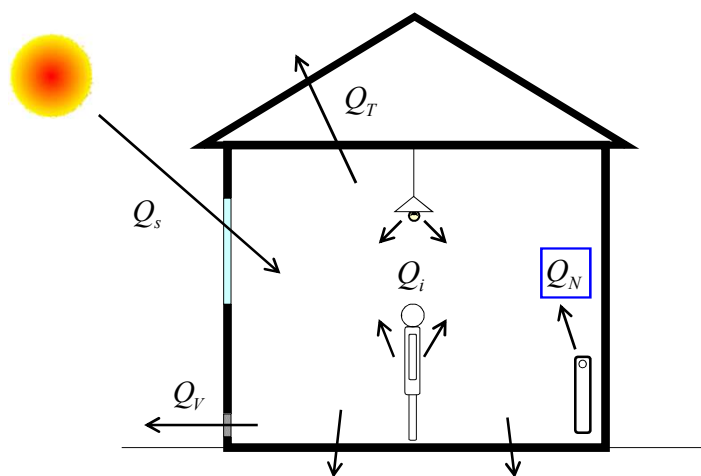
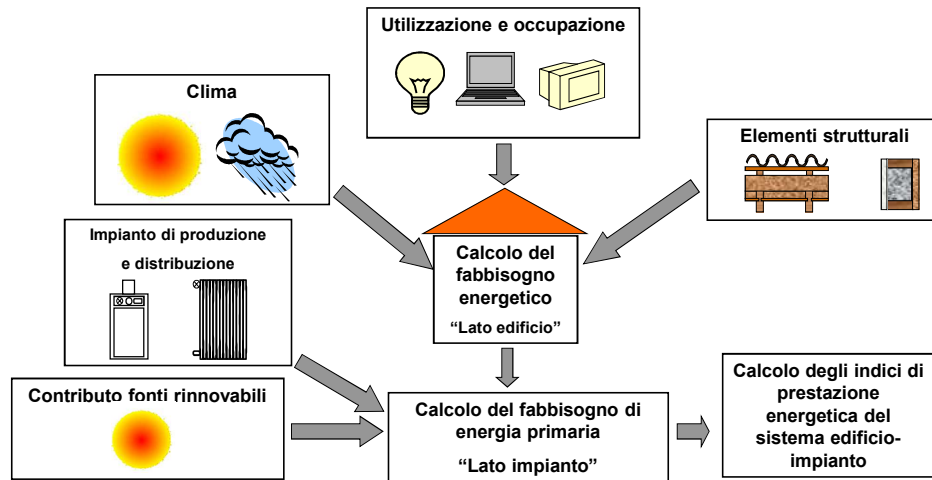


L'ENERGIA NEGLI EDIFICI

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.

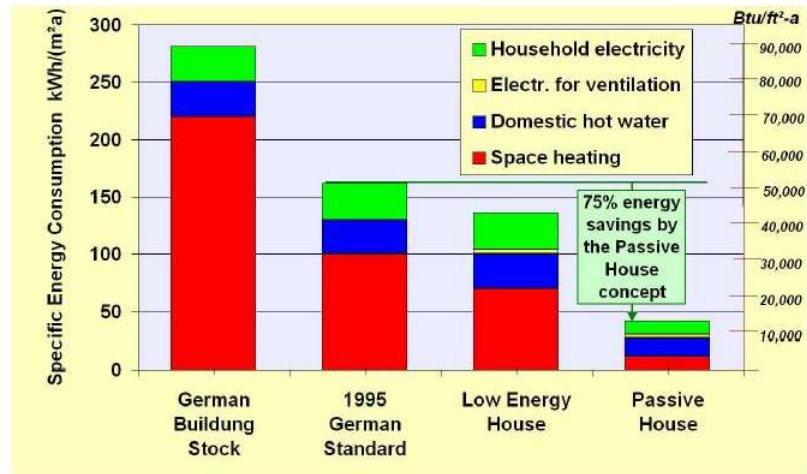
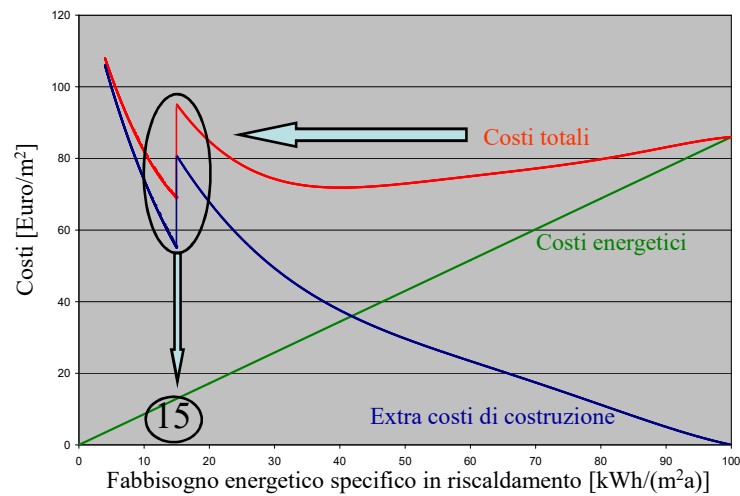


