluminium window frames |
| U-values (W/(m²K)) | External wall: 0.11; ground: 0.11; roof: 0.11; glazing: 0.6;<br>window frame: 1.2; whole window: 0.88 |
| Building services | |
| Heating | Preheating of fresh air by subsoil heat exchanger, packaged ventilation unit with air-air/water heat pump for supplementary supply air heating and hot water heating |
| Ventilation | Controlled ventilation supply and extraction with heat recovery from extract air |
| Hot water | Service water storage is heated by the heat pump of the packaged ventilation unit or directly electrically |
| Electric appliances | Use of appliances with very low energy requirements |
| Energy parameters | |
| **Total Floor Area (TFA)** | 613 m² |
| Annual space heat consumption (measured) | 21.0* kWh/(m²a)<br>*The measured values were normalized to 20°C indoor temperature and extrapolated across a full year. |
| **Space heat requirement (calculated by PHPP)** | 15.0 kWh/(m²a) |

# Consumi energetici nel residenziale

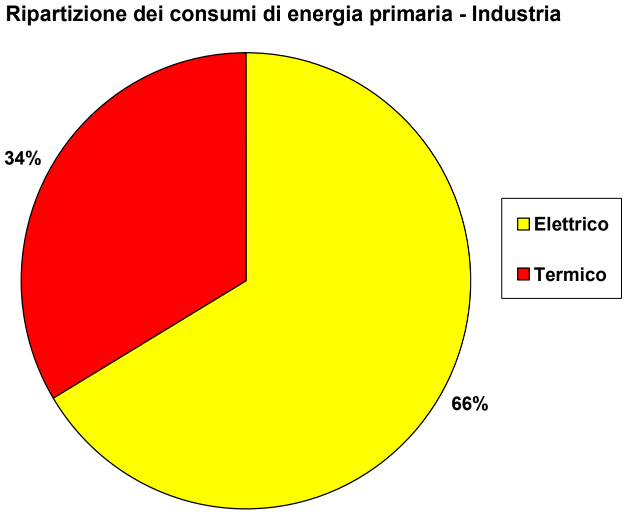


# Consumi energetici nel terziario





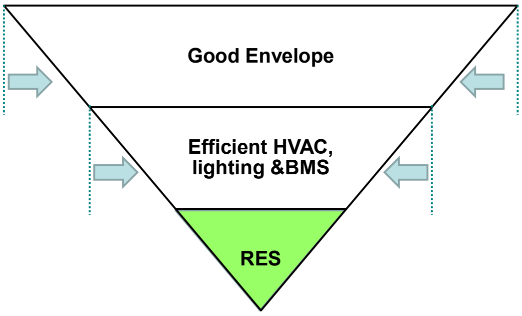
## SETTORE INDUSTRIALE



## Criteri per aumentare l'efficienza energetica di un edificio

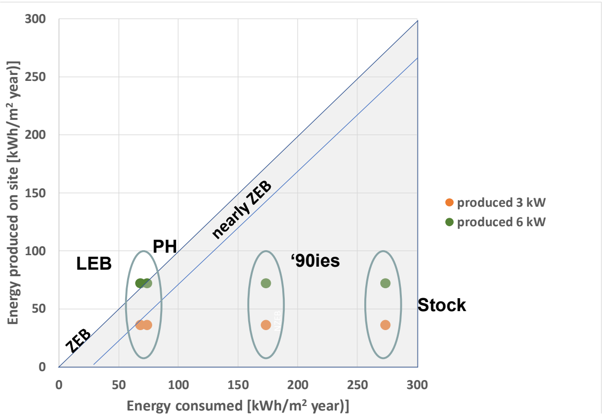
1. Aumento dell'isolamento termico globale dell'involucro e limitazione delle infiltrazioni d'aria non necessarie
2. Controllo dei guadagni gratuiti di calore
3. Aumento dell'efficienza degli impianti tecnici
4. Utilizzo delle enrgie rinnovabili

