The context of Responsive Building Elements and Integrated Building Concepts

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EU’s Climate- and Energy Plan

- 20% reduction of CO₂ emission in 2020
- 20% renewable energy in 2020 (In Denmark 30%)
- 20% reduction in energy use in 2020
Political Agreement in Denmark of February 21, 2008

- 20% renewable energy in 2011 (minimum 30% in 2020)

- Energisavings on average 1.5% in 2010-2020 (total about 16%)

- Demands for energy use in new buildings are reduced by at least 25% in 2010, 2015 and 2020 to a maximum of 25% of today's demand in 2020.
Development in Maximum Energy Use in New Buildings

Energiforbrug (2006 = 100)

2005 2006 2010 2015 2020
Development in Maximum Energy Use in New Buildings

Energiforbrug (kWh/m2 år)

- Bolig (150 m2)
- Kontor (1500 m2)

COMFORT HOUSES, Vejle

www.komforthusene.dk
ENERGY NEUTRAL RESIDENCE

- **BOLIG+ dogma:**
  - Energy neutral on a yearly basis,
  - Intelligent and userfriendly
  - Flexibel in use and time
  - Comfortable and healthy indoor climate
  - Adapted to the local context

- First demonstration project constructed in Aalborg 2009-2010

www.boligplus.org
Primary Energy Use

Kilde: Rob Marsh, SBi
Christophorus Haus, Østrig

**Net conditioned area:** 2000 m²
**Start of operation:** 2003
**Energy use heating and cooling:** 26.4 kWh/m²/yr (measured)
**Total Building Cost:** € 1200
Christophorus Haus, Østrig

- **Reduction of energy demand**
  - High level of thermal insulation (U-value 0.1 W/m²K), avoidance of thermal bridges
  - Airtight construction (n50<0.6h⁻¹)
  - Heavy thermal mass for buffering (100 tons) and natural cooling (natural night ventilation)
  - Application of solar and heat protection glass, solar shading

- **Application of renewable energy**
  - Deep pipes in ground (8x100 m Duplex, double u-pipes DN32)
  - PV-system (cover yearly electricity demand for heat pump, 10kWpeak)
  - Solar Thermal System (Domestic hot water, 5 m²)

- **Efficient energy conversion**
  - Heat pump (heating, nominal power 43 kW, COP 4.0)
  - Balanced mechanical ventilation system with high efficient heat recovery (78- 86%, rotation heat exchanger)
  - Surface heating and cooling panels
  - Optimized lighting systems

- **Total energy use**: 20 kWh/m²/yr heating, 6.4 kWh/m²/yr cooling (75% less than standard)
The Centre for Sustainable Building (ZUB), Kassel, Tyskland

Net conditioned area: 1347 m²
Start of operation: 2001
Total energy use: 32 kWh/m²/yr (measured)
Total Building Cost: € 1800
Energy Costs in Office Buildings

- Yearly energy costs in 92 individual office buildings

Realization of saving potential requires efforts on three levels:

- **Reduction of energy demand**
  - Thermal insulation, air tightness, utilization of passive solar loads, buffering, reduction of heat and contaminant loads, natural cooling

- **Application of renewable energy**
  - Sun, wind, geothermal heat, biomass

- **Efficient energy conversion**
  - HE gas boiler, heat/power applications, heat pumps, efficient ventilation, heating, cooling and lighting systems

Realization requires:

- **An Integrated Building Concept Approach**
Integrated Building Concept

- An integrated building concept includes all aspects of building construction (architecture, facades, structure, function, fire, acoustics, materials, energy use, indoor environmental quality, etc...).
- An integrated building concept can be regarded to consist of three parts:
  - **the architectural building concept,**
  - **the structural building concept**
  - **the energy and environmental building concept**
Integrated Building Concept

**Concept Level**
- Architectural Quality
- Indoor Climate
- Occupant Behavior

**System Level**
- Building Construction and Envelope System
- Building Services System
- Energy Supply and Renewable Energy System
- Glazed Facade
- Counter Flow Heat Recovery
- PCM Energy Storage
- Micro CPH
- Thermal Mass Activation
- Solar Wall
- Heat Pump

**Component Level**
- Integrated Building Concept
Design Strategy and Technical Solutions

CFF = Cleanest Fossil Fuels
FFT = Fossil Fuel Technology
Design Strategy and Technical Solutions

- **Reduce Demand**
  - Optimize building form and zoning, apply super insulated and air tight conventional envelope constructions, apply efficient heat recovery of ventilation air during heating season, apply energy efficient electric lighting and equipment, ensure low pressure drops in ventilation air paths, etc.
  - Apply Responsive Building Elements if appropriate including advanced façades with optimum window orientation, exploitation of daylight, proper use of thermal mass, redistribution of heat within the building, dynamic insulation, etc.