Figure 1: Comparison of specific energy consumption levels of dwellings

Edifici passivi "PassivHaus" (2/2)



A comparative analysis

Let's consider a 100 m² 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 kWh 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	electr.	overall
	gas	electr.	gas	electr.	gas	electr.	electr.		
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

Electricity: 0.22 €/kWhe

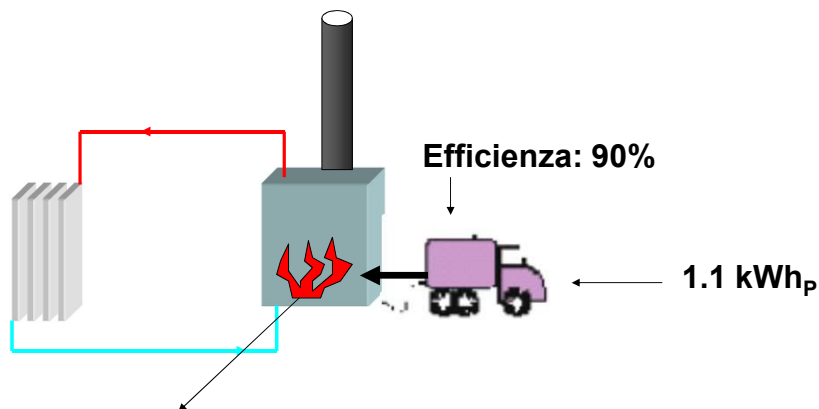
Natural gas: 0.08 €/kWht

	Final energy per energy carrier [kWh/(m ² y)]								
	heating		DHW		cooking		cooling	electr.	overall
	gas	electr.	gas	electr.	gas	electr.	electr.		
Stock	16	-	1.6	-	0.8	-	1.76	7.7	27.9
Buildings '90ies	8	-	1.6	-	0.8	-	1.76	7.7	19.9
LEB	-	2,42	-	1.76	-	1.32	1.76	7.7	15
PH	-	3.3	-	2.2	-	1.32	1.76	7.7	16.3

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	electr.	overall	
	gas	electr.	gas	electr.	gas	electr.	electr.			
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	

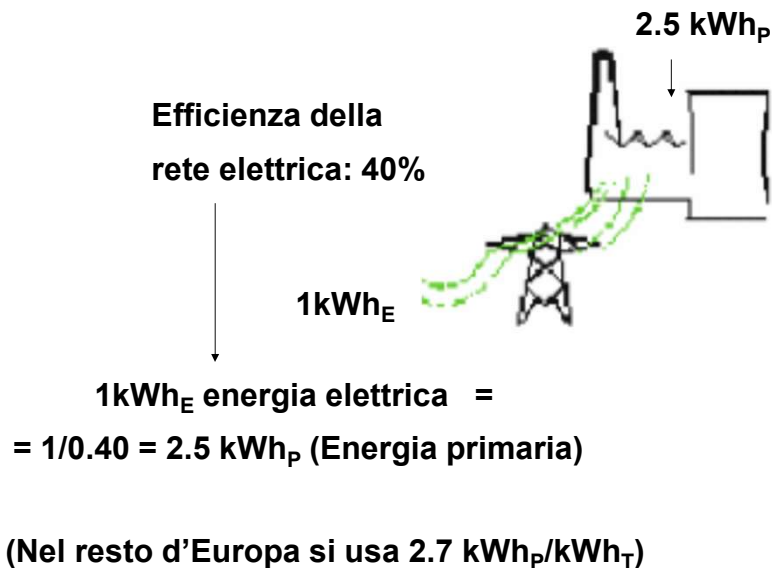
Energia primaria da fonti fossili



$1 \text{ kWh}_T \text{ bruciato} = 1/0.9 = 1.1 \text{ kWh}_p$ (Energia primaria)

(Nel resto d'Europa si usa $1.1 \text{ kWh}_p/\text{kWh}_T$)

Energia primaria da energia elettrica



Considering again the specific final energy per energy carrier:

	Final energy per energy carrier [kWh/(m ² y)]								
	heating		DHW		cooking		cooling	electr.	overall
	gas	electr.	gas	electr.	gas	electr.	electr.		
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/(m ² y)]								
	heating		DHW		cooking		cooling	electr.	overall
	gas	electr.	gas	electr.	gas	electr.	electr.		
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 kWh/(m² year) and 72 kWh/(m² year) respectively.

