ANNEX 44

INTEGRATING ENVIRONMENTALLY RESPONSIVE ELEMENTS IN BUILDINGS

International Energy Agency
Energy Conservation in Buildings and Community Systems Programme

Annex 44 Website: www.civil.aau.dk/Annex44

Annex 44

Annex 44 is a task-shared international research project initiated by the IEA implementing agreement Energy Conservation in Buildings and Community Systems (ECBCS). Annex 44 is a four year project running from 2005 – 2008 and about 25 research institutes, universities and private companies from 14 countries world wide participate

The objectives of the project are:

To improve and optimise responsive building elements

To develop and optimise new building concepts with integration of responsive building elements, HVAC-systems as well as natural and renewable energy strategies

To develop guidelines and procedures for estimation of environmental performance of responsive building elements and integrated building concepts

Project Intro

Research into building energy efficiency over the last decade has focused on efficiency improvements of specific building elements like the building envelope, including its walls, roofs and fenestration components and building services systems such as heating, ventilation, cooling equipment and lighting.
Significant improvements have been made, and whilst most building elements still offer opportunities for efficiency improvements, the greatest future potential lie with technologies that promote the integration of responsive elements in buildings. With the integration of responsive building elements and building systems, building design completely changes from adding up individually designed elements and systems to an integrated way of designing reflecting an holistic approach which will allow optimal use of natural energy strategies as well as integration of renewable energy devices.

Integrated Building Concepts are defined as design solutions where responsive building elements together with energy systems are integrated into one system to reach an optimal environmental performance in terms of energy performance, resource consumption, ecological loadings and indoor environmental quality.

Acknowledgement

Frontpage:
Picture of Kvernhuset School, Norway, photographer: Terje Heen.
Picture of The Lowry, Manchester, England, courtesy of Buro Happold/Mandy Reynolds

Building Responsive Elements:
Thermal Mass Activation: Vertical section through slab. Illustration by Bjarne W. Olesen, Technical University of Denmark, Denmark
Earth coupling: Ad van der Aa, Cauberg-Huygen, The Netherlands
Advanced Integrated Facade: Illustration by Fernando Marques da Silva, National Laboratory for Civil Engineering, Portugal and Matthias Haase, University of Hong Kong
Phase Change Materials: Stratification of a wall with inserting PCM layer (Rubitherm GmbH)
Dynamic Insulation: Dr. Mohammed Imbabi, The University of Aberdeen, United Kingdom

Integrated Design:
Trias Energetica, introduced by Novem in the Netherlands, futher development by the Technical University of Delft, The Netherlands.
The Kyoto Pyramid for dwellings by A.Rødsjø, Husbanken, Norway
The Integrated Design Process by IEA Task 23, Diagram by Solidar, Berlin Germany
Eco-Factor Method, developed within the EU-FP5 project IDEEB (Intelligently Designed Energy Efficient Buildings), Aalborg University, Denmark

Deliverables

Results from the project will be collected and transformed into information that meets the needs of the main target groups.
The main deliverables include:

- State-of-the-art report of responsive building elements, integrated building concepts as well as integrated design methods and environmental performance assessment tools
- Manufacturers' Guide for development, optimization and performance assessment of responsive building elements including examples of application in integrated building concepts
- Designers' Guide for design of integrated building concepts, including integration of responsive building elements and HVAC-systems and build examples, and for rough evaluation of building performance with regard to functionality, flexibility, energy savings, indoor climate, robustness and cost.
- Experts' Guide with detailed information regarding design and analysis of integrated building concepts, integration strategies of responsive building elements and HVAC-systems and optimum use of simulation methods and tools to assess environmental performance and robustness of integrated building concepts.
- General Booklet describing the principles of responsive building elements and integrated building concepts, their benefits and limitations, economical feasibility and impact on energy savings, company image, comfort, productivity, building functionality and flexibility.

All deliverables will after the project period be available for download from the Annex website (www.civil.aau.dk/Annex44) and from the ECBCS website (www.ecbcs.org).

Benefits

Integration of responsive building elements and energy-systems in integrated building concepts has a number of important advantages:

- Integration of responsive building elements with energy-system will lead to substantial improvement in environmental and operating cost performance.
- It enhances the use and exploits the quality of energy sources (exergy) and stimulates the use of renewables and low valued energy sources (like waste heat, ambient heat, residual heat etc.)
- It will further enable and enhance the possibilities of passive and active storage of energy (buffering)
- It will integrate architectural principles into energy efficient building concepts
- Responsive building elements lead to a better tuning of available technologies in relation to the building users and their behaviour
- It enhances the development of new technologies and elements in which multiple functions are combined in the same building element.
- It will lead to a better understanding of integrated design principles among architects and engineers.

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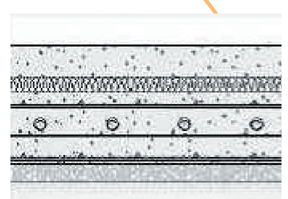
Responsive Building Elements

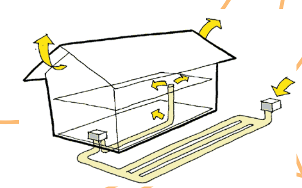
Responsive Building Elements are defined as building construction elements which are actively used for transfer and storage of heat, light, water and air. This means that construction elements, like floors, walls, roofs, foundation etc., are logically and rationally combined and integrated with building services systems such as heating, cooling, ventilation and lighting. The development, application and implementation of responsive building elements are considered to be a necessary step towards further energy efficiency improvements in the built environment.
The work in IEA Annex 44 focuses on the following examples of RBE's:

Thermal Mass Activation



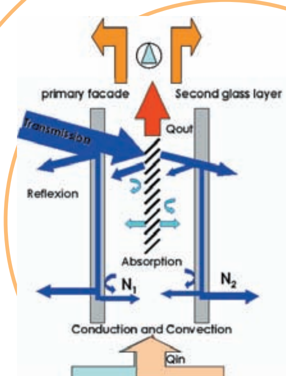
Thermal mass activation is a relatively new approach to radiant heating and cooling. Water circulation in pipes activates the thermal mass of the slab, which both has a direct heating-cooling effect and reduces the peak load by transferring part of the heat load outside the period of occupancy. These systems operate at water temperatures close to room temperature and increase the efficiency of heat pumps and other systems using renewable energy sources.

