Climate Envelopes for contemporary Architecture – Developing Zero Emission Buildings

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EU Road Map to ZEB

- EU Target: nZEB near Zero Energy Building
- Definition: very high energy efficient building near zero, the energy consumed to be covered to a significant extent by renewables including on-site/nearby production
- Methodology: holistic building approach, up to Member States to define levels and details

- New criteria: “cost-optimal solution”
- Definition: lowest cost over entire life time (energy investment, gains, earnings etc.)
- Methodology: EU frame under work till mid-2011, details left to Member States

- Forecast
  - Countries to develop national nZEB road maps and action plans during 2011 + 2012
  - Taking off of nZEB requirements before 2015 and gradually increase towards the 2020 targets
Energy Consumption to operate

Actions needed:

a. Highly insulated building envelope (Passivehouse Standard)
b. Effective sun protection system – exterior, adjustable
c. Heat reflection/heat capture/heat storage – passive
d. Natural ventilation whenever possible – night cooling
e. Double skin – Breathing Facade solutions
f. Integrate solar gaining systems - active.
The Building Envelope
Impact of the Building Envelope

1° Celsius lower room temperature can reduce the cooling load by 5 to 10% annually.
Building Envelopes in Comparison
Outdoor Test Facilities – e.g. Toulouse
Green Labs Test Centre Network

- Lab SOLAR
- Lab ENVELOPE
- Lab GREEN

Locations: Toulouse, Bellenberg, Doha
HBS Research Centres – Cross check the numerical Simulations

Yearly sum of global irradiance

- 2300 kWh/m²
- 1300 kWh/m²
- 1000 kWh/m²
- 2300 kWh/m²

Source: Meteonorm 6.0 (www.meteonorm.com); uncertainty 10%
Period: 1961 - 2000; grid cell size: 1°
Outdoor Test Facilities – e.g. Bellenberg

Comparison measurements between Reference (1) and Variations (2,3,4)
Sensor equipment

- CO₂ - Injection
- Room Temperatures
- Surface Temperatures
- Air Velocity
- Solar Radiation
- Gas Chromatograph
InventSkin
ZEB Technology
Overheating – challenging opportunities
How to deal with overheating?

Endessa HQ, E-Madrid
Sun Protection

A/B.  Single Skin window and facades
C. Box and Coupled Windows
D.  Exhaust air Window
E.  Double Skin Facade
Sun protection
Results

Exhaust Air Window (Version D)
Double Skin Facade, inc. Sun Protection (Version E)
HI Glazing, interior Sun Protection (Version B)
HI Glazing incorporated Sun Protection (Version C)
HI Glazing, exterior Sun Protection (Version A)

Temperature / °C

20 22 24 26 28 30 32

2012-09-01
Sun protection

Up to 43% cooling energy savings with Brise Soleil

Room 1

Room 2

Cooling energy demand

Room 1 = 714 kJ
Room 2 = 1268 kJ

Total solar radiation on the facade
InventSkin® – Hydro´s Powder Coatings

Hydro´s Low Absorption Coatings

- Reflect sunlight
- Reduce cooling energy demand by up to 30%
Sun protection

Measurement of HBS Low A Powder coatings
Sun protection

Measurement of HBS Low A Powder coatings
Energy Storage

Phase Change Material (PCM) in Curtain Wall

Application:

PCM in aluminium construction stores 3000 Wh thermal Energy or 300 W per 100 kg PCM.

A 3 m tall aluminium profile can host ~ 30 kg PCM.
Energy Storage - Measurement

**Theoretical (approximated)**
Volume = 1.4 x 2 x 10 x 94 x 8 = 21056 cm$^3$
Mass = 21.056 x 1.5 = 31.58 kg
Latent heat of fusion = 31.58 x 158 = 4990 kJ
Heat due to temperature increase = 31.58 x 6.2 x 2.7 = 528 kJ
Total heating energy = 5518 kJ

**Measured**
Total heating energy = 5718 kJ
Energy Storage

- Heat storage
- Heat release

Temperature [°C]

- 26.06.2010 with PCM
- 20.07.2010 w/o PCM

T_Room_1_mit
T_Room_5_ohne
Breathing Facade
Double Skin Solutions
Impact of the Building Envelope – An Example

1° Celsius lower room temperature can reduce the cooling load by 5 to 10% annually.

Standard Curtain Wall
Interior Temperature + 33°C

HBS TOP Window
Interior Temperature + 27°C

TOP Window
Fleischerschule, D-Augsburg
Impact of the Building Envelope – WICLINE 215

U-window = 1.0 W/m²K, g = 0.50

Real Performance incl. annual solar gains:

U eq – North  + 0.20 W/m²K
U eq – South  - 0.20 W/m²K

A Window is a solar collector. Aluminium windows allow higher solar gains.
Solar
Building Integration
Possibilities for Solar Application

Solar Systems:

Annual Solar Energy
In kWh per year
Heating Oil Price Development 2002/2012

Between 2002 and 2012 the heating oil price increased by more than 200%.

1 Liter oil equals
~10 kWh energy
~ 2.64 kg CO₂ emissions
Between 2006 and 2011 the PV module price decreased by more than 50%.

Annual energy output of 1m² PV equals up to 15 l oil consumption or 40 kg less CO2 emissions.
Photovoltaic Building Integration

- Solar façade
- Gard-corps
- Sun screen
- Skylight
- Test field Barcelona
- Sun shading
- Roof integration
Photovoltaic Building Integration
Solar Thermal Collector – Optimal Orientation
Solar Thermal

Design Principle:

Curtain wall collector integrated into a double skin solution

Combination with a back packed reflector to increase efficiency

Reflector is semi perforated to enable view through.

Collector liquid of above +90°C enable solar cooling.
WICTEC CPC – Principle of Function

Measurement series made with CPC 12 OEM and OEM 21 with reflection sheet and perforation. Grades of none, 19%, 30%, 38%, 51%.

Collector with and without cover glazing.

Energy Gain ~ 250 until 350 kWh/m²a at south elevation, 90° vertical installation and 19% perforation grade.
Energy + Building – Do it
Future is ...

... Fusion of Construction and Transportation

Sobek

R8 e-tron
Future is „e“, „autarc“ and „lightweight“