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

	Final energy [kWh/(m ² 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%

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

	Primary energy [kWh/(m ² 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%

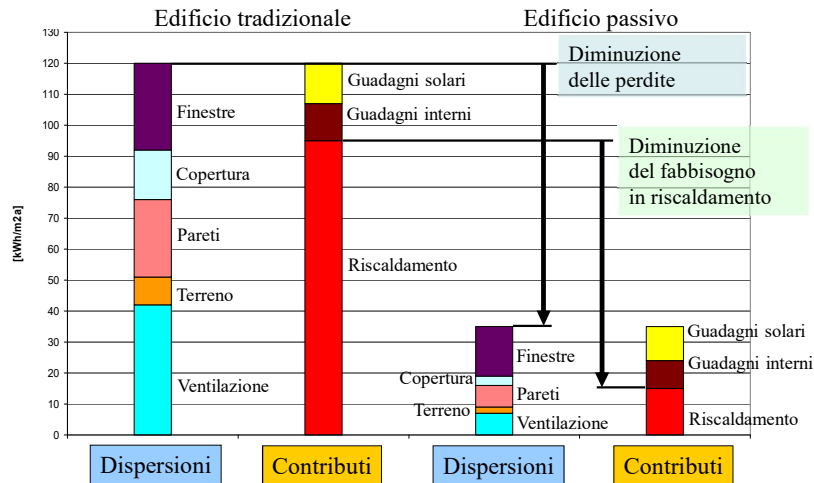
Costs

Natural gas costs 0.08 €/kWh and electricity costs 0.22 €/kWh.

The costs assume that 50% of electricity produced is self-consumed and 50% is sold, leading to an average value of 0.15 €/kWh 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 €

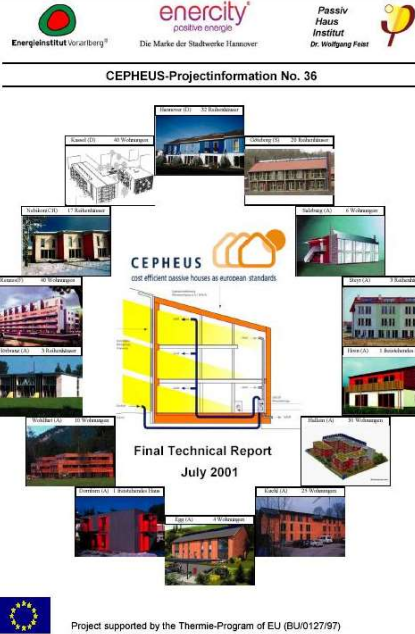
Esempio di confronto del bilancio termico tra un edificio tradizionale ed un edificio passivo



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 energie rinnovabili

PROGETTO CEPHEUS



"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/(m²a). 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.

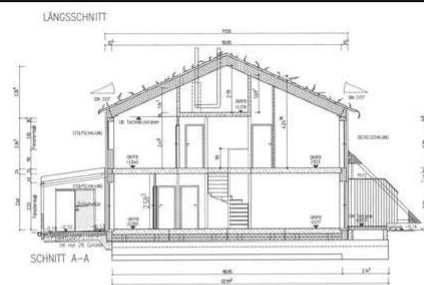
It is a part of the Passive House philosophy that efficient technologies are also used to minimize the other sources of energy consumption in the building, notably electricity for household appliances. The target of the CEPHEUS project is to keep the **total primary energy requirement** for space heating, domestic hot water and household appliances below 120 kWh/(m²a). 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 m ²

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/(m ² K))	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 m ²) 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 Lûx house type (mid- and end-terrace): 119.5 m ² , Jangster house type: 97 m ² , "123"house type: 75 m ²
Annual space heat consumption (measured)	15.3* kWh/(m ² a) *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/(m ² a)

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 ASP Planungs- und Bauleitungs-GmbH, Kassel Lot 2: Prof. Dr. Schneider, Detmold
Engineers	Statics: Klute & Klute, Kassel 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 *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) 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 m ²
Construction	
Type of construction	Timber
Windows and glazing	Double low-emissivity glazing with coated glass, TSET: 40%, wooden window frames
U-values (W/(m ² K))	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 m ²) 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 m ²
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/(m ² a)

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 m ²

Construction	
Type of construction	Solid (brickwork with external thermal insulation compound system)
Windows and glazing	Triple low-emissivity glazing, TSET: 53%, standard wooden window frames
U-values (W/(m ² K))	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, 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 m ²), 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 m ²
Annual space heat consumption (measured)	24.5* kWh/(m ² a) *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/(m ² a)

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 m ²

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/(m ² K))	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, supplementary heating of supply air by a water/air heat exchanger, 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 m ² per house) with ca. 3000 l buffer storage
Electric appliances	High-efficiency appliances are used predominantly
Energy parameters	
Total Floor Area (TFA)	381 m ²
Annual space heat consumption (measured)	7.5* kWh/(m ² a) *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/(m ² a)

