CITTÀ STUDI
CAMPUS SOSTENIBILE

POLITECNICO
MILANO 1863

SCUOLA
Smart Campus as Urban Open LAbs

EUGUGLE

RENEW SCHOOL

19 ottobre 2015
Giornate della Sostenibilità

I CAMBIAMENTI CLIMATICI: DAGLI SCENARI GLOBALI ALL'AULA DEL POLITECNICO

La ristrutturazione degli edifici nel settore educazione e per uffici

Prof. L. PAGLIANO

Ing. M. PIETROBON

end-use Efficiency Research Group www.eerg.it del POLITECNICO DI MILANO

Energy Directive (2010) art.9: stimulate zero-energy retrofit

Article 9

Nearly zero-energy buildings

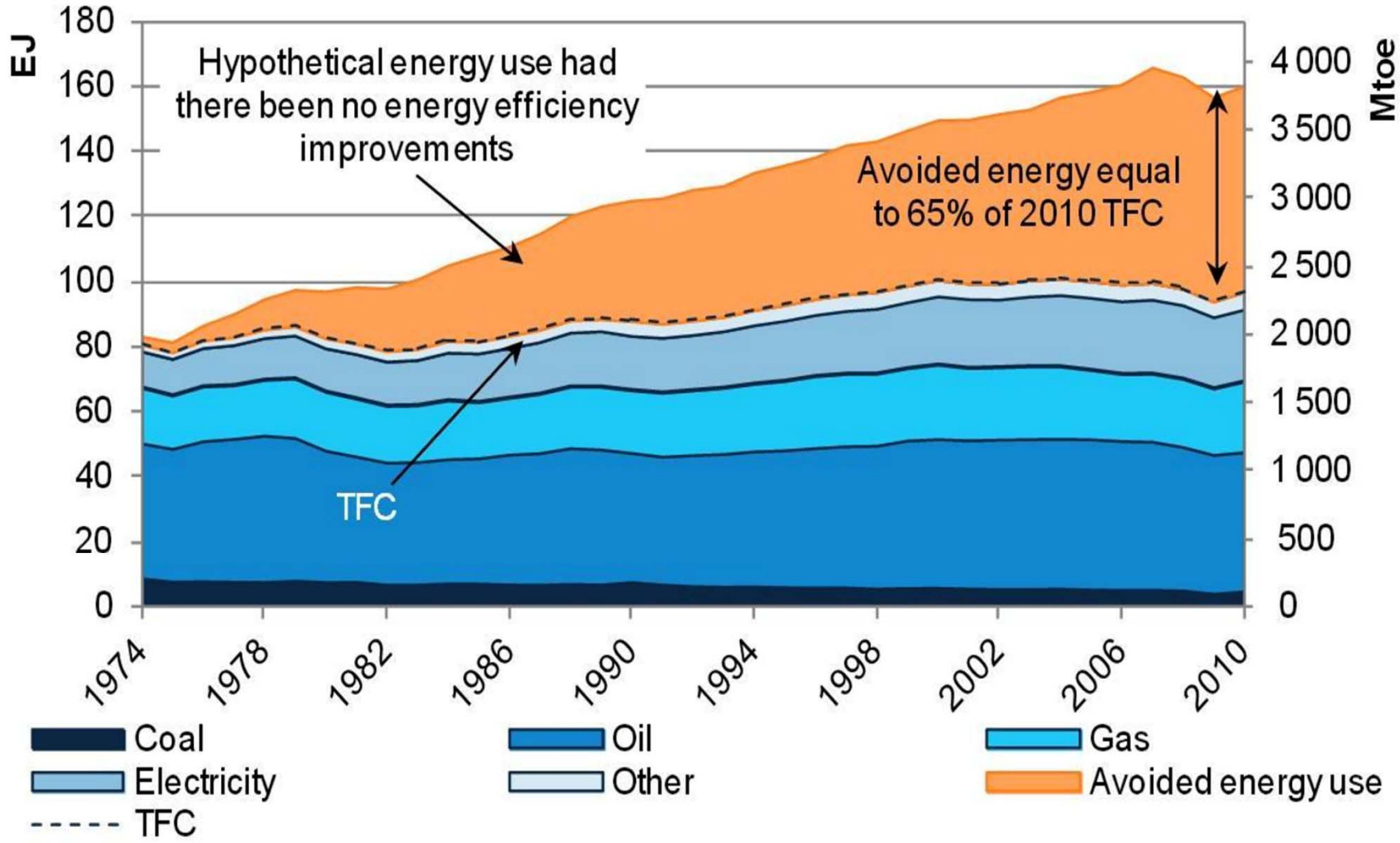
1. Member States shall ensure that:

(a) by 31 December 2020, all new buildings are nearly zero-energy buildings; and

(b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

2. Member States shall furthermore, following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings, and inform the Commission thereof in their national plans referred to in paragraph 1.

Energy efficiency is the first fuel, equivalent to 65% of Total Fuel Consumption (International Energy Agency 2013)



Analisi da cui partire (più alcuni casi studio da “SCUOLA” e altri progetti EU in cui siamo partner/coordinatori)

a) Towards nearly-zero energy buildings

Gruppo eERG del Politecnico di Milano con

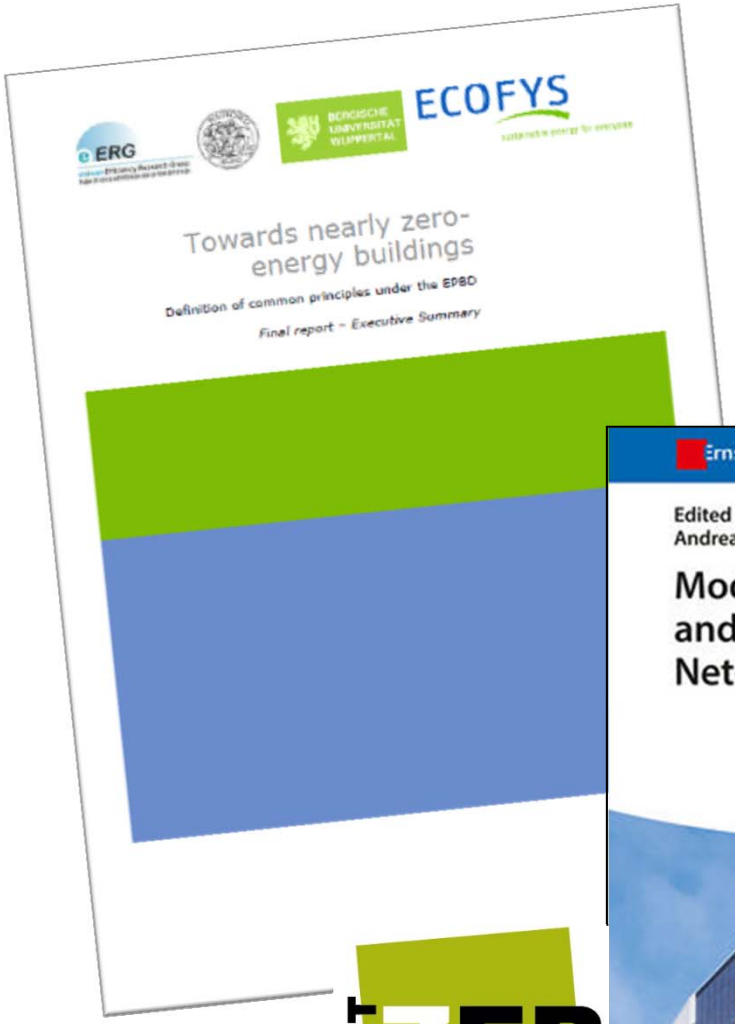
Università di Wuppertal e ECOFYS

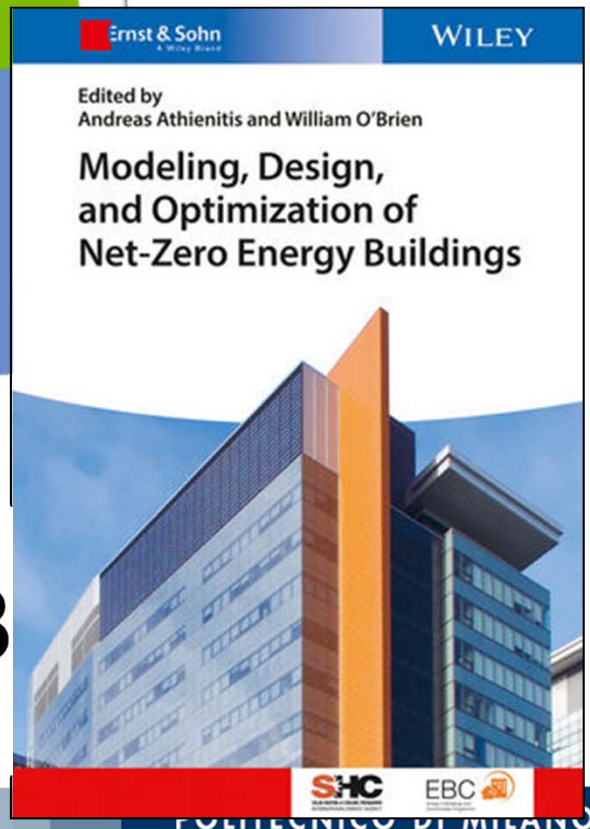
Scaricabile da

www.eerg.it e dal sito DG-Energy / NZEB

b) Modelling, design, optimization of NZEBs, International Energy Agency Annex 52 working group, Wiley,

c) Cost-optimal Regulation of EU Commission, JRC report





NET ZEB
TASK 40 / ANNEX 52

a) Limit on the **ENERGY NEEDS** (fabbisogno di energia per riscaldamento, raffrescamento, illuminazione):

Prescriptive approach = limit to the minimum performance components

U-values and g-values, installed power for lighting, specific fan power

b) COMFORT: limit for the thermal (and visual) discomfort using a **LONG-TERM DISCOMFORT INDEX**. (e.g. LDP, suggeste by IEA)

c) Target for the **TIME MATCH or MISMATCH BETWEEN BUILDING ENERGY NEEDS AND ENERGY PRODUCTION FROM RENEWABLE** (e.g. LOAD-MATCHING INDEX):

d) Limit on the **YEARLY NET PRIMARY ENERGY** as defined in EN 15603 accompanied by balances over shorter periods e.g. month

Energy NEEDS and NET PRIMARY ENERGY (from Cost-optimal methodology)