**Gerarchie di soluzioni**



# Cos’è un Net Zero Energy Building (ZEB) ?

- Definizione più semplice:
  - Su base annua, uso nullo di energia netta



## Cos’è un Net Zero Energy Building (ZEB)?

- Definizione più complicate (ma sempre su base annuale):

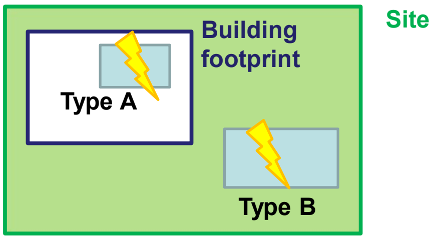
| Definitions | Descriptions |
|---|---|
| Net zero **site** energy building | Building produces as much energy as it consumes when measured on site |
| Net zero **source** energy building | Building produces the same amount of energy as the amount of source (primary) energy it consumes. |
| Net zero energy **cost** | Cost of the energy added to the grid by the building is same as the cost of the energy consumed by it. |
| Net zero **emission** | Net emission due to building energy consumption is zero. |

*P. Torcellini et al., Zero energy buildings: a critical look at the definition, www.nrel.gov/docs/fy06osti/39833.pdf*

# How to reach a ZEB

**Buildings Classified as NZEB:A**
NZEB:A buildings generate and use energy through a combination of energy efficiency and RE collected within the building footprint.

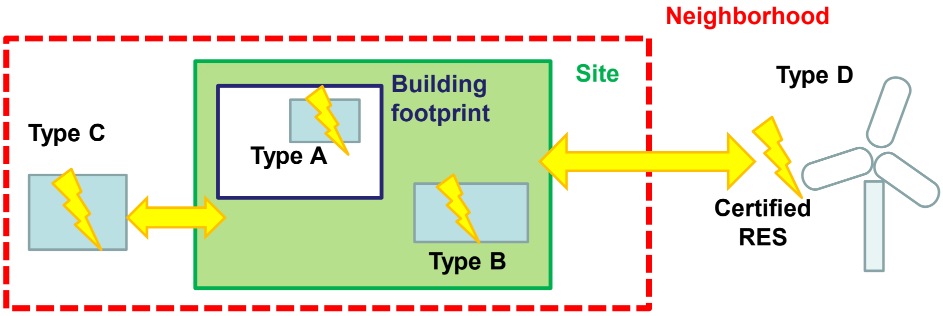
**Buildings Classified as NZEB:B**
NZEB:B buildings generate and use energy through a combination of energy efficiency, RE generated within the footprint, and RE generated within the site.



*The energy Pyramid aas a guiding principal in the  move to net zero, Michael Barancevwicz and John Lord*

**Buildings Classified as NZEB:C**
NZEB:C buildings use the RE strategies as described for NZEB:A and/or NZEB:B buildings to the maximum extent feasible.
These buildings also use Option 3, off-site renewable resources that are brought on site to produce energy.

**Buildings Classified as NZEB:D**
NZEB:D buildings use the energy strategies as described for NZEB:A, NZEB:B, and/or NZEB:C buildings. On-site renewable strategies are used to the maximum extent feasible.
These buildings also use Option 4, purchasing certified off-site RE such as utility-scale wind and RECs from certified sources.