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 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 m ²
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/(m ² K))	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 m ²), 2500 l joint storage per building
Electric appliances	Provision is made for high-efficiency appliances
Energy parameters	
Total Floor Area (TFA)	1296 m ²
Annual space heat consumption (measured)	15.7* kWh/(m ² a) *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/(m ² a)

CEPHEUS 13 Switzerland, Nebikon



South elevation

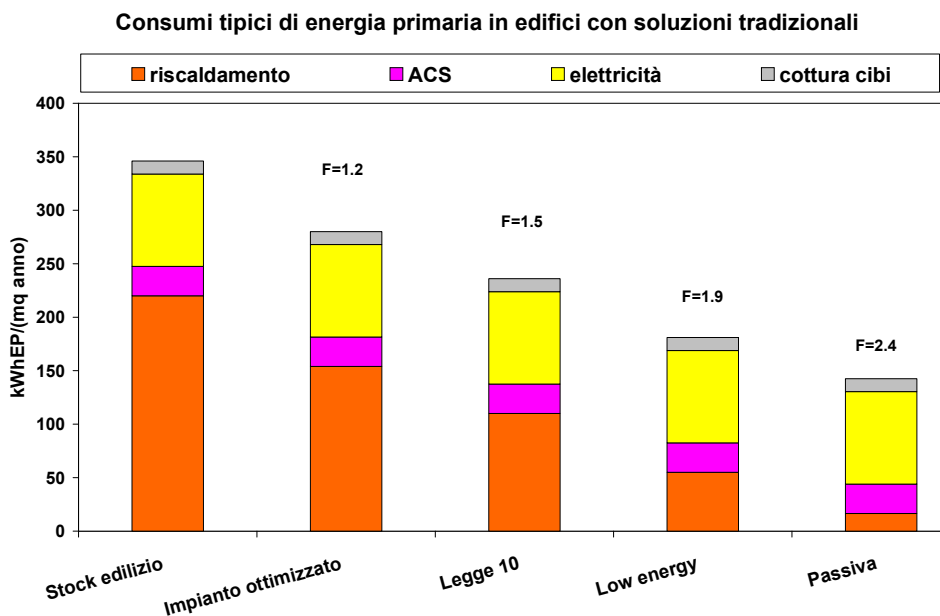


Bird's eye perspective

Project brief	
Location	CH-6244 Nebikon (Lucerne, Switzerland)
Client	Renggli AG, Schötz
Architect	Susan Amrhein, Renggli AG, Schötz ASP Architectur und Bauleitungs GmbH, Kassel 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 m ²

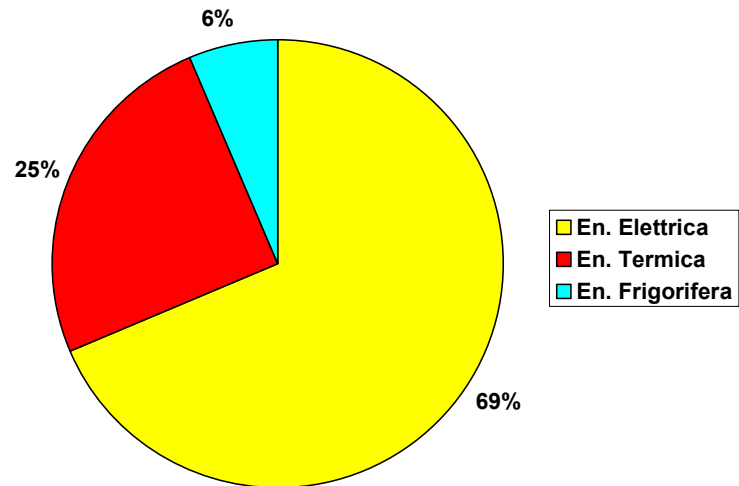
Construction	
Type of construction	Timber
Windows and glazing	Triple low-emissivity glazing, TSET: 42%, wood-aluminium window frames
U-values (W/(m ² K))	External wall: 0.11; ground: 0.11; roof: 0.11; glazing: 0.6; window frame: 1.2; whole window: 0.88
Building services	
Heating	Preheating of fresh air 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 m ²
Annual space heat consumption (measured)	21.0* kWh/(m ² a) *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/(m ² a)