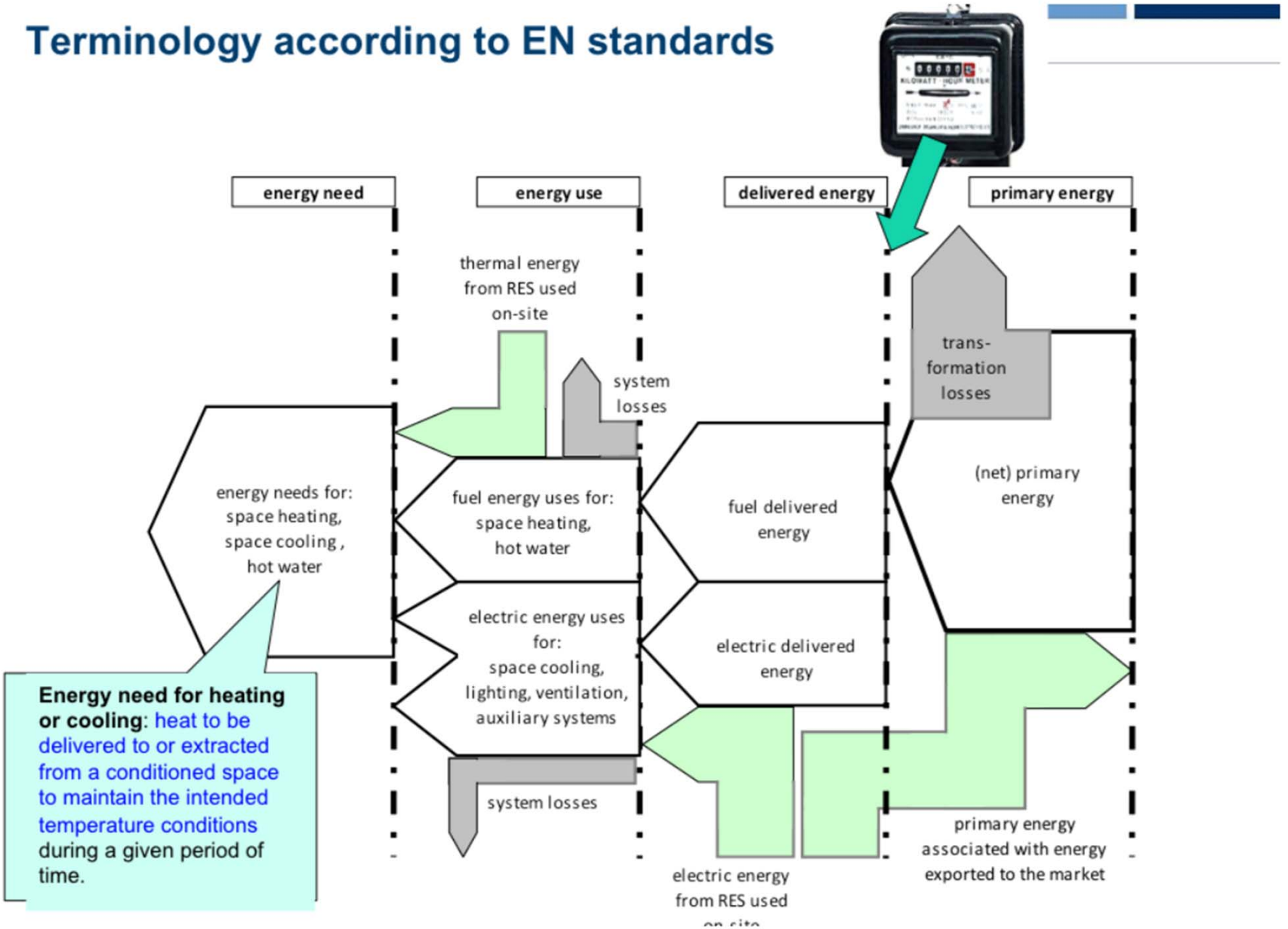
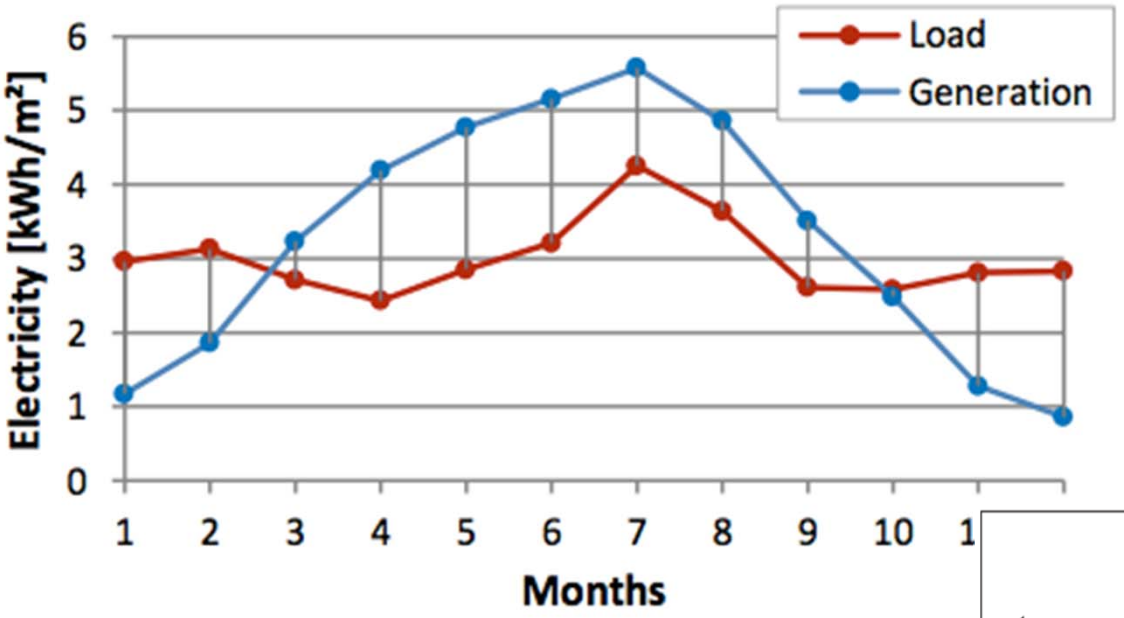


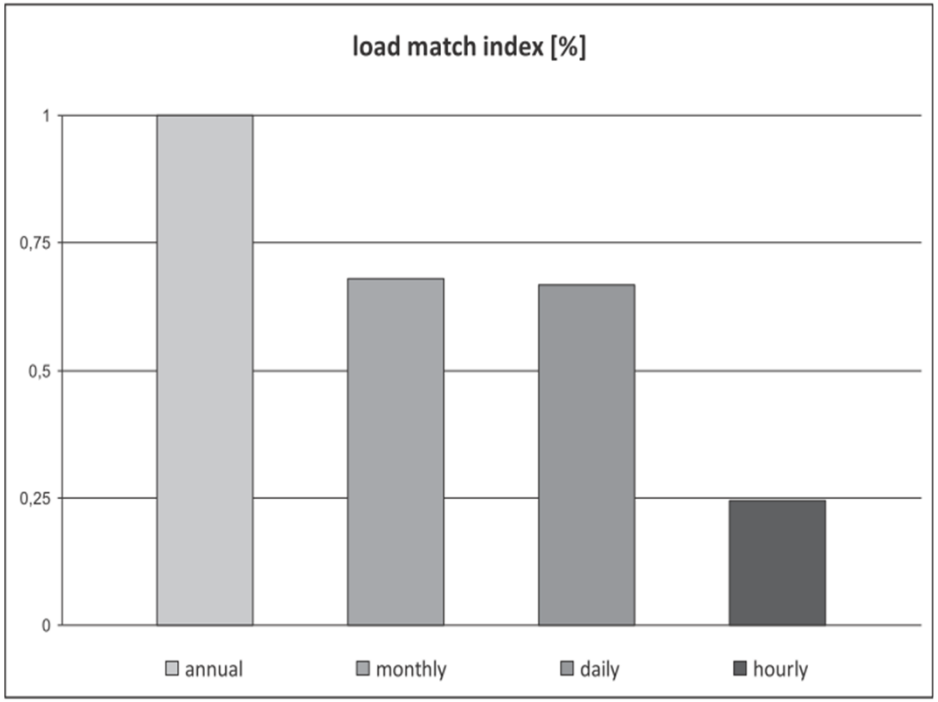
Figure 38 Scheme of calculation of the (net) primary energy demand resulting from the application of

Load match index



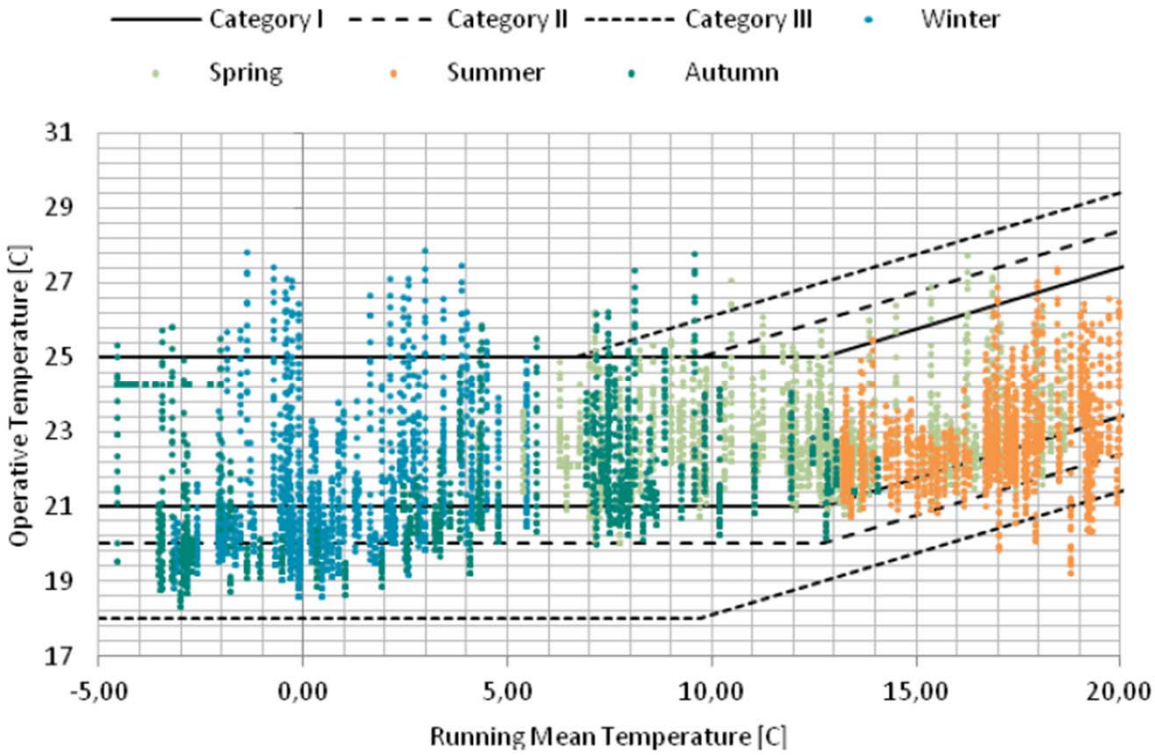
$$f_{\text{load},i} = \frac{1}{N} \times \sum_{\text{year}} \min\left[1, \frac{g_i(t)}{l_i(t)}\right] \qquad (7)$$

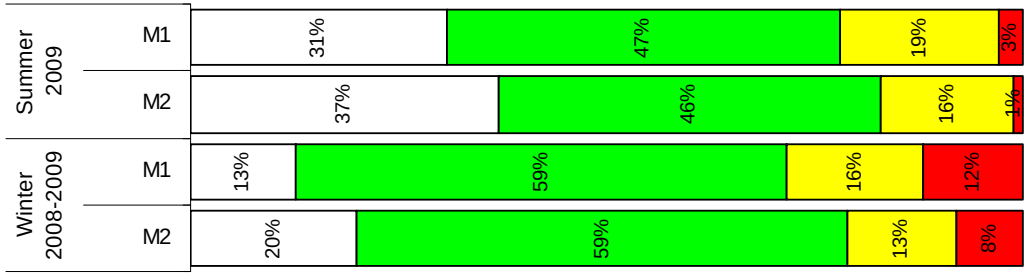
where g and l stands for generation and load, respectively; i stands for energy carrier and t is the time interval used, e.g. hour, day or month. N stands for the number of data samples, i.e. 12 for monthly time interval and 8760 for hourly time interval, respectively.

