654: Developing Integrated Energy Design as a standard practice of building design

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Abstract

Integrated Energy Design (IED) is a notion for a design process that results in lower building running costs, more comfortable indoor climate and reduced CO2 emissions. This paper presents an effort to develop IED as a standard European practice of building design beyond the level of the Directive of Energy Performance of Buildings (EPBD). This is the main objective of an ongoing EU supported project called INTEND (Integrated Energy Design in public buildings) looking especially on the processes of Integrated Energy Design. In the framework of INTEND project tools and methods for IED have been developed for practical use by the design teams for new building projects. At least 12 buildings in Europe will serve as examples showing how IED can be used in planning and designing building projects.. Furthermore, an Internet database has been created based on the "wiki" concept to spread knowledge and experience of buildings of high-energy performance, eco design, etc. The project results will be disseminated to leading architects, engineers, consultants, real estate organisations and developers through a number of activities that include workshops, lectures and an international conference.

Keywords: integrated energy design, low-energy buildings, design process

1. Introduction

The global drive towards sustainable development and rising energy prices are putting increasing pressure on building developers and designers to produce buildings with a markedly higher environmental performance. Although various experts have somewhat different interpretations, a consensus view is that such buildings must achieve high performance in the following areas:

- Minimal consumption of non-renewable resources, including land, water, materials, and fossil fuels;
- Minimal atmospheric emissions related to global warming and acidification;
- Minimal liquid effluents and solid waste;
- Minimal negative impacts on site ecosystems;
- Maximum quality of indoor environment, in the areas of air quality, thermal comfort, lighting and acoustics/noise.

In addition, the building industry is faced with more stringent performance requirements being imposed by markets and regulations. Chief amongst these is energy performance, and this poses a definite challenge to designers in terms of reducing purchased energy consumption and in the application of renewable energy technologies, all within the constraints of minimal fees and the time pressure of the modern development process.

In order to meet all these requirements, a new type of design process is called for – the Integrated Energy Design (IED) process. IED is a prerequisite for achieving high-performance buildings with low energy consumption and good acceptable? indoor environment, without sacrificing architectural quality or result in excessive costs. It demands the cooperation of all the members of the design team from the very beginning of a project. IED should be a natural and integrated part of any building process. INTEND is an EU supported project looking especially on the processes of Integrated energy design. The main objective of INTEND is to develop Integrated Energy Design as a European practice of building design and to set a new standard substantially beyond the anticipated level of the EC Directive on Energy Performance of Buildings [1].

The specific targets of INTEND project are:

-To create an Internet home page www.intendesign.com to communicate the IED message and the project results to the target groups (architects, consulting engineers, developers, real estate organizations etc.)

-To develop tools and methods for IED to support the implementation of the Energy Performance of buildings (EPBD)

-To show how IED can be used in practical, at least 12 demo projects (will serve as examples, and it will be demonstrated how IED can contribute to energy optimised design in these buildings.

-To develop an Internet database to spread knowledge and experience of buildings of high-energy performance, eco design, etc.

-To disseminate the IED methods, tools and experience of the 12 pilot projects through seminars, workshops, an internet database and an international conference on IED

INTEND project, is coordinated by KanEnergi AS, Norway and the participating countries are Norway, Denmark, Austria, Greece, Poland and the UK. The project is still ongoing (from January

2007 to December 2009), so this paper focuses mainly in explaining the notion of Integrated Energy Design and in presenting the tools and methods for IED as well as the Internet Database with the low energy buildings.

2. Integrated energy design

Integrated Energy Design (IED) is a notion for a design process, which tries to insure coherence between shape, function, architecture, and energy consumption so that the building convinces with its architecture, ensures the desired functions and flexibility and relieves its user with low energy costs during the whole life cycle of the building.

Contrary to the traditional design process, IED demands mutual cooperation between the design teams, i.e. between architects, developers, clients, engineers, etc from the very beginning of the project. Traditionally the developer does not communicate his objectives from the very beginning. The architect and the client agree on a design concept, consisting of a general massing scheme, orientation, fenestration and, usually, the general exterior appearance as determined by these characteristics; The mechanical and electrical engineers are then asked to implement the design and to suggest appropriate systems to achieve acceptable indoor climate. None of the two parties hold the full answer to the physical challenges the building has to solve. Often they work their way into the projects from different perspectives related to their specific knowledge and interest. This "draw-and-repair" way to design is not an efficient way to work. The result is often expensive and sub optimised solutions.