Consumi energetici nel residenziale

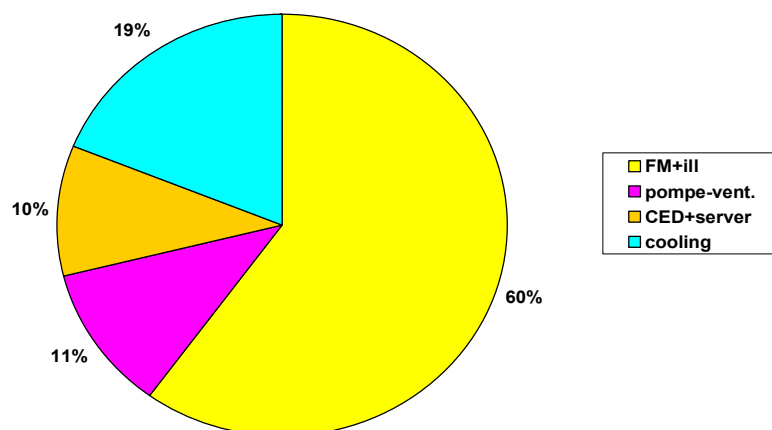


Consumi energetici nel terziario

Ripartizione dell'energia primaria - Terziario

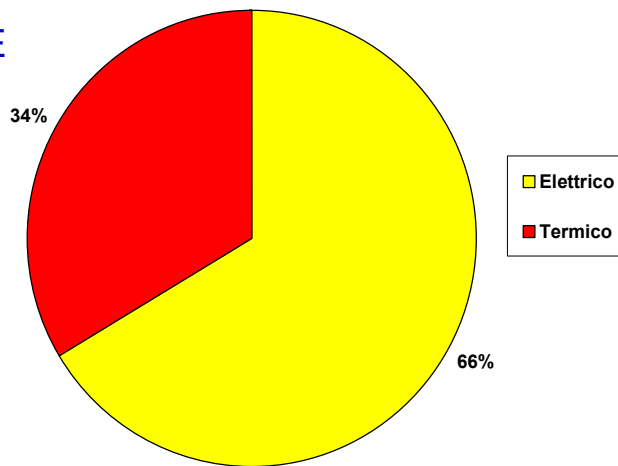


Ripartizioni elettrico terziario



SETTORE INDUSTRIALE

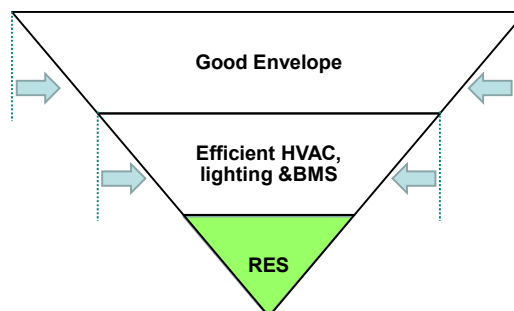
Ripartizione dei consumi di energia primaria - Industria



Criteri per aumentare l'efficienza energetica di un edificio

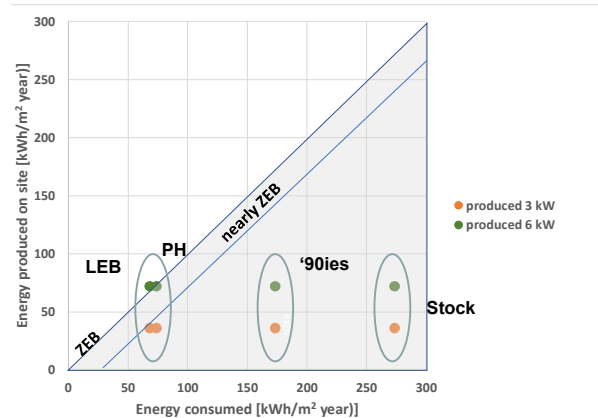
1. Aumento dell'isolamento termico globale dell'involucro e limitazione delle infiltrazioni d'aria non necessarie
2. Controllo dei guadagni gratuiti di calore
3. Aumento dell'efficienza degli impianti tecnici
4. Utilizzo delle energie rinnovabili

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

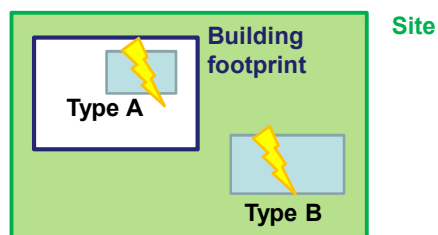
How to reach a ZEB

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 as a guiding principal in the move to net zero, Michael Barancewicz and John Lord

Buildings Classified as NZEB:C

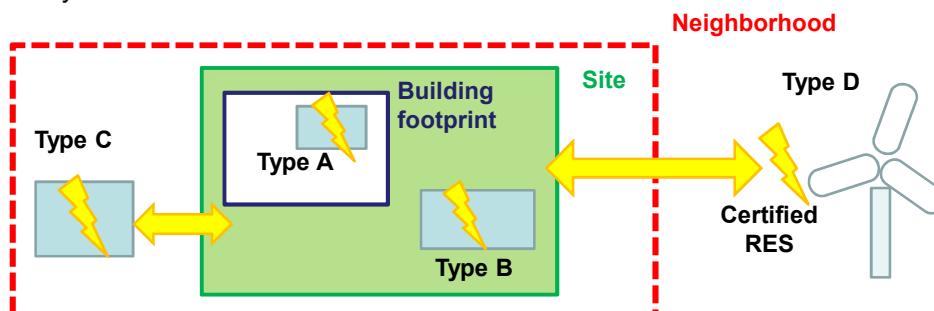
NZEB:C buildings use the RE strategies as described for NZEB:A and/or NZEB:B buildings to the maximum extent feasible.