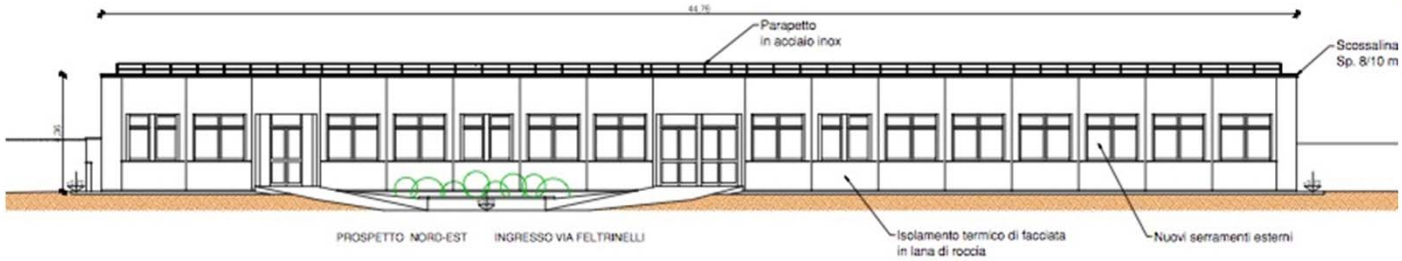


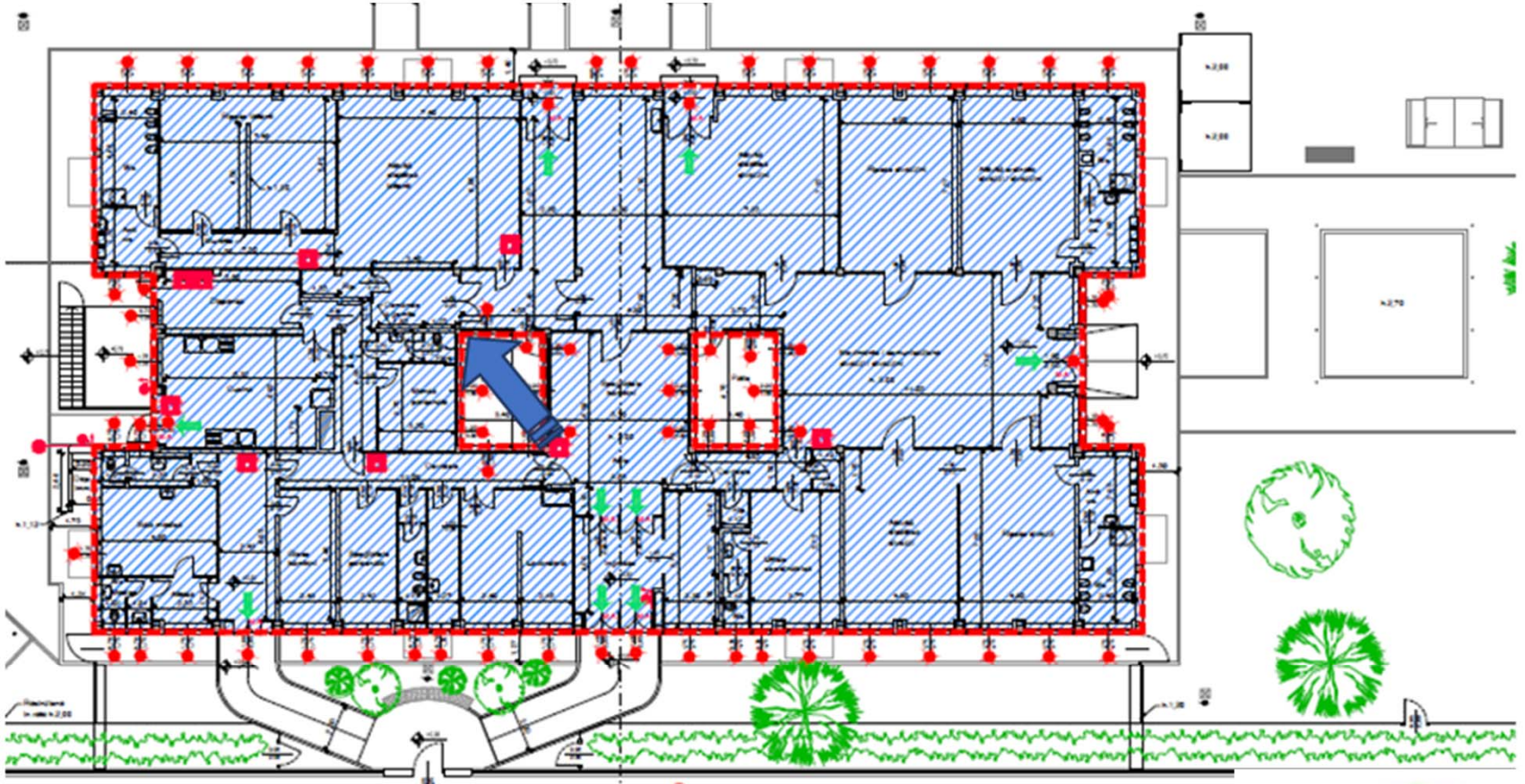
indoor comfort (thermal and visual): Long-term Percentage of Dissatisfied

$$LPD(p, LD) = \frac{\sum_{t=1}^{T}\sum_{z=1}^{Z} p_{z,t} \cdot LD_{z,t} \cdot h_t}{\sum_{t=1}^{T}\sum_{z=1}^{Z} p_{z,t} \cdot h_t}$$







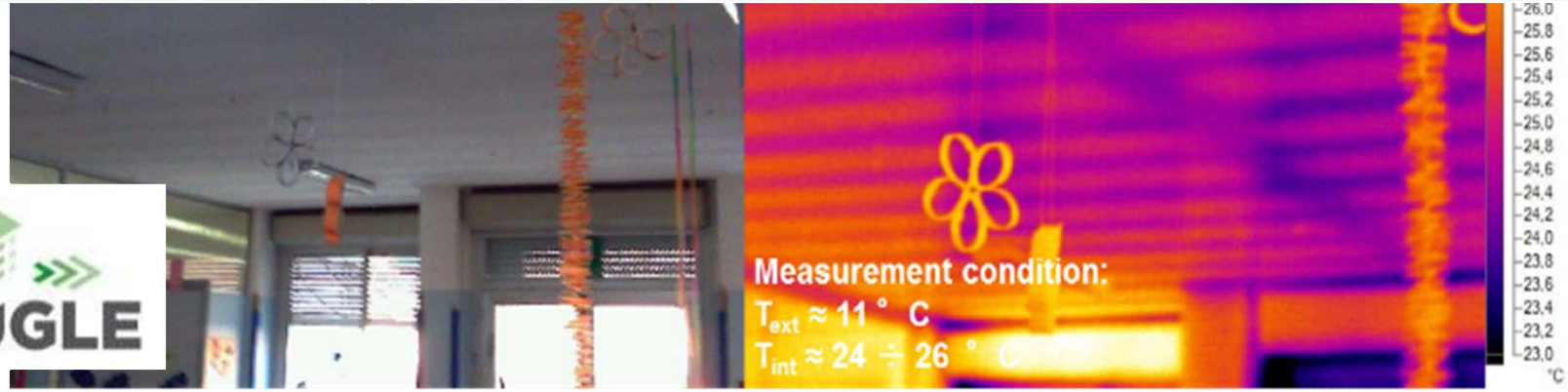


- Owner : Municipality of Milano; Built: 1980-1990
- 1 floor + basement
- Net floor area: 944 m2

EUGUGLE

Reduce thermal trasmittance of the envelope and reduce “thermal bridges”

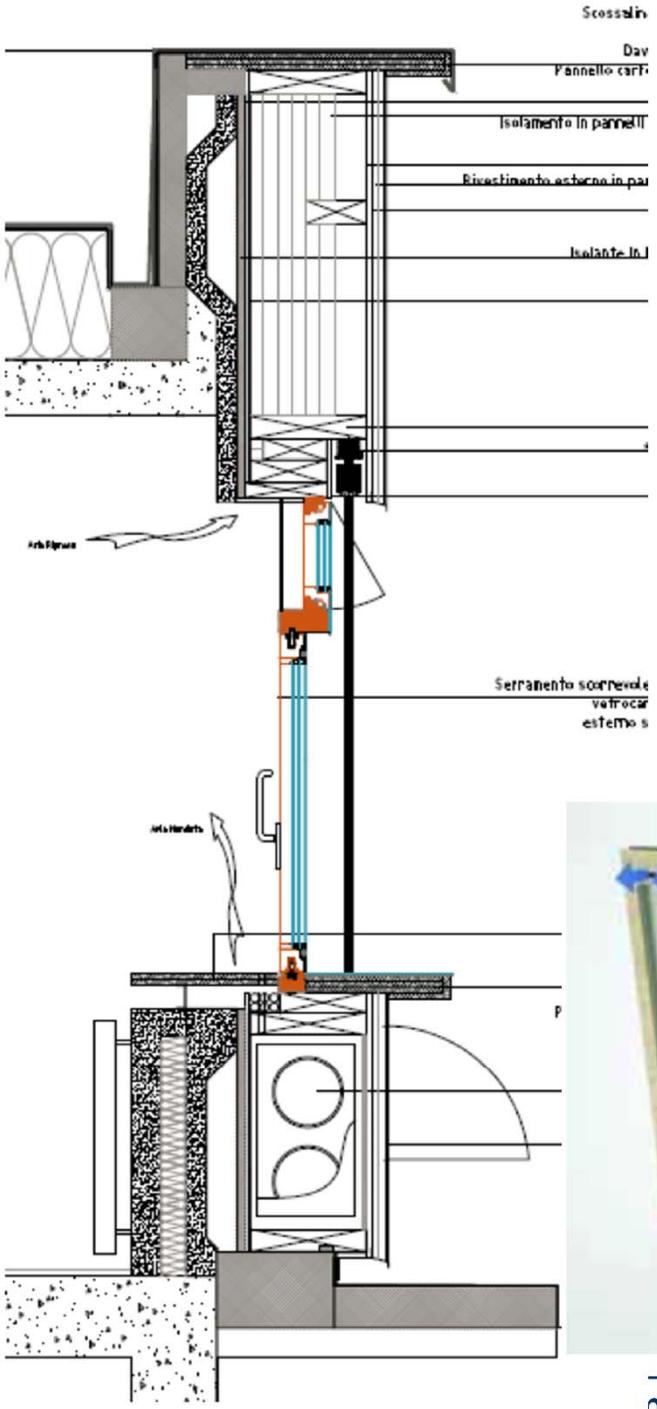
	PRE-retrofit	POST-retrofit
U external walls [W/(m²K)]	1,00	0,10
U roof [W/(m²K)]	0,90	0,10
U windows [W/(m²K)]	5,85	0,73