- **Utilize renewable energy sources**
  - Provide optimal use of passive solar heating, daylighting, natural ventilation, night cooling, earth coupling.
  - Apply solar collectors, solar cells, geothermal energy, ground water storage, biomass, etc.
  - Optimise the use of renewable energy by application of low exergy systems.

- **Efficient use of fossil fuels**
  - If any auxiliary energy is needed, use the least polluting fossil fuels in an efficient way, e.g. heat pumps, high-efficient gas fired boilers, gas fired CHP-units, etc.
  - Provide intelligent control of system including demand control of heating, ventilation, lighting and equipment
Integrated Building Concept

Concept Level

System Level

Component Level

Architectural Quality

Indoor Climate

Occupant Behavior

Building Construction and Envelope System

Building Services System

Energy Supply and Renewable Energy System

Micro CPH

Glazed Facade

Counter Flow Heat Recovery

PCM Energy Storage

Heat Pump

Thermal Mass Activation

Solar Wall

Integrated Building Concept

Integrated Building Concept

Integrated Building Concept
Multifunctional Building Facades

- The facade should be considered as a system solution, which fulfills several functions in relation to the indoor climate in an energy efficient way.
- Its characteristics and functions are adaptable to changes in the outdoor climate and indoor climate demands.
- The facade is the building skin through which exchange of heat, air light, moisture, view, noise, etc takes place.
WICONA – TEmotion – Selfsustaining Facades The Intelligent Solution

Multifunctional element facade with a high level of prefabrication

1. Ventilation in and out
2. Heating and cooling
3. Lighting
4. Solar shading
5. Energy supply
Scope

- To develop **Integrated Building Concepts**, where appropriate **Responsive Building Elements and HVAC-systems** are integrated into one system to reach an optimum **Environmental Performance**.
Objectives

- Improve and optimise the integration of responsive building elements and building services
- Develop and optimise new building concepts with integration of responsive building elements, building services as well as natural and renewable energy strategies
- Develop guidelines for procedures and tools for detailed estimation of environmental performance of responsive building elements and integrated building concepts
Annex Organization

Subtask A: Responsive Building Elements

- The subtask will focus on development and improvement of responsive building element concepts including assessment of the advantages, requirements and limitations. The subtask will focus on systems that has the potential to be successfully integrated with integrated building concepts.

Subtask B: Integrated Building Concepts

- The subtask will focus on development of integrated building concepts where responsive building elements, energy-systems and control systems are integrated into one system to reach an optimal environmental performance.

Subtask C: Implementation and Dissemination

- The focus of the subtask will be to guide, collect, packet, transform and disseminate the findings generated in Subtasks A and B. The main target groups are designers (architects and engineers), but also end-users and building owners.
## Workprogramme

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*INTEGRATING ENVIRONMENTALLY RESPONSIVE ELEMENTS IN BUILDINGS*
Participation

Austria
Canada
France
Italy
Japan
Sweden
United Kingdom
The Netherlands
Portugal
USA
Norway
Annex Leadership

- Operating Agent
  - Per Heiselberg, Aalborg University, Denmark

- Subtask A
  - Marco Perino, Politecnico di Torino, Italy

- Subtask B
  - Inger Andresen, SINTEF, Norway (until 2007)

- Subtask C
  - Ad van der Aa, Cauberg-Huygen, The Netherlands
Deliverables

Subtask A
Responsive Building Elements
- Review of Existing Technologies
- Investigation of Performance of Existing Technologies
- Development and Optimization of New Technologies
- Analysis of robustness, performance sensitivity and simulation accuracy

Subtask B
Integrated Building Concepts
- Review of Existing Concepts
- Investigation of Performance of Existing Concepts
- Development and Optimization of New Concepts
- Analysis of robustness, performance sensitivity and simulation accuracy

Subtask C
Implementation and Dissemination
- Review of Market Potential & Needs of Target Groups
- Collect and Transform Result of Subtask A & B

State-of-the-art Report
Basic Design Guide