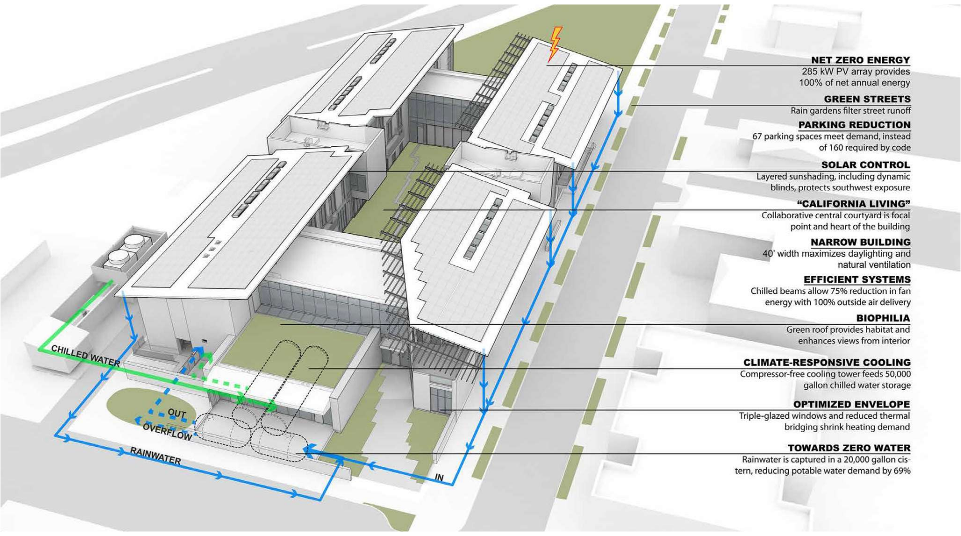


# Un esempio di edificio ZEB

*David and Lucile Packard Foundation HQ – EHDD*

① PV panels supply 100% of energy
② Solar hot water panels
③ 100% of rainwater captured for reuse
④ 40' width maximizes daylighting and natural ventillation
⑤ Dynamic exterior blinds lower with direct sun
⑥ Layered shading strategies
⑦ Triple-glazed, highly insulating windows
⑧ Exposed FSC certified wood structure
⑨ Chilled beams with 100% fresh air
⑩ "Green Street" strategies to capture and filter stromwater

Source: Packard F



**NET ZERO ENERGY**
285 kW PV array provides 100% of net annual energy

**GREEN STREETS**
Rain gardens filter street runoff

**PARKING REDUCTION**
67 parking spaces meet demand, instead of 160 required by code

**SOLAR CONTROL**
Layered sunshading, including dynamic blinds, protects southwest exposure

**"CALIFORNIA LIVING"**
Collaborative central courtyard is focal point and heart of the building

**NARROW BUILDING**
40' width maximizes daylighting and natural ventilation

**EFFICIENT SYSTEMS**
Chilled beams allow 75% reduction in fan energy with 100% outside air delivery

**BIOPHILIA**
Green roof provides habitat and enhances views from interior

**CLIMATE-RESPONSIVE COOLING**
Compressor-free cooling tower feeds 50,000 gallon chilled water storage

**OPTIMIZED ENVELOPE**
Triple-glazed windows and reduced thermal bridging shrink heating demand

**TOWARDS ZERO WATER**
Rainwater is captured in a 20,000 gallon cistern, reducing potable water demand by 69%

Source: Packard F

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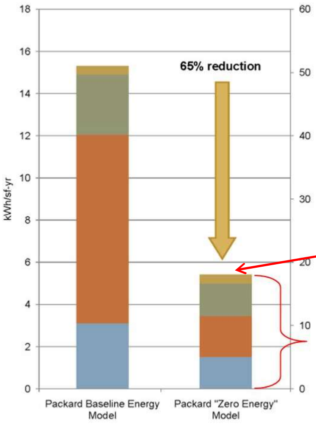
# Energia annua stimata



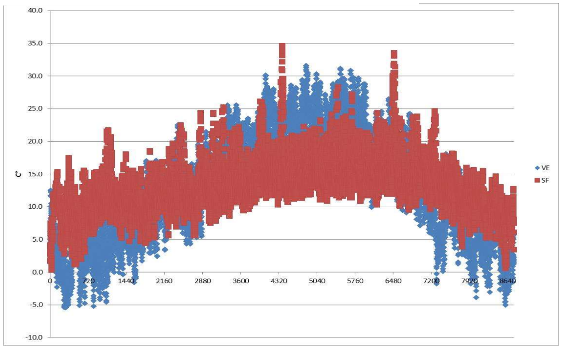
- 🟧 Electric car charging stations
- 🟩 Lighting
- 🟧 HVAC
- 🟦 Plug loads