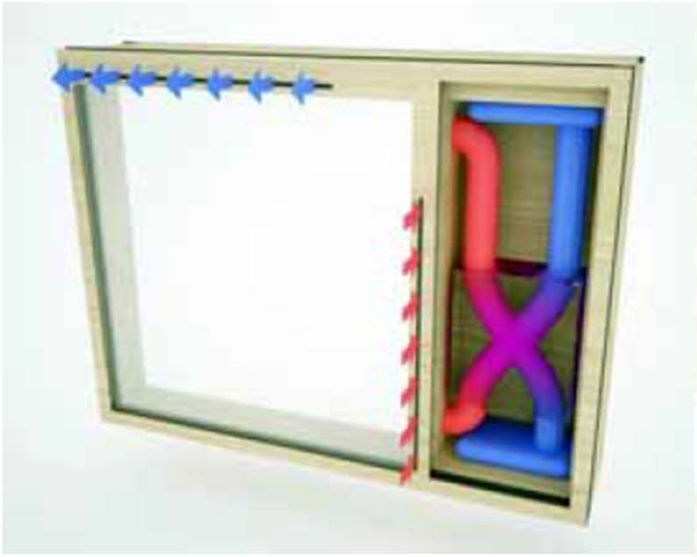


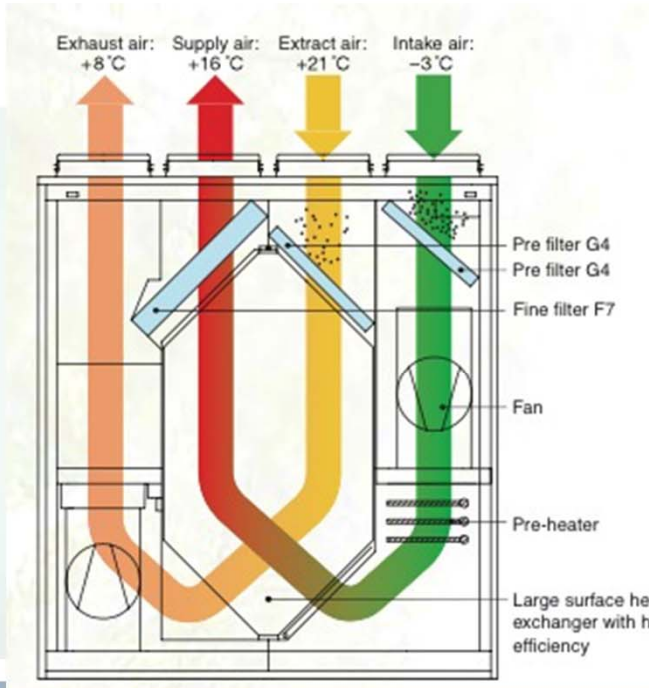
EUGUGLE

Integrated wooden prefabricated façade element

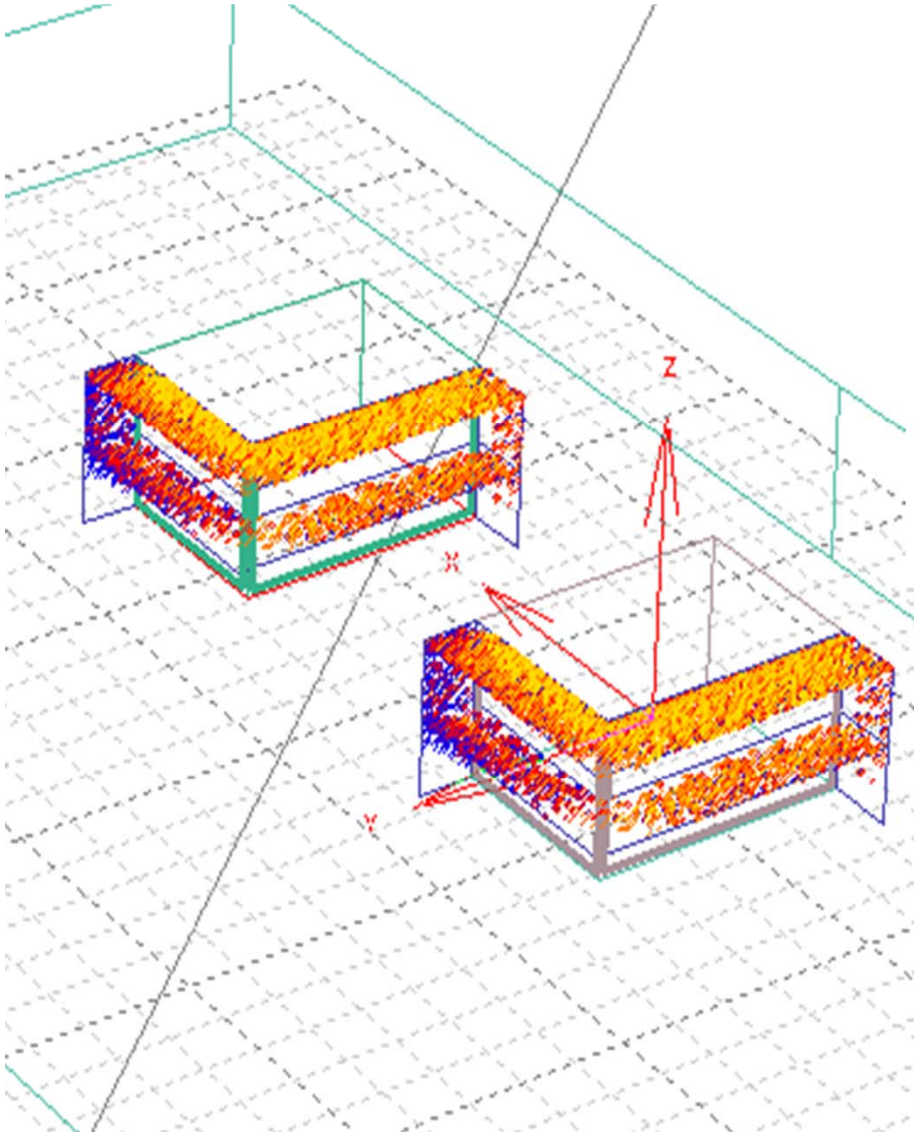
- High Thermal insulation of opaque and transparent surfaces
- Automated movable Solar shading
- Automated openings for automatic natural ventilation
- Air-infiltration
- Mechanical ventilation with heat recovery