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

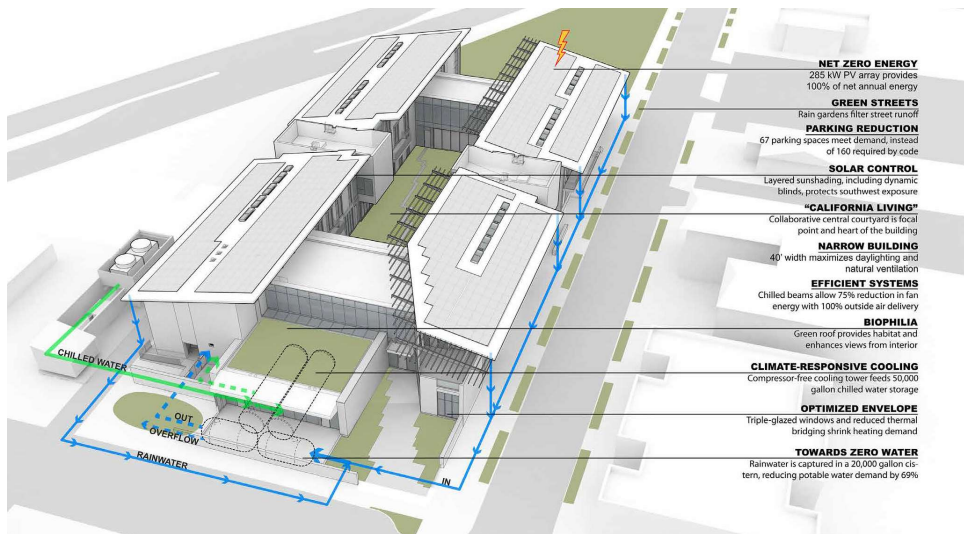


David and Lucile Packard Foundation HQ – EHDD

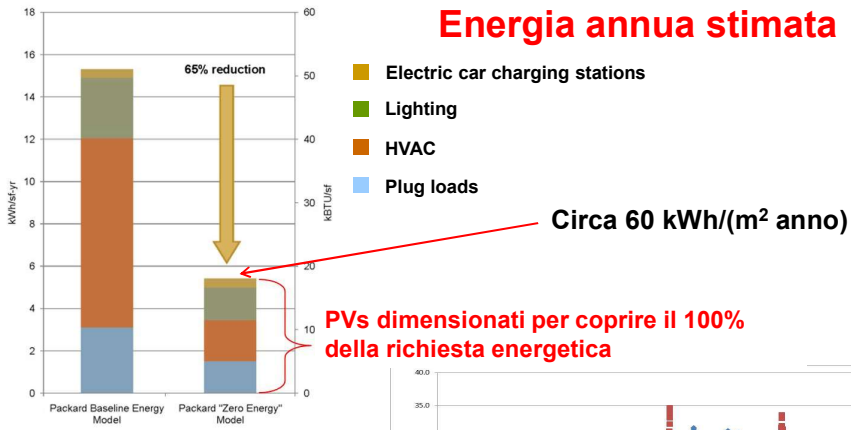


- | | |
|---|---|
| 1 PV panels supply 100% of energy | 4 Layered shading strategies |
| 2 Solar hot water panels | 7 Triple-glazed, highly insulating windows |
| 3 100% of rainwater captured for reuse | 8 Exposed FSC certified wood structure |
| 4 40' width maximizes daylighting and natural ventilation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