**Circa 60 kWh/(m$^2$ anno)**

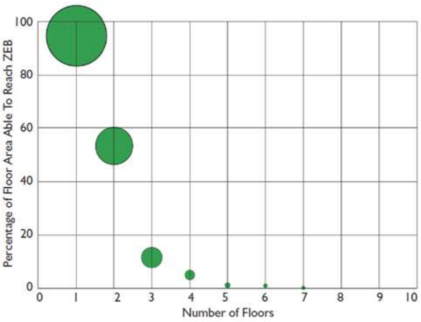
**PVs dimensionati per coprire il 100% della richiesta energetica**

**Ma …**

**Il clima di San Francisco è più favorevole**



# Alcune considerazioni

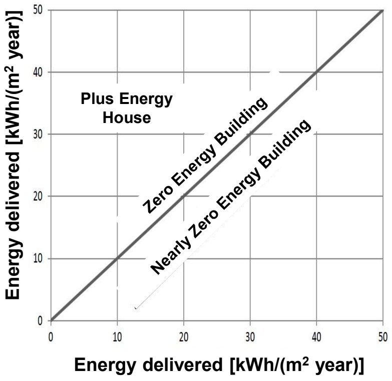


*Torcellini et al 2006*

- All’aumentare dell’altezza diventa più difficile raggiungere uno ZEB
- Più del 50% fegli ZEB sono edifice pubblici
- Normalmente lo ZEB considera altri aspetti di sostenibilità (ad es. Ciclo dell’acqua)

- Carichi elettrici hanno un ruolo importante nei consume finali e non si può più di tanto ridurli
- Bellezza aspetto fondamentale: Bellezza + Ispirazione + Educazione
- La disponibilità di radiazione solare in loco è fondamentale (area del tetto e ombreggiamenti da altri edifici)

# Plus Energy Buildings



- Edificio che produce più energia di quella che consuma
- Una plus energy house deve ottimizzare il consume finale di energia

- La chiave per un PEH è assicurare un adeguato sincronismo tra energia elettrica richiesta e prodotta (massimizzare l’autoproduzione di energia elettrica)

## The first example of PEH 1/2

The German Federal Ministry of Transport, Building and Urban Developments has erected a model building to expand the new initiative «Efficiency House Plus» It was realized in Berlin at the end of 2011.

- Wall heat transfer 0.33 W/($m^2$ K)
- $A_f$ = 149 $m^2$
- Air/water heat pump with a thermal power of 5.8 kW, and storage tank
- Mechanical ventilation with heat recovery
- Photovoltaic array, 22 kW
- Lithium battery with capacity of 40 kWh
- Building management system

## The first example of PEH 2/2

What was supposed to happen:

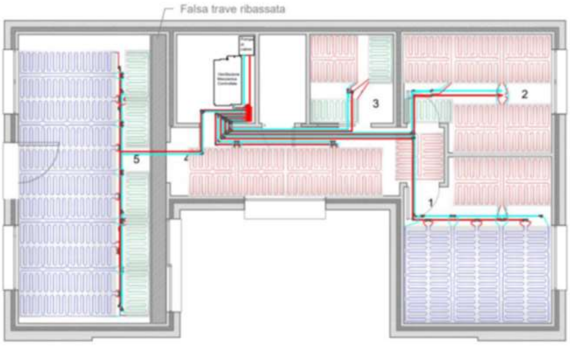
- The annual generation from the PV system should be 16625kWh
- The annual whole energy demand (electricity for the house and for electro-mobility) should be 15380kWh

What happened:

- The first year of operation resulted in 13306 kWh produced by the PV
- 6555 kWh self-consumed
- House energy consumption was 12400 kWh (almost 7000 kWh more than predicted)

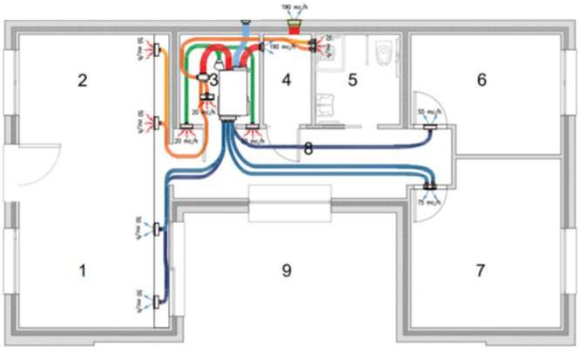
## E noi?