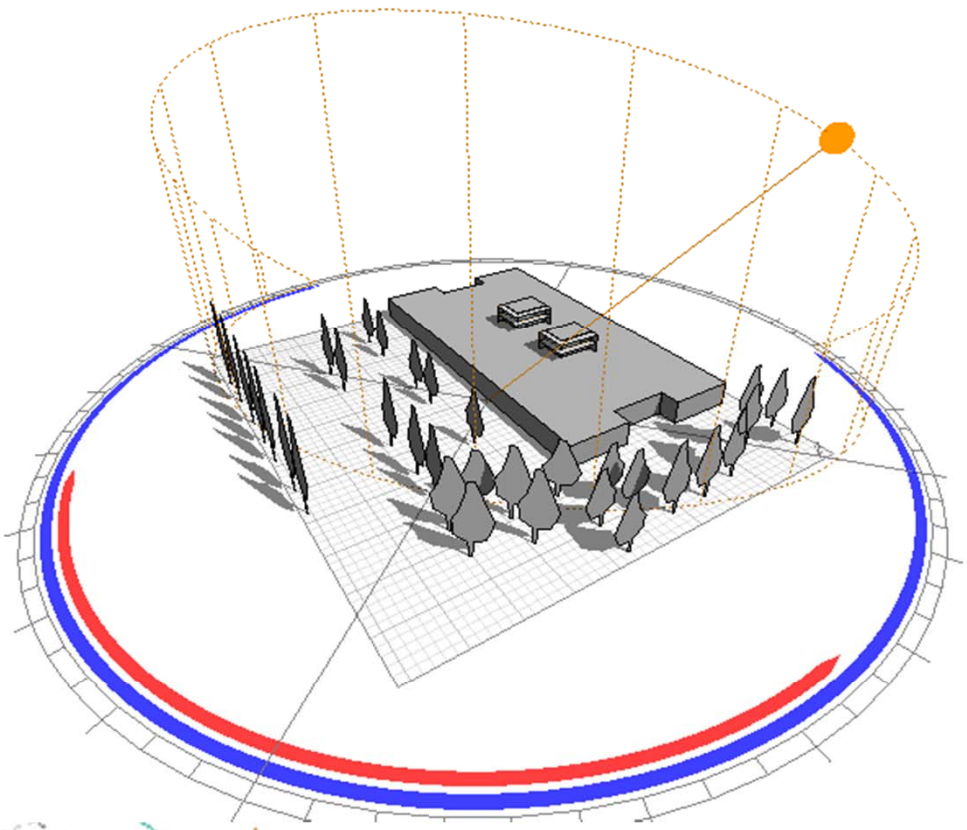






Solar shading optimization for chimneys / light wells

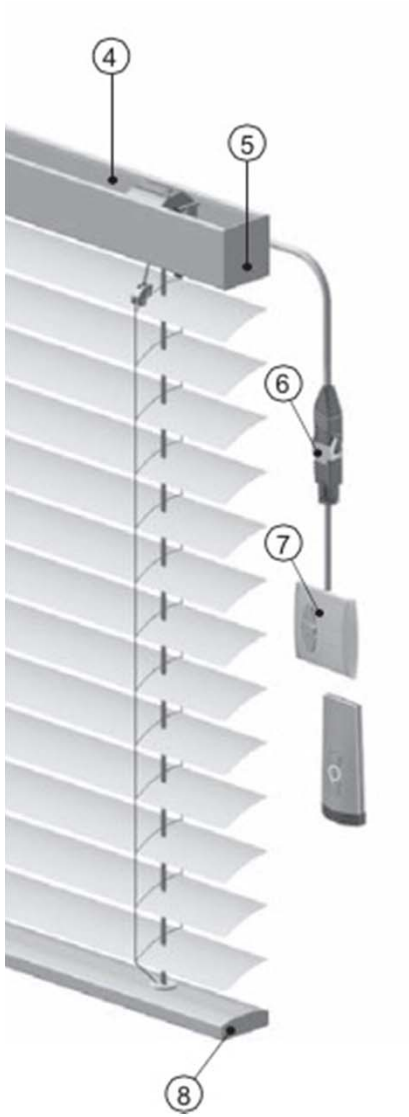


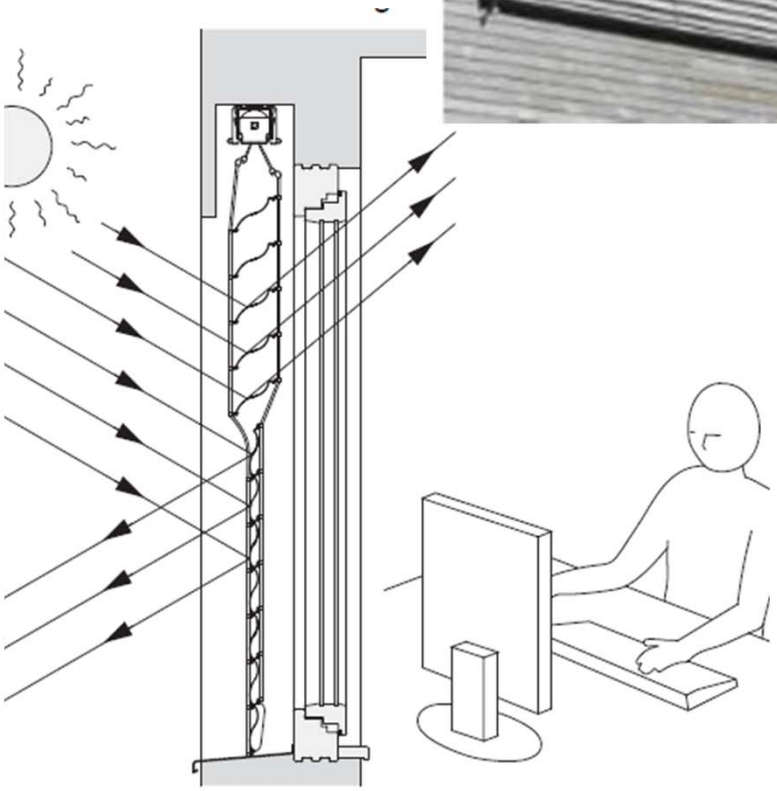


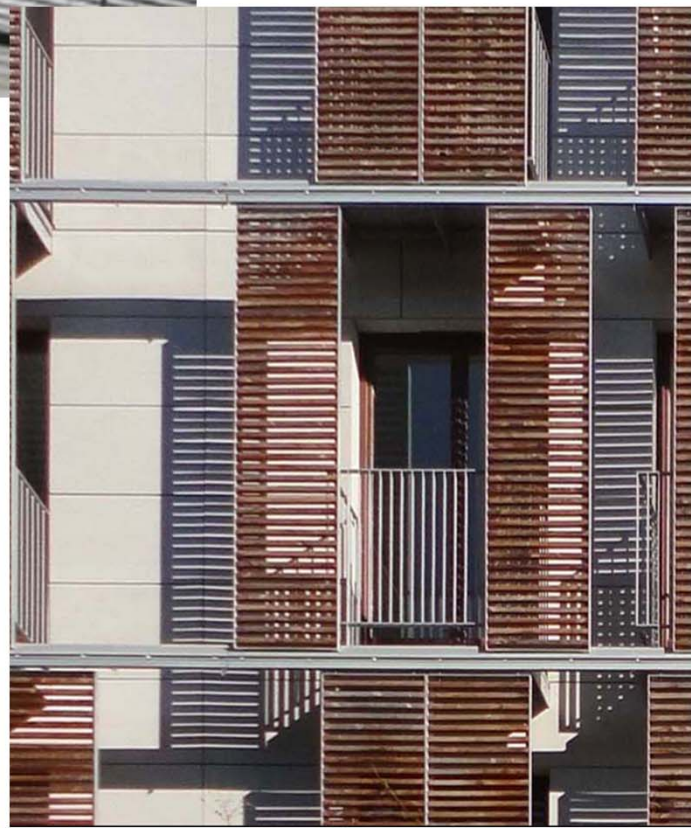
EUGUGLE

NO

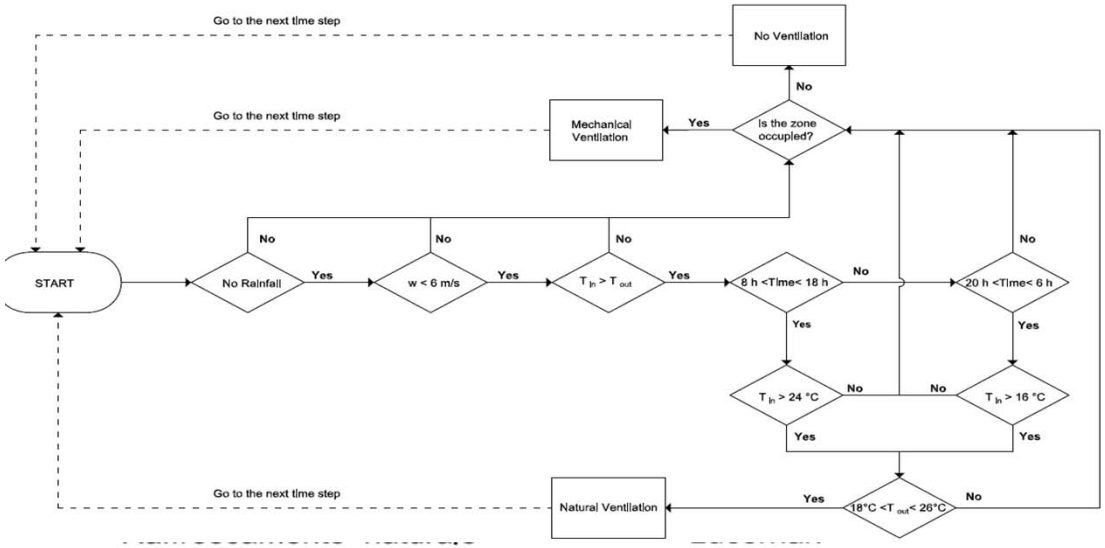
Automated movable shading

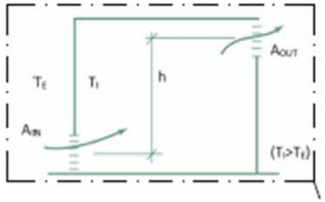


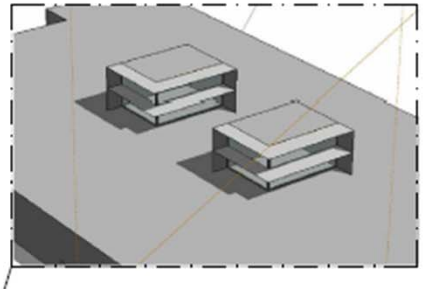


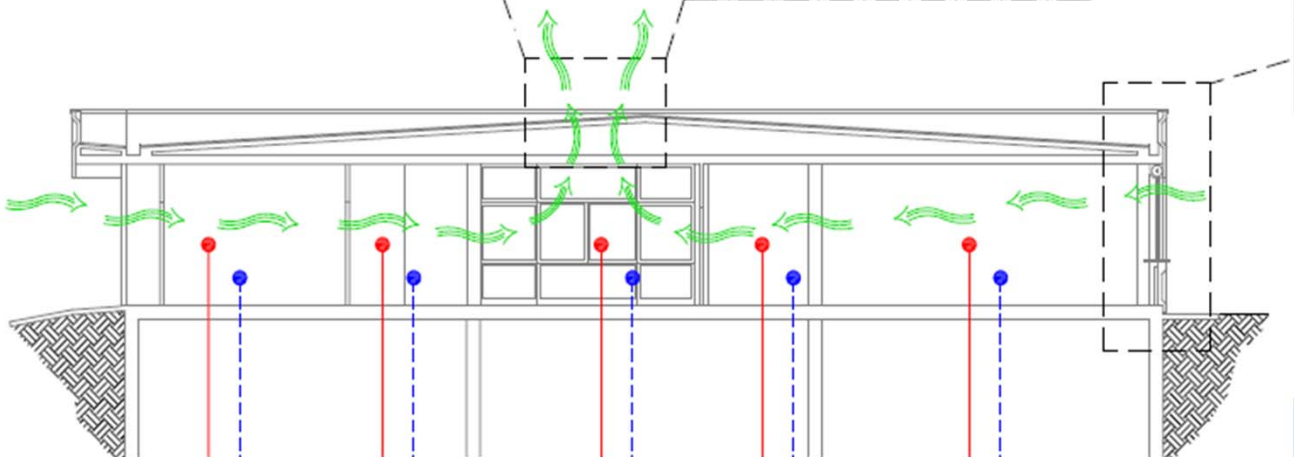


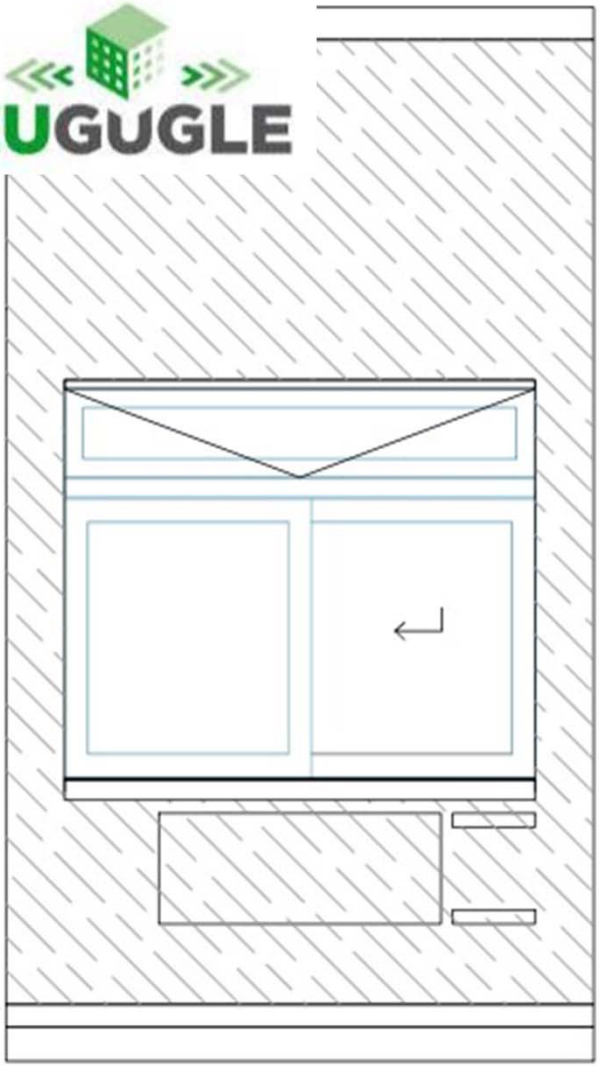
Automated night natural ventilation

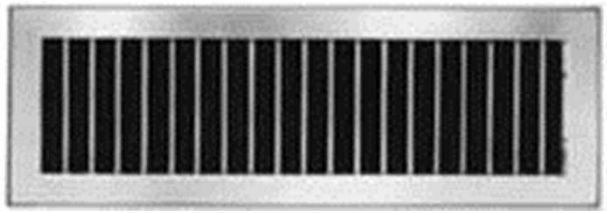






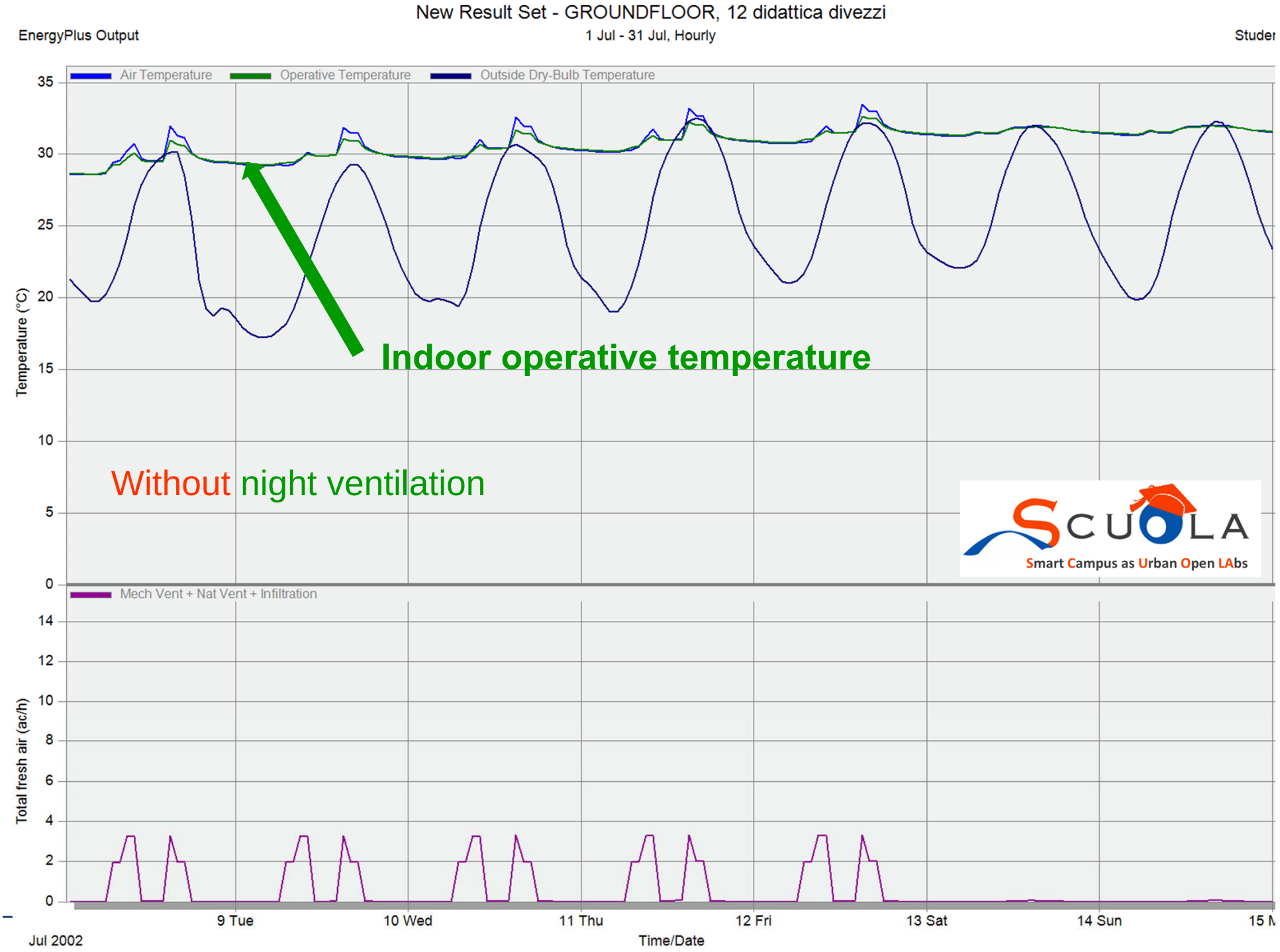


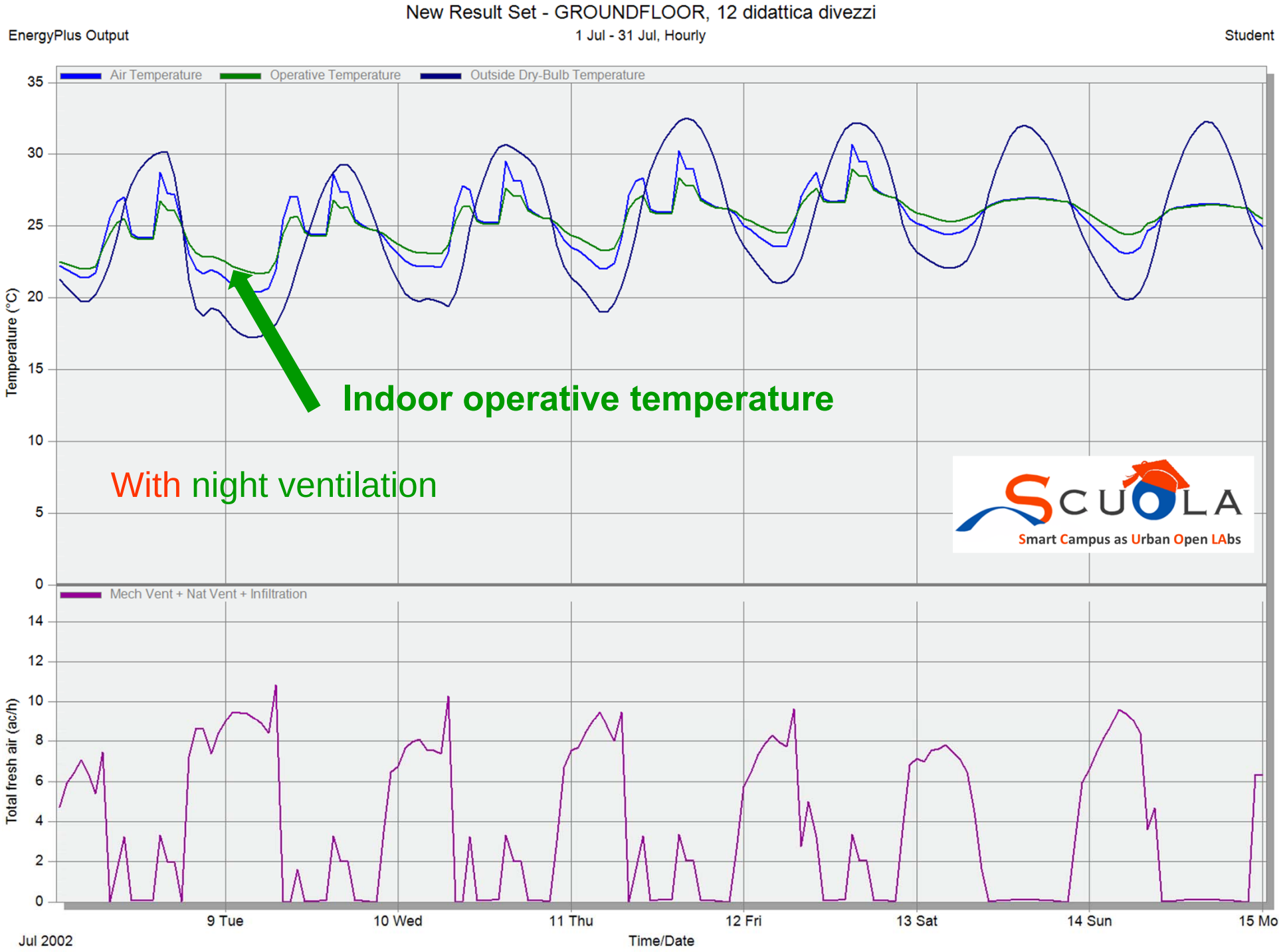




EUGUGLE

POLITECNICO DI MILANO

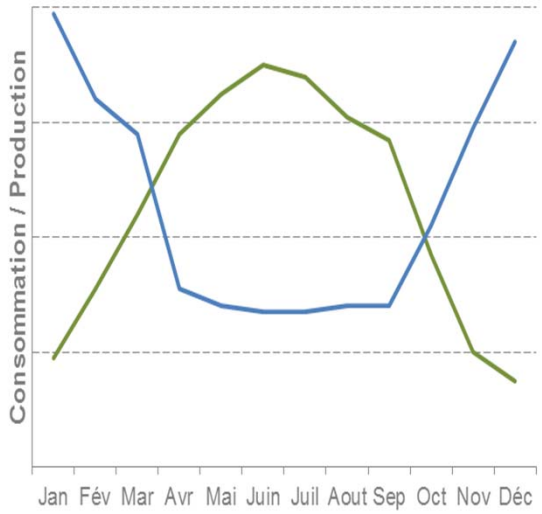

New Result Set - GROUNDFLOOR, 12 didattica divezzi
EnergyPlus Output
1 Jul - 31 Jul, Hourly
Stude
Air Temperature
Operative Temperature
Outside Dry-Bulb Temperature
Temperature (°C)
35
30
25
20
15
10
5
0
Indoor operative temperature
Without night ventilation
Mech Vent + Nat Vent + Infiltration
Total fresh air (ac/h)
14
12
10
8
6
4
2