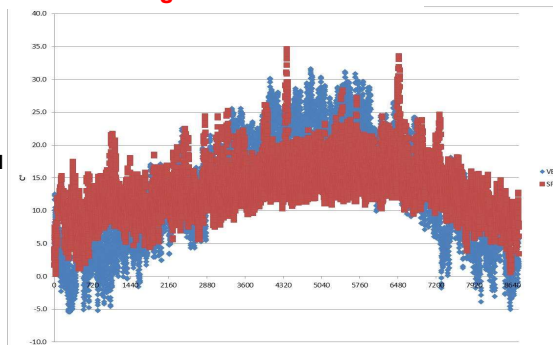
Source: Packard F



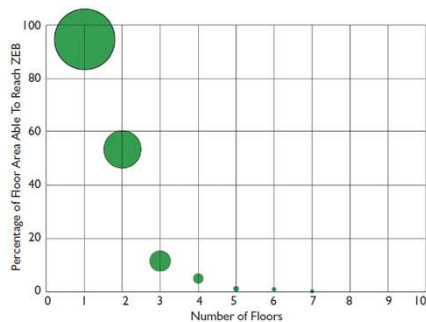
Source: Packard F



Ma ...
 Il clima di San Francisco è più favorevole



Alcune considerazioni

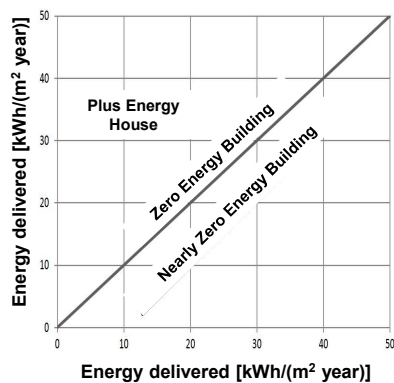


Torcellini et al 2006

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

- Carichi elettrici hanno un ruolo importante nei consumi 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 consumo 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 $0.33 \text{ W}/(\text{m}^2 \text{ K})$
- $A_f = 149 \text{ m}^2$
- 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:

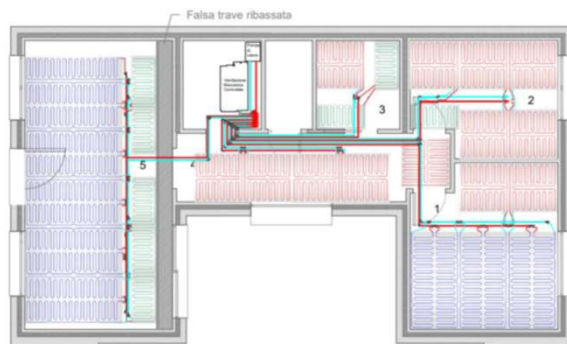
- The annual generation from the PV system should be 16625kWh
- The annual whole energy demand (electricity for the house and for electro-mobility) should be 15380kWh

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)

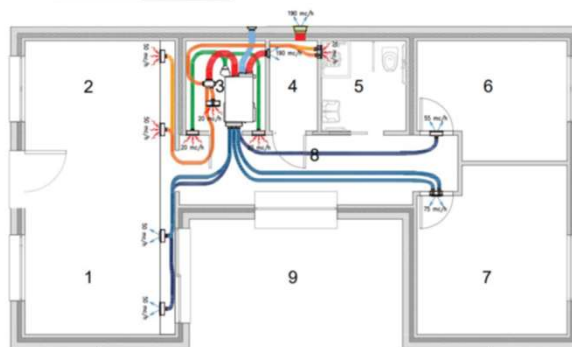
E noi?

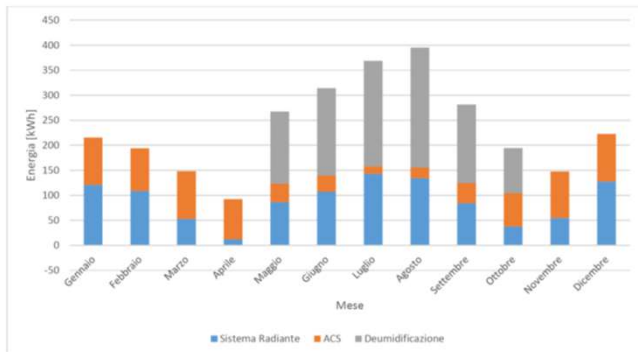
**Progetto UNIZEB
(laboratorio ZEB
dell'Università di Padova)**



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

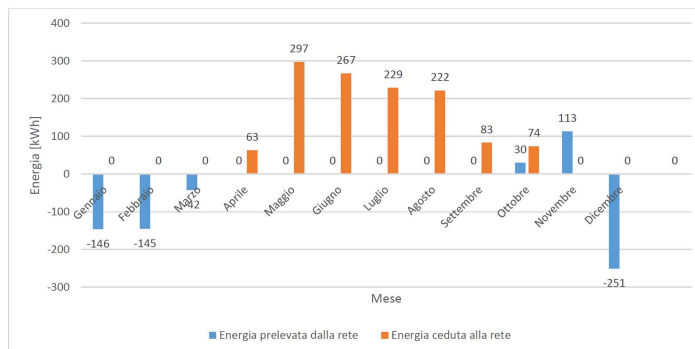
**Ventilazione
meccanica
controllata (VMC)
con aria
deumidificata in
estate**





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
 - CO₂ emission indicator
- Recommendation for cost effective improvements
- Must be displayed in **public buildings** over 1000m² (*shops, banks, hotels?*)