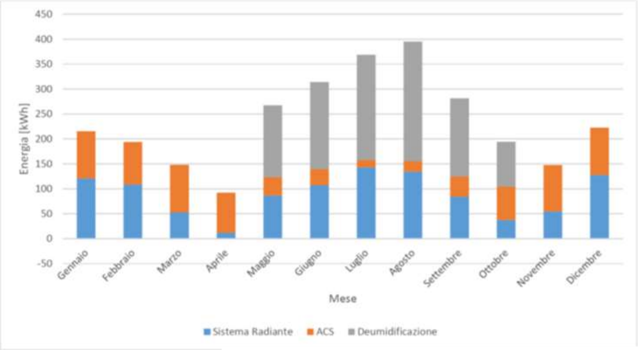
**Progetto UNIZEB (labiratorio ZEB dell'Università di Padova)**



**Impianti raidanti (per caldo e freddo)**

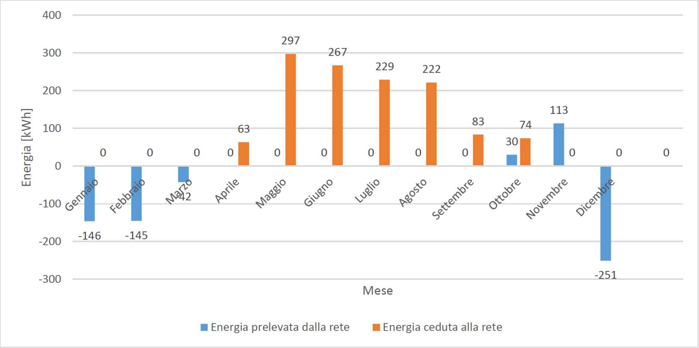
**Ventilazione meccanica controllata (VMC) con aria deumidificata in estate**





**Energia elettrica richiesta dagli impianti**

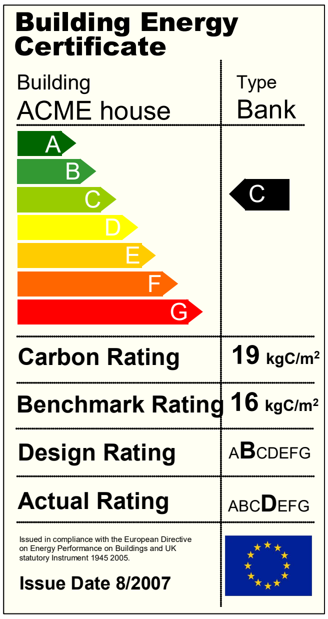
**Energia elettrica complessiva richiesta o venduta mensilmente**



# Energy Performance Certificates

- Energy performance certificate no less than 10 years old available to purchaser/tenant
  *(all domestic and commercial buildings)*
- Label to show:
  - current legal standard
  - benchmarks
  - $CO_2$ emission indicator
- Recommendation for cost effective improvements
- Must be displayed in ***public buildings*** over 1000m$^2$ *(shops, banks, hotels?)*