0
9 Tue
10 Wed
11 Thu
12 Fri
13 Sat
14 Sun
Jul 2002
Time/Date

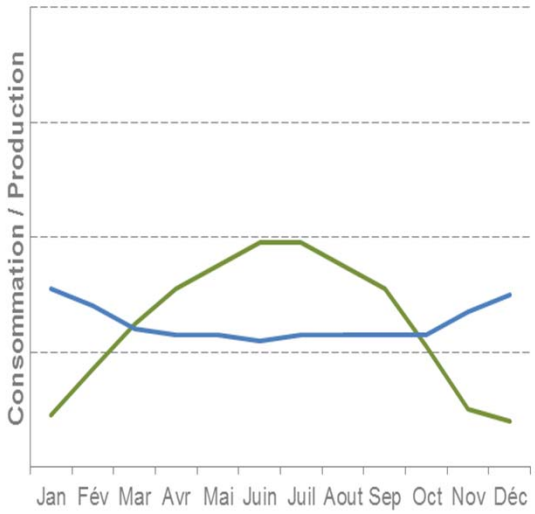

New Result Set - GROUNDFLOOR, 12 didattica divezzi
EnergyPlus Output
1 Jul - 31 Jul, Hourly
Student
Air Temperature
Operative Temperature
Outside Dry-Bulb Temperature
Temperature (°C)
Indoor operative temperature
With night ventilation
Mech Vent + Nat Vent + Infiltration
Total fresh air (ac/h)
9 Tue
10 Wed
11 Thu
12 Fri
13 Sat
14 Sun
15 Mo
Jul 2002
Time/Date
SCUOLA
Smart Campus as Urban Open LAbs

Performance pre and post retrofit

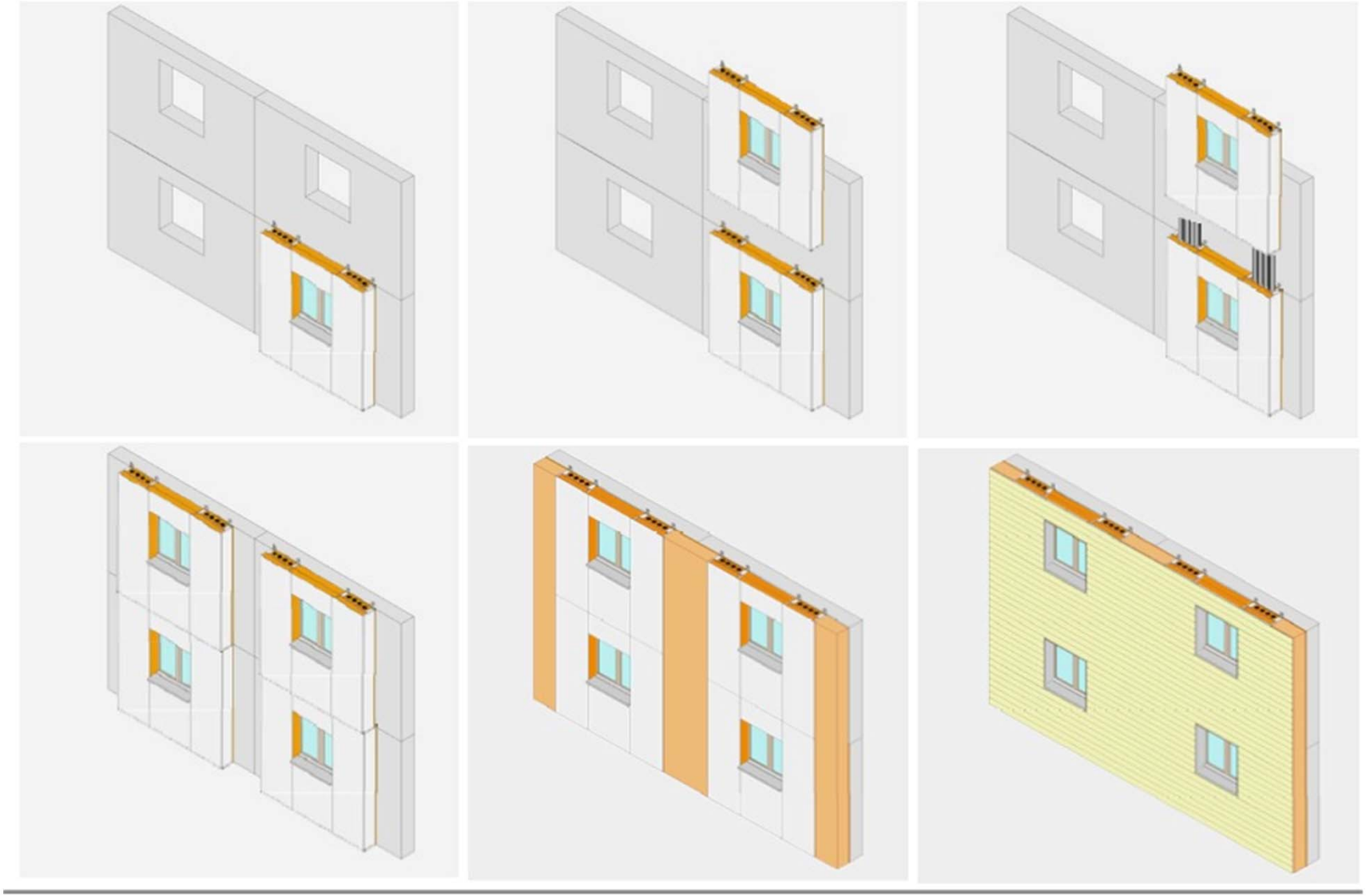
Building condition	Energy carrier	Delivered energy kWh/(m²a)	Primary energy conversion factor	Primary energy kWh/(m²a)
Existing building (pre-retrofit)	Fuel (Natural gas)[1]	202.07	1.00	202.07
	Electricity[2]	35.32	2.18	77.00
Post retrofit (scenario C2)	District heating[1]	36.82	0.8	29.46
	Electricity[2]	4.35	2.18	9.48

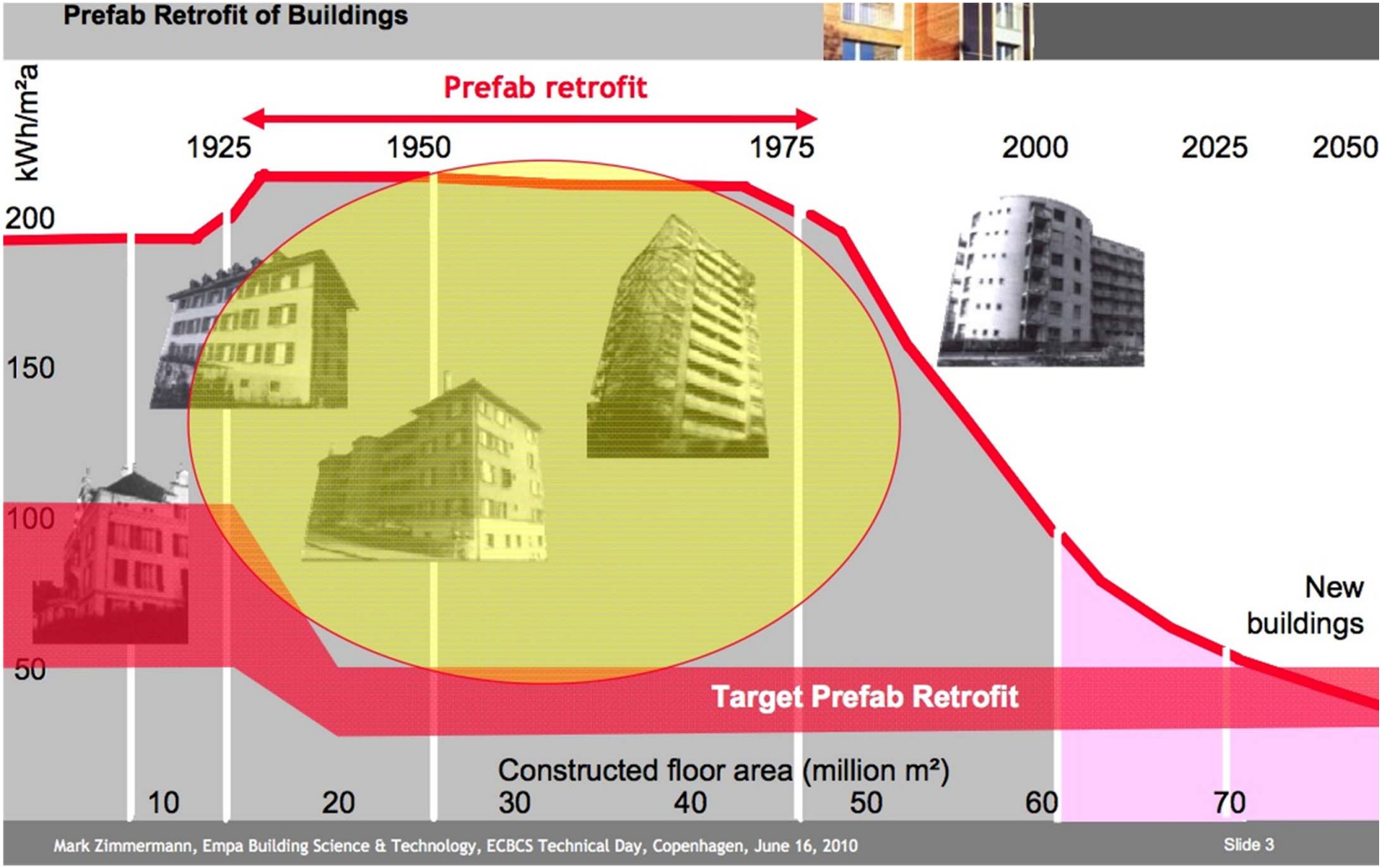
(1) Heating and production of domestic hot water
(2) Lighting, laundry, kitchen, equipment, mechanical ventilation