IED includes some typical elements that are related to integration [2]:

- Inter-disciplinary work between architects, engineers, costing specialists, operations people and other relevant actors right from the beginning of the design process;
- Early design phases offer opportunity for large impacts on performance to the lowest cost and disruption.
- A clear articulation of energy/ environmental performance targets and strategies, to be updated throughout the process by the design team;
- Budget restrictions applied at the whole-building level and no strict separation of budgets for individual building systems, such as HVAC or the building structure. This reflects the experience that extra expenditures for one system, e.g. for shading devices, may reduce costs in other systems, e.g. capital and operating costs for a cooling system.
- The addition of one or more specialist in the field of energy, environment and comfort;
- The testing of various design assumptions through the use of energy simulations throughout the process, to provide relatively objective information on this key aspect of performance;
- In some cases, a Design Facilitator may be added to the team, to raise performance issues throughout the process and to bring specialised knowledge to the table.
- Quality control throughout the design, engineering, and construction phases to achieve the project targets

Furthermore the IED approach is based on an iterative process consisting of a series of design loops, separated by transitions with evaluations and decisions about milestones. In each of the design loops, the design team members relevant for that stage participate the process. The objective is to bring the desired decision or result closer to discovery with each repetition.

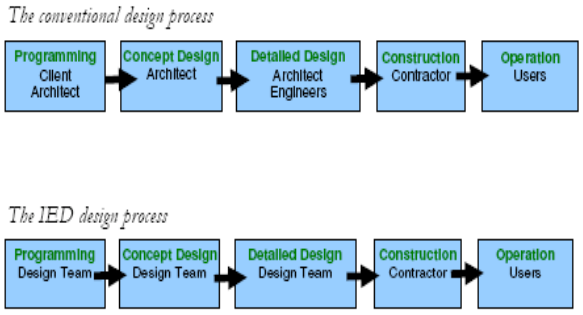

Fig. 1. The phases of the conventional and the IED process indicating the main actors participating at each stage. See Chapter 4 for a more detailed diagram of the IED process.

In an IED process the focus is firstly on achieving as much comfort as possible through the passive qualities solutions (daylighting, glazing, natural ventilation, shading, thermal mass, etc). Subsequently, the focus will be on supplementing with as few, but as efficient active solutions as possible in terms of installations, adjustments and other technical systems. This way, buildings are much more robust against changes of use and user behaviour. The design philosophy of IED is the "Trias Energetica". "Trias Energetica" strategy consists of three steps where the next step should only be taken, when possibilities for the former step are completely exhausted [3].

These steps are:

1. Reduction of the energy use
2. Use of renewable energy sources
3. Efficient use of fossil energy

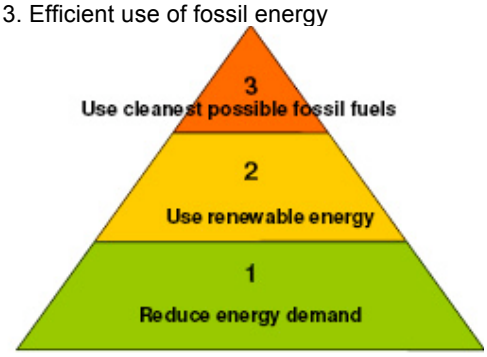

Fig 2. Trias Energetica: Passive before active

An example of using the Trias Energetica philosophy for passive cooling would be the following:

1. Reduce heat gains (building form, floor plan, solar control, minimize internal gains, efficient equipment)
2. Modulate heat gains (control system, thermal storage)
3. Utilize natural ”cool” sources (natural ventilation, geothermal, evaporation, radiation)

The benefits from practicing Integrated Energy Design are:

- Lower running energy costs (40-70% reduction)
- Less CO2-emissions
- Better indoor air climate
- Less voluminous technical installations

Experiences show, that IED-designed buildings are build with 40-70% low energy consumption than conventional buildings, and the financial feasibility (rate of return) for the IED-measures is often more than 10%.

However, there are a number of barriers that prevent the implementation of IED like:

- The conservative building industry,
- A lack of legislation,
- The fact that builders do not care about the annual running costs (as new buildings will be sold or rented out),
- A lack of cooperation in early design stages,
- The fact that architects and engineers “do not speak the same language”,
- The thought that investment cost will go up,
- Difficulties in forming multidisciplinary teams, etc.

INTEND project through its activities will try to overcome these barriers. In order to communicate the message of Integrated Energy Design to the relevant target groups an Internet web page has been created www.intendesign.com. This page contains all the information about the project (description, phases, partners and contact details), information on IED and web resources, the publications and the deliverables, the Internet Database.

Fig 3. INTEND website

3. Tools and methods for IED

Although efforts have been made in many European countries to revise the national building

codes in order to limit the energy use of buildings and at the same time ensure a comfortable indoor climate, in many situations the design team has difficulties to optimise the building design regarding energy use in combination with good indoor climate. This is why tools and methods for an integrated energy design are highly needed.