This could impact on property values

Building Energy Certificate	
Building ACME house	Type Bank
Carbon Rating	19 kgC/m²
Benchmark Rating	16 kgC/m²
Design Rating	ABCDEFG
Actual Rating	ABCDEFG
<small>Issued in compliance with the European Directive on Energy Performance on Buildings and UK statutory instrument 1945/2005.</small>	
Issue Date 8/2007	

Certificato energetico



Non modificabile o se modificabile richiede un nuovo certificato energetico

Edifici residenziali

- Caldo
- Freddo
- ACS

Edifici non residenziali

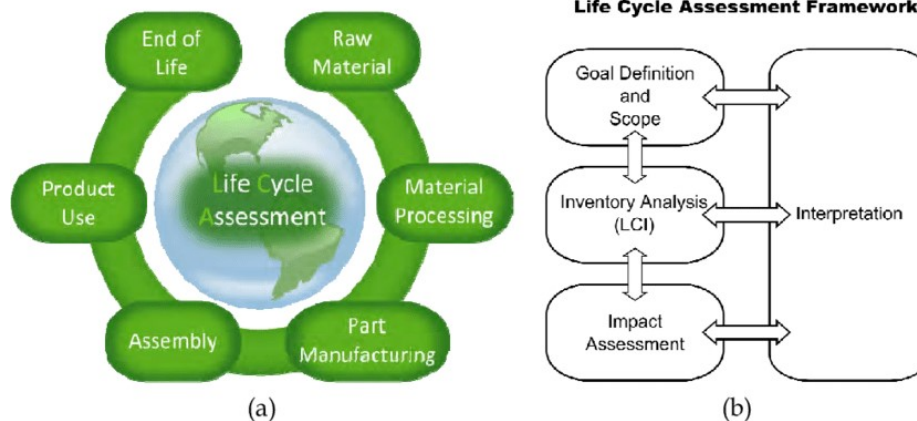
- Caldo
- Freddo
- ACS
- Illuminazione
- Ascensori & scale mobili

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 emissioni complessive di un Sistema si ricorre all'analisi LCA (Life Cycle Analysis).



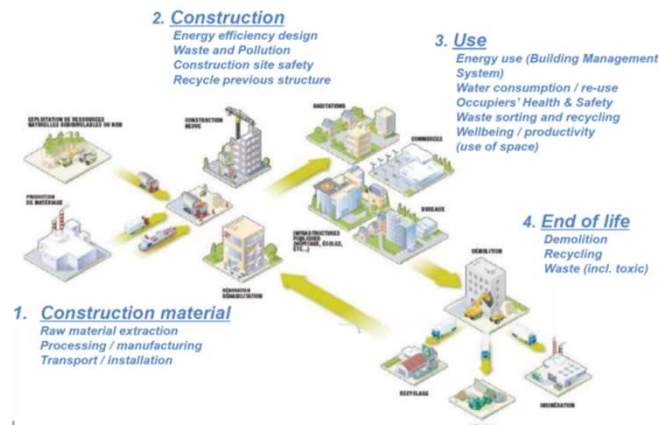
LCA, although interesting, is complicated and limited in buildings.

Certificati ambientali

LCA negli edifici 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 univoca (30 anni? 70 anni? Secoli?)
- Negli edifici 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 iterativi
- Usualmente il maggiore impatto è in condizioni operative

Pertanto i **certificati ambientali** sono stati introdotti permettendo di avere una votazione per i diversi criteri, considerando i diversi aspetti dell'edificio, non solo il consumo 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.

Area 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 possibili 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, firmando regole per gli occupanti.

Il Palazzo Bo è certificato BREEAM in use



Politiche e soluzioni

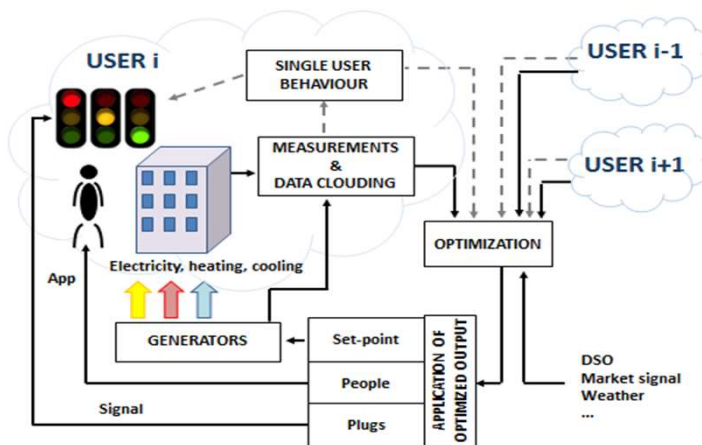
L'Europa ci chiede di aumentare l'efficienza e di arrivare al 2050 a completa decarbonizzazione

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