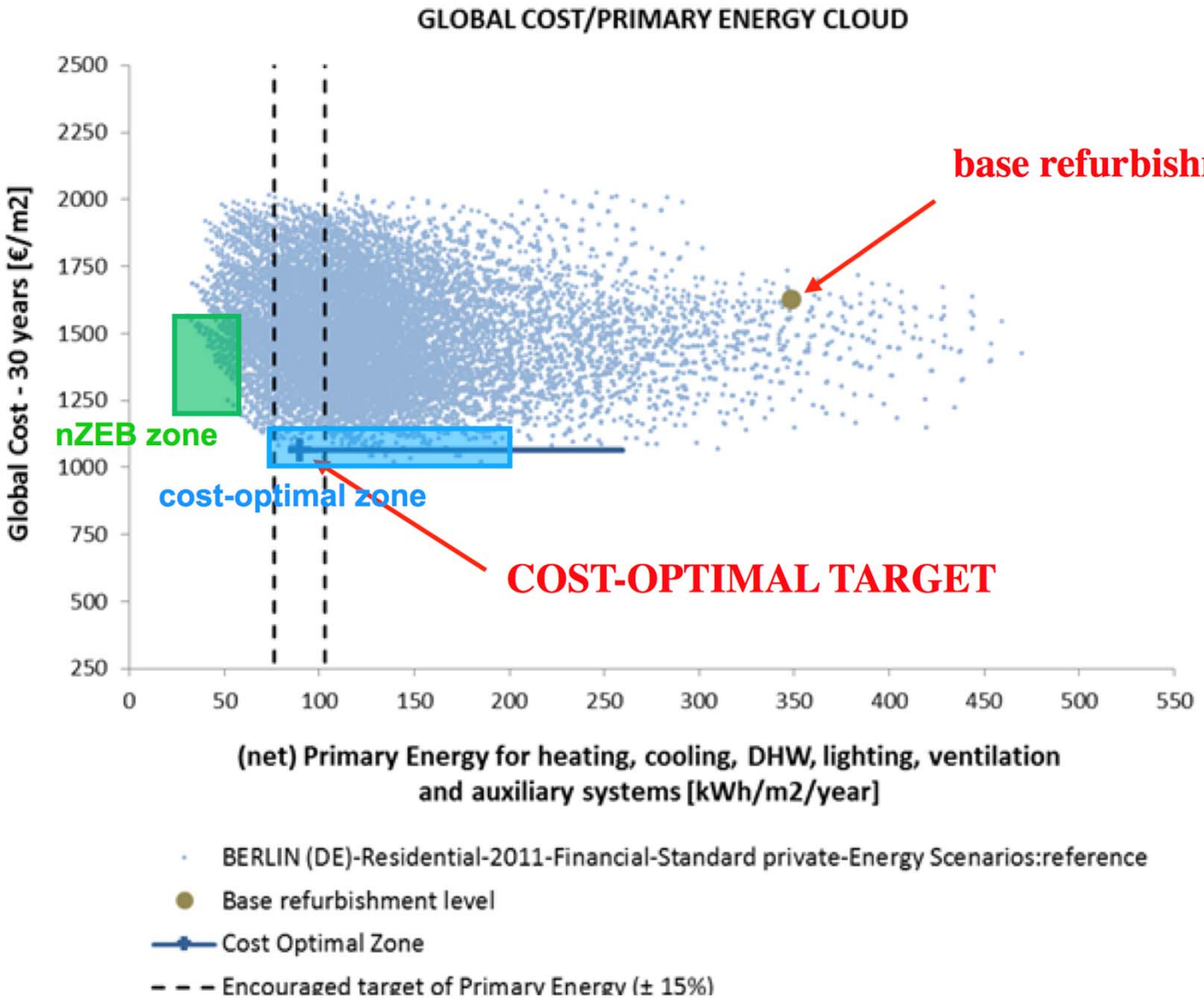


Ristrutturazioni a standard Passivhaus con elementi di facciata prefabbricati

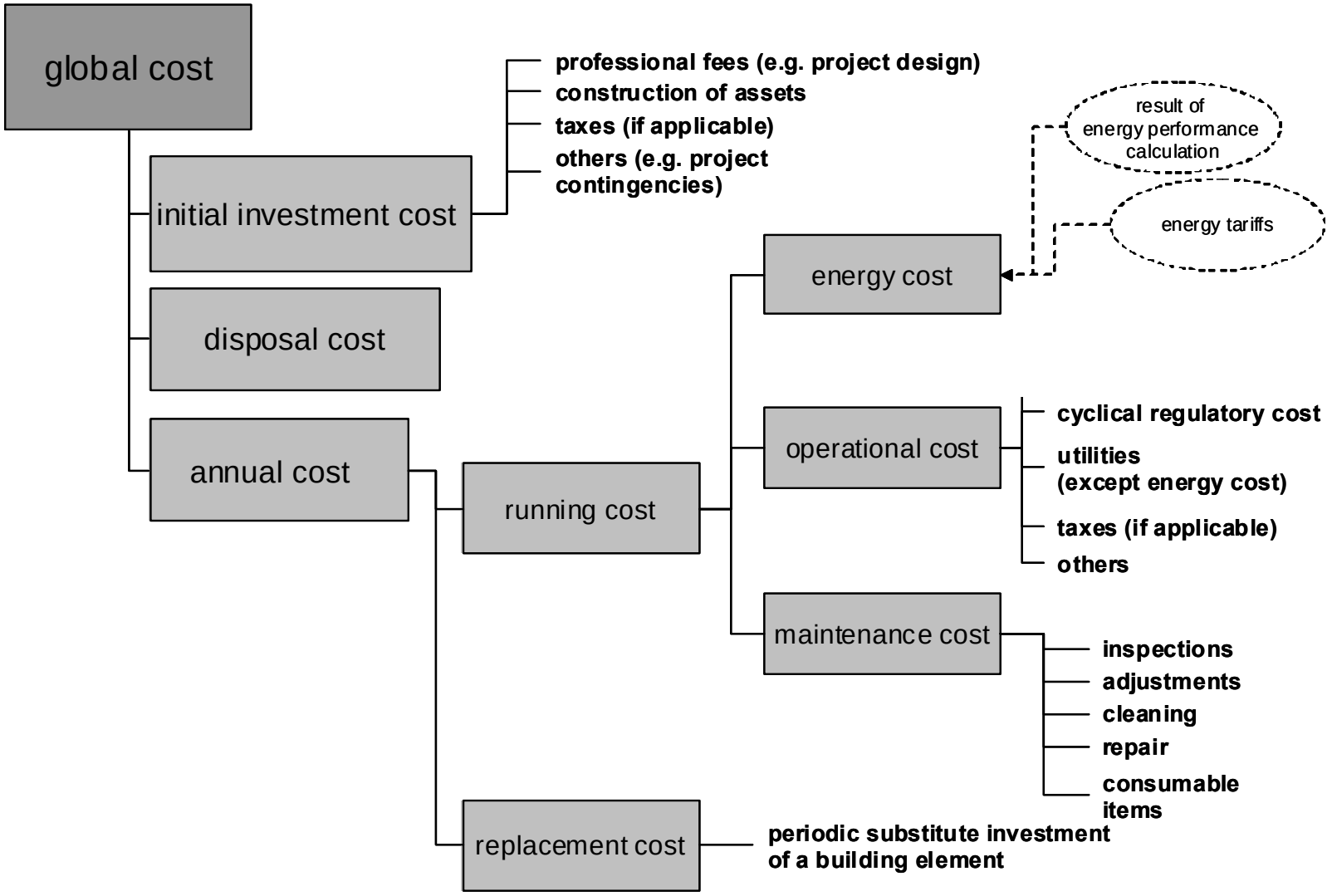


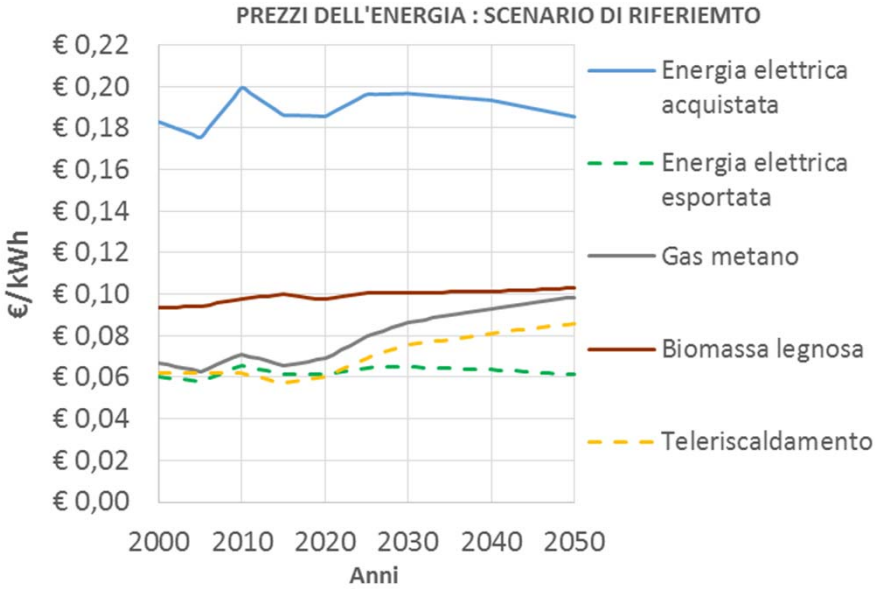

Prefab Retrofit of Buildings
kWh/m²a
Prefab retrofit
1925
1950
1975
2000
2025
2050
200
150
100
50
New buildings
Target Prefab Retrofit
Constructed floor area (million m²)
10
20
30
40
50
60
70
Mark Zimmermann, Empa Building Science & Technology, ECBCS Technical Day, Copenhagen, June 16, 2010
Slide 3

COST/ENERGY ANALISYS



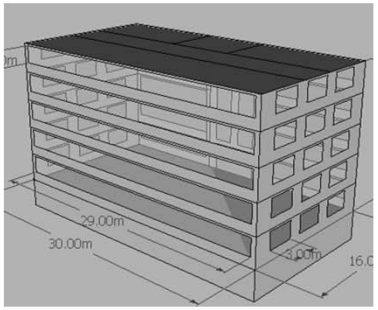
Costo Globale (Global Cost):