In the framework of INTEND project a survey of the existing methods and tools for integrated energy design (IED) processes around the world has been carried out. In total 9 initiatives towards integrated building concepts have been mapped: 1) Integrated Design process (IDP) by IEA Task 23, 2) Integrated Design process (IDP) by Knudstrup, Aalborg University 3) Integrated Building design System (IBDS) by Steemers, Cambridge University 4) Eco-Factor Method by Wahlgren, Bjørn and Brohus 5) Trias Energetica by Novem, Delft University and Cauberg-Huygen 6) Kyoto Pyramid by Dokka and Rødsjø, Norway 7) ABCplanner by RH Architects and Niras Consulting Engineers 8) SBTool by iiSBE (International Initiative for Sustainable Built Environment) 9) CLEAR – Comfortable Low Energy Architecture [4]. These integrated building concepts can be grouped in three different categories:

a. Process focused methods (how to work in integrated design teams, what to consider when and by whom)
b. Design evaluation methods (structured evaluation of potential design solutions, design criteria)
c. Design strategy methods (what technologies to apply, and in what order)

The report on "Mapping of previous integrated energy approaches" can be downloaded from INTEND's website. The reason for investigating previous work on tools and methods for integrated building concepts is to learn from these concepts, and use this knowledge for the development of INTEND 's own tools and methods for an integrated energy design process. The mapping of the existing methods and tools for IED processes has shown the importance of the process focused method and the Guidelines that have been developed focus on this method to overcome the barriers of working in a design team with many disciplines.

Two separate documents have been prepared to serve as a guide for practicing IED:

a) Introduction to Integrated Energy Design – a guideline to the process and
b) A text "book" of how to design low energy buildings

The purpose of the process guideline is not to create experts in IED but after reading it one should know the principles and be able to adapt and adjust them to each project.

The Guide is divided into 10 chapters [5]

1. Executive summary describing **IED in 9 steps**:
2. **Preface**: short introduction to the guide
3. Introduction to IED: The IED process and its main principles
4. **Communication and cooperation**: The relevant actors in a project and the way they should work together
5. **The design process**: The main phases in IED with the most important IED milestones.
6. **Programming**: establishing a set of clearly defined goals with respect to energy/environmental performance of the project.
7. **Concept Design**: define an energy-efficient building concept that corresponds in a best possible way to the performance targets that was set up in preceding phase.
8. **Detailed design**: detail the design concept in order to produce construction documents, along with updated energy budgets and an updated quality control plan.
9. **Construction, Commissioning and Building Hand-Over:** produce and deliver the building according the specifications made in the previous phases.
10. **References**

The first three chapters focus on the IED process, its main principles and philosophy (see previous paragraph). In the rest of the chapters the guideline demonstrates how the IED approach works though the building phases from idea to demolition, giving the corresponding examples, and through this it gives developers knowledge of the process to develop sustainable buildings with special focus on energy. The differences between the traditional and the IED process are highlighted as well as the possible mistakes that are avoided following the IED process.

In simplified terms, the main steps in IED are made up of 3 roughly defined phases: Programming, Concept Design, and Detailed Design. As part of the integrated design optimization, iterations have to take place during the various design phases. The need for iterations, however, is most pronounced in the early design phases. By going some extra rounds in the beginning, the need for more costly iterations in the later phases may be reduced. The iterations are illustrated by the "quality-wheel". The quality-wheel is a tool to keep track of the iterative process of IED. The main tasks in the wheel are:

1. define the goals;
2. develop and decide strategies to meet the goals;
3. make activity plans (e.g. quality assurance plans, control plans);
4. evaluate the design, and make corrections if needed.

Fig. 4. The Quality Wheel.

Firstly relevant goals to the project are defined. These goals are then defined as one or several strategies to investigate. A plan of activities is defined. Finally the process and its activities are evaluated and corrections needed according to the evolutions are done before moving into the next cycle. The corrections can bring you back in the phases because you have find new knowledge which leads to corrections or redefined goals or it can correct to any other of the steps in the quality-wheel. The transitions between phases are marked by milestones where the current status of the design is evaluated, major decisions are made, and documentation is produced. The documentation may include updated quality assurance plans and control plans, energy and power budgets, and performance specifications.

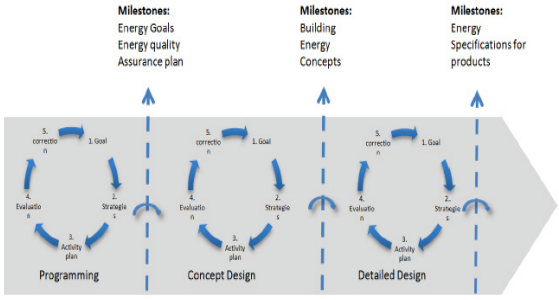

Fig. 5. The main phases in IED with the most important IED milestones.

The "text book" is an informative guide on the central themes examined by the process steps in IED: Daylight, Fire, thermal comfort and indoor air quality, ventilation and cooling. It gives the basic information (definitions, requirements, climate specific rules of thumb, factors that affect them etc.) on several subjects related to these themes as well as useful references for further study. In the end an evaluation of the design tools related to these central themes is presented (e.g. calculation tools for daylight, ventilation etc.).
Both documents are available on INTEND's web site.

As implementation of energy conscious designs will contribute significantly to the reduction of the overall energy demand in the EU building sector, public buildings would play a very important role. At least two public buildings in each one of the participating countries are being designed by implementing thoroughly the IED tools and methods. These pilot projects that will serve as examples, demonstrating how IED