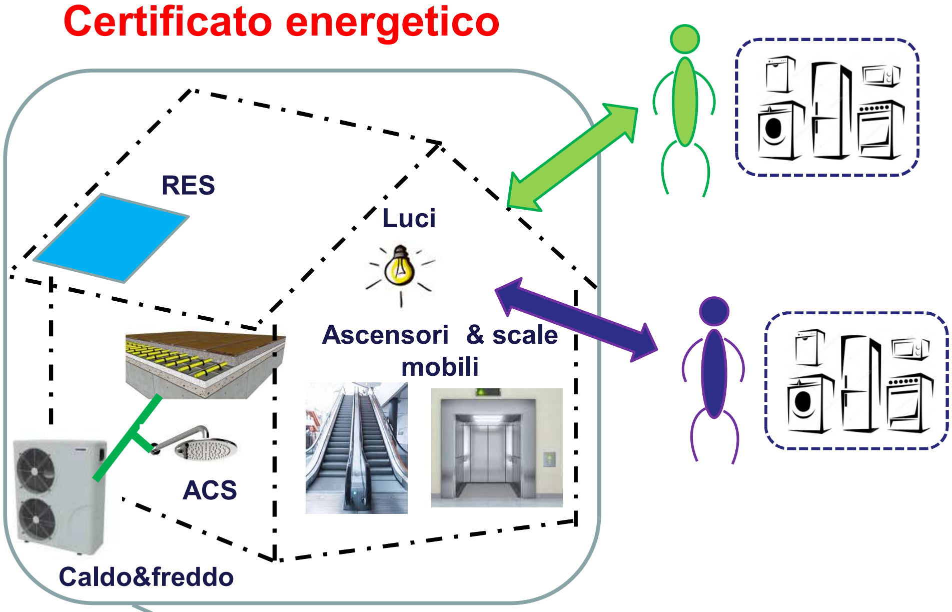
*This could impact on property values*



**Building Energy Certificate**

| Building<br>ACME house | Type<br>Bank |
|---|---|
| A<br>B<br>C<br>D<br>E<br>F<br>G | C |
| **Carbon Rating** | **19** kgC/m$^2$ |
| **Benchmark Rating** | **16** kgC/m$^2$ |
| **Design Rating** | A**B**CDEFG |
| **Actual Rating** | ABC**D**EFG |
| Issued in compliance with the European Directive on Energy Performance on Buildings and UK statutory Instrument 1945 2005.<br>**Issue Date 8/2007** | |

# Certificato energetico



**Non modificabile o se modificabile richiede un nuovo certificate energetico**

**Edifici residenziali**

- **Caldo**
- **Freddo**
- **ACS**

**Edifici non residenziali**

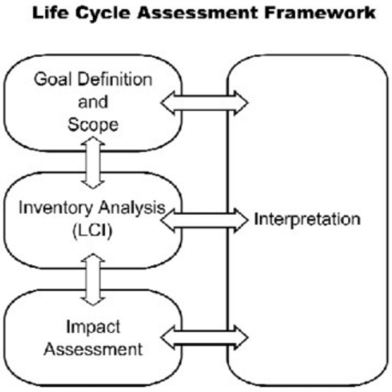
- **Caldo**
- **Freddo**
- **ACS**
- **Illuminazione**
- **Ascensori & scale mobili**

A causa del limitato impatto dell’illuminazione rispetto al consumo complessivo di edifici residenziali, per questi si richiede caldo, freddo e ACS
Negli edifici non residenziali l’illuminazione e la movimentazione di persone ha un ruolo più importante e quindi se ne tiene conto

# Life Cycle Analysis

Per considerare le emission complessive di un Sistema si ricorre all'analisi LCA (Life Cycle Analysis).

(a)



(b)

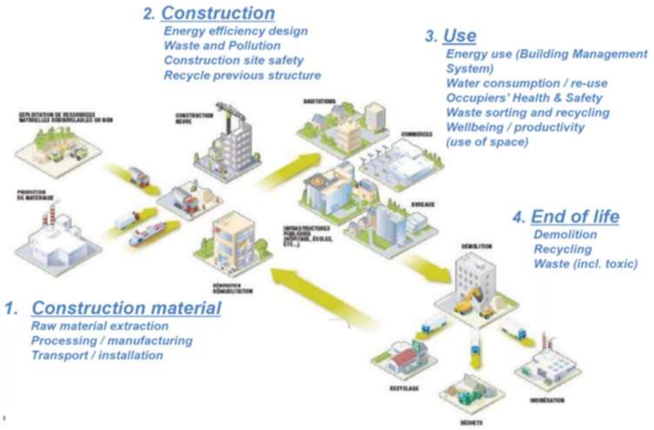
**LCA, although interesting, is complicated and limited in buildings.**

# Certificati ambientali

LCA negli edifice è un approccio interessante ma ha molti limiti e presenta diverse problematiche dal momento che non è un prodotto standardizzato o di serie come accade per prodotti industriali:

- L'impatto dei materiali non è sempre del tutto chiaro
- La scelta della durata dell'edificio non è sempre univocal (30 anni? 70 anni? Secoli?)
- Negli edifice I processi costruttivi sono complessi e molto spesso la stessa edificazione è complessa.
- Ci sono alcuni aspetti architettonici che non possono essere facilmente misurati e valutati
- L'analisi LCA si basa sulla quantificazione precisa dei materiali e la conoscenza esatta dei materiali si può avere solo alla fine del processo progettuale (progetto esecutivo o costruttivo), quindi non è uno strumento progettuale che aiuta a migliorare il progetto con processi iterative
- Usualmente il maggiore impatto è in condizioni operative

Pertanto **i certificate ambientali** sono stati introdotti permettendo di avere una votazione per I diversi criteri, considerando I diversi aspetti dell'edificio, non solo il consume di energia in condizioni operative.



- BREEAM, BRE (Building Research Establishment) Environmental Assessment Method, proposed by BRE in the United Kingdom;
- LEED (Leader in Energy and Environmental Design), proposed by GBC, Green Building Council of the United States
- Green Star, proposed by the Green Building Council Australia
- CASBEE, Comprehensive Assessment System for Built Environment Efficiency, proposed by Japan GreenBuild Council and Japan Sustainable Building Consortium.

## Aree di valutazione dei certificate ambientali degli edifici

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation in design
- Sustainable transportation

## Due possibiuli certificazioni

**Progettazione, costruzione e fase operativa**

Verifica dell’edificio in fase progettuale.

Collaborazione costante tra I diversi progettisti secondo un approccio integrato. Lavoro ricorsivo per ottimizzare l’edificio.

Validazione dell’edificio durante la costruzione e nella prima fase di funzionamento dell’edificio (commissioning)

**Fase operativa**

Verifica di come viene gestito l’edificio e come le raccomandazioni di sostenibilità vengono rispettate

Fornisce anche delle linee guida che stabiliscono il percorso su come migliorare ulteriormente la sostenibilità dell’edificio, firnendo regole per gli occupanti.

Il Palazzo Bo è certificato BREEAM in use

## Politiche e soluzioni

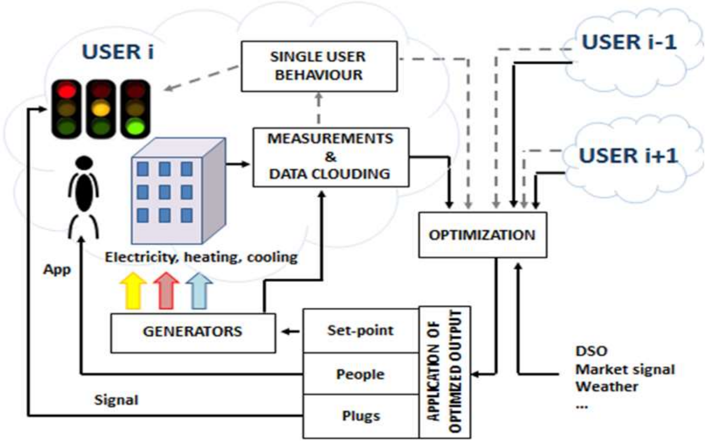
L’Europa ci chiede di aumentare l’efficienza e di arrivare al 2050 a completa decarbonizzazione

Settori:

- Riqualificazione degli edifici
- Sistemi prefabbricati
- Materiali (isolanti)
- Energie rinnovabili
- Stoccaggio
- Soluzioni a basso costo (soluzioni «Plug and play»)

- Richiesta di housing sociale (2000 edifici solo nel comune di Padova)
- Povertà energetica
- Necessità di ristrutturazioni (retrofit)
- ZEB (Zero Energy Buildings) e PEH (Plus Energy Houses)

- Come rendere le persone più attive nei consumi energetici (occupant’s behaviour and engagement, demand-response)



- Sensori, software, devices, modelli socio-economici

- Infrastrutture (reti di teleriscaldamento/teleraffrescamento)
- Recupero energetico (da acque reflue, dall’industria)