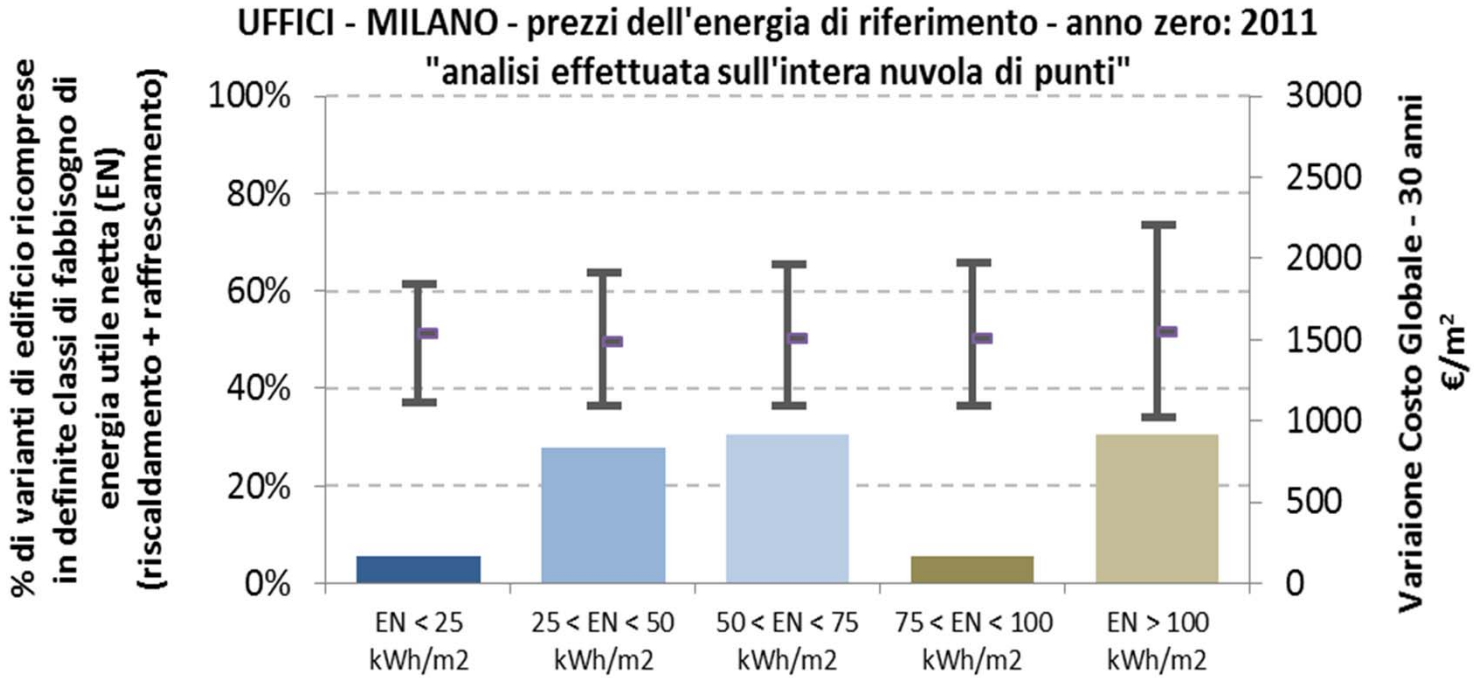


eERG **cost-tool: economic analysis of retrofit actions** (most visited tool on www.build-up.eu)

RISTRUTTURAZIONE UFFICI
MILANO



Passivhaus retrofit:
Energy need
<= 25 kWh/m_2a



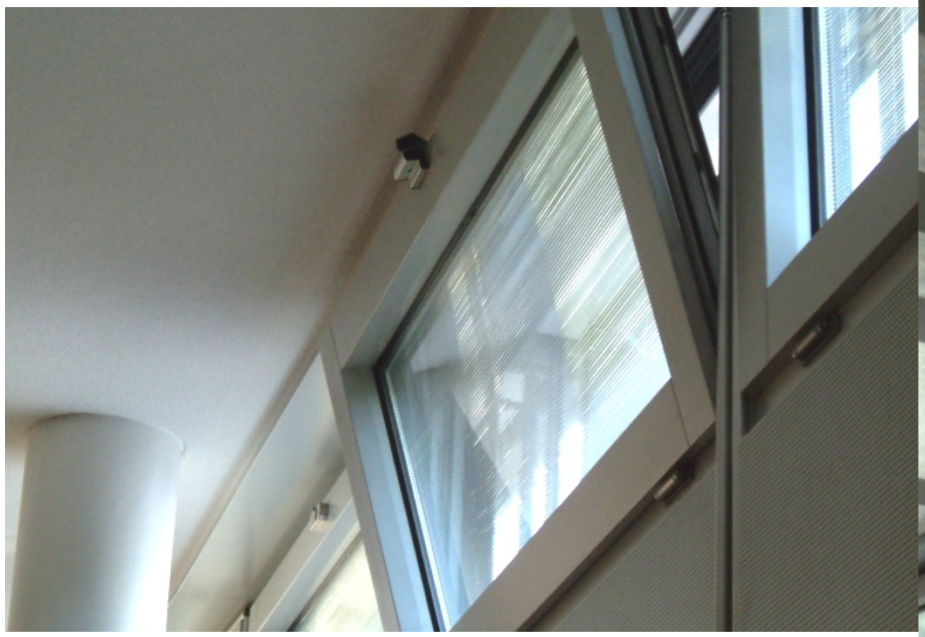
Retrofit to Passivhaus standard can be cost-effective if accurately planned

- Energy need <= 25 kWh/m_2a

- Total primal energy demand
<= 120 kWh/m_2a + ((QH - 15 kWh/(m_2a)) * 1.2)
(where QH: energy need for heating)

- Airtightness n50 <= 1 vol/h (con target value <= 0,6 vol/h)

Illuminazione naturale ed artificiale



Utilizzare tecniche per favorire la penetrazione in profondità della luce naturale

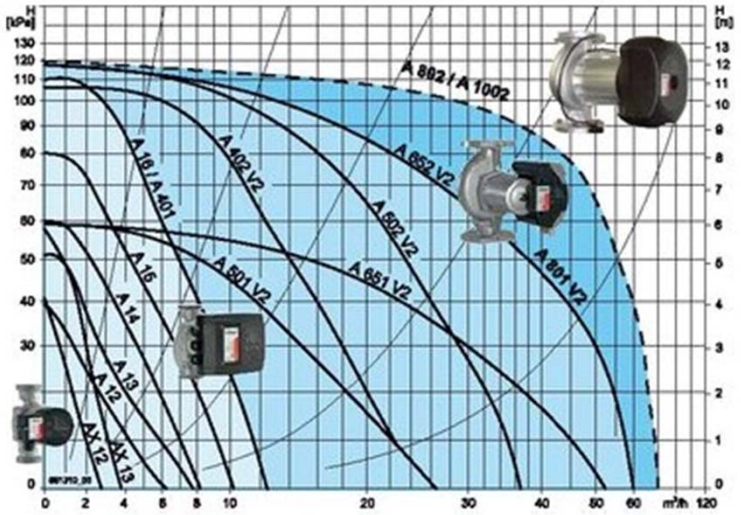
Installare illuminazione artificale ad alta efficienza, e controlli

Ridurre la domanda di energia meccanica (e dunque elettrica) per la movimentazione dei fluidi

Utilizzare materiali a basse emissioni di sostanze inquinanti in modo da ridurre la necessità di ventilazione dell'edificio secondo EN15251

Progettare e realizzare impianti di distribuzione dell'aria in modo da minimizzare le perdite di carico (tubi di diametro abbondante, ridurre al minimo le curve a 90),

e installare ventilatori ad alta efficienza, in modo da ottenere Specific Fan Power (SFP) minori di 1,5 ÷ 2 kW/(m^3/s)



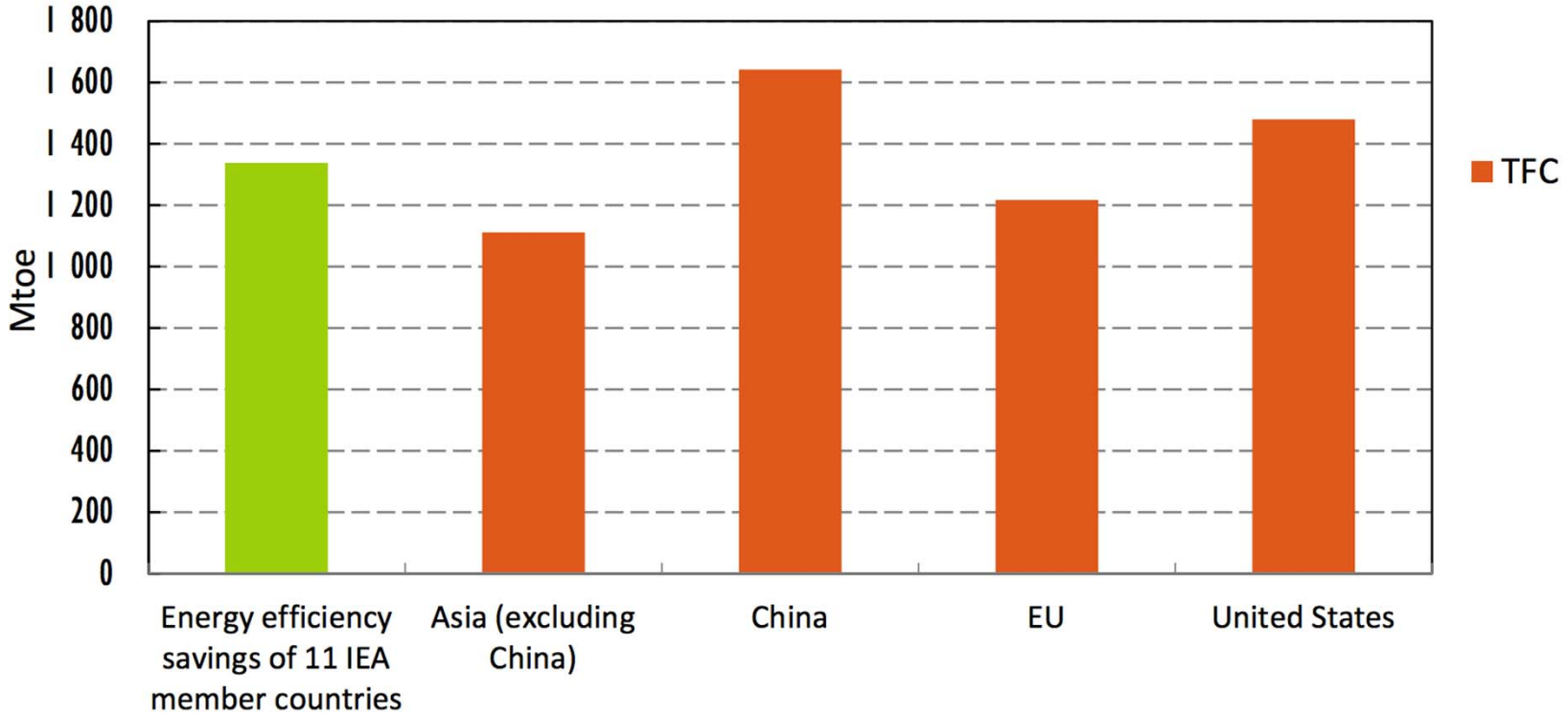
Progettare e realizzare impianti di distribuzione di acqua calda sanitaria e per riscaldamento in modo da minimizzare le perdite di carico (tubi di diametro abbondante, ridurre al minimo le curve a 90°)

Installare pompe di circolazione dell'acqua ad alta efficienza

Hearth to air heat exchanger

Energy Efficiency first fuel in the world (though “hidden”)

“IEA analysis has shown that energy efficiency is not just a hidden fuel but is also the “first fuel” in the IEA’s largest economies. 2014 report shows that energy efficiency investments over the past four decades have avoided more energy consumption than the total final consumption of the European Union in 2011”. IEA Executive Director Maria van der Hoeven *Energy Efficiency Market Report 2014*.



Prof. Lorenzo Pagliano, PhD

Course of Advanced Building Physics - Master Course of Building Engineering

Director of eERG – end-use Efficiency Research Group www.eerg.polimi.it
Member of the Board of the European Council for an Energy Efficient Economy, www.eceee.org
Director of Master RIDEF (Energy Efficiency, Renewables, Energy Economics and Policy) www.ridef.it

More details on www.eerg.it

RENEW SCHOOL

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

SCUOLA
Smart Campus as Urban Open LAbs

EUGUGLE

SEVENTH FRAMEWORK PROGRAMME

European Commission

My personal contribution:

- No airplane travel in the last 12 years (and I have been responsible of 20 EU research projects): I travel by train in EU and web-conference with colleagues of other continents
- No car: I use public transport (with help of e.g. citymapper, transit or moovit apps for metro and bus connection, and http://www.bahn.com/i/view/ITA/it/about/orari-prenotazioni.shtml for train connections all over Europe), bike (with help of e.g. bikecitizens app for finding low traffic, bike-friendly routes and be guided by voice), walking