Earth Coupling



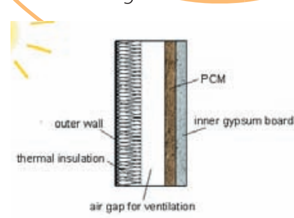
An Earth-to-Air heat exchanger ventilates air to the indoor environment through one or several horizontally buried ducts to use the ground's large thermal capacity and relatively stable temperatures. It is primarily used for cooling purposes since soil temperatures are usually below room temperature but can also be used for winter preheating.

Advanced Integrated Facades



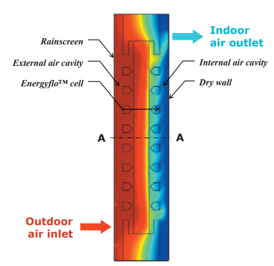
An Advanced Integrated Façade is the outer envelope of a building that by adaptation to both the physical and climatic conditions of a particular building and location performs functions that can be individually or cumulatively adjusted to maintain comfort in the building with the least use of energy"

Phase Change Materials



Phase Change Materials in the construction field aims to control thermal flows by using its enormous capacity to accumulate heat at temperatures close to its melting point. These materials act as heat accumulators; keeping their temperature unaltered and thus avoiding the overheating of the elements they are contained in.

Dynamic insulation

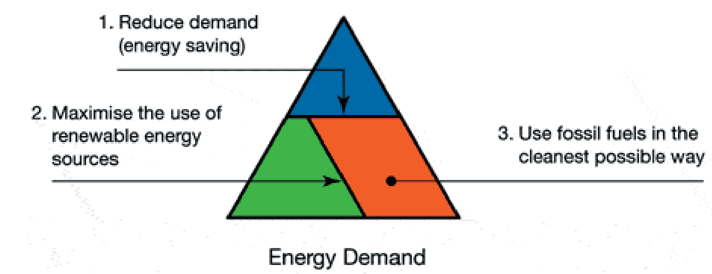


Unlike conventional insulation, dynamic insulation uses the heat exchange characteristics and filtration properties of air permeable media to enable the wall and roof of a building to pre-heat and filter the incoming ventilation air. The immediate benefit is significant reduction in the heating (and cooling) energy used to offset fabric and ventilation heat transfer.

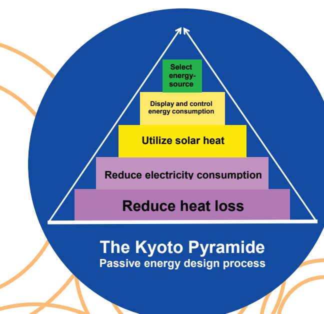
Integrated design

Until recently energy efficient design of buildings mostly focused on improving certain techniques or apparatus. Nowadays an energy efficient building design supported by energy efficient building services has to be developed as one integrated energy efficient concept with an optimal performance in terms of energy use, thermal comfort, user's satisfaction etc. This requires an integral design approach in which well balanced choices and optimizations are made.
The application of responsive building elements needs the improvement of integrated design approaches.
This requires that a number of methods and tools are improved and combined especially regarding principles of energy efficient building design, integrated design process, integrated design of components and systems, design evaluation and decision making.

Examples of methods and tools related to energy efficient building design

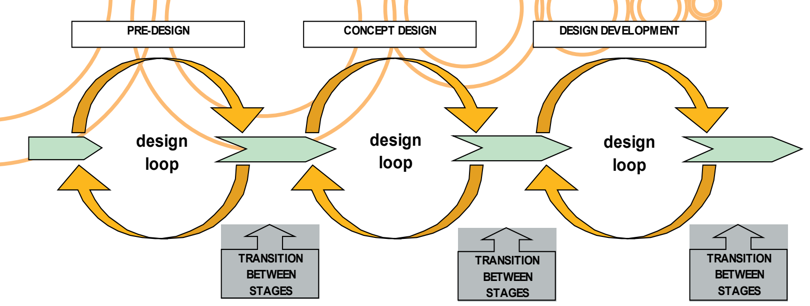


Trias Energetica, introduced by Novem in the Netherlands, futher development by the Technical University of Delft.



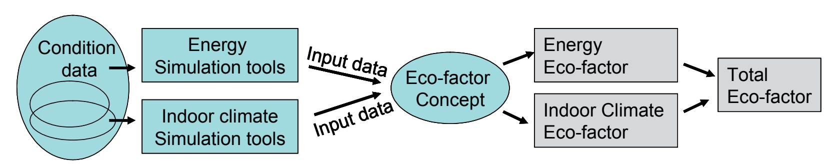
The Kyoto Pyramid for dwellings by A.Rødsjø, Husbanken

Examples of methods and tools related to the integrated design process



The Integrated Design Process by IEA Task 23, Diagram by Solidar, Berlin Germany

Example of tool for design evaluation



Eco-Factor Method, developed within the EU-FP5 project IDEEB (Intelligently Designed Energy Efficient Buildings), Aalborg University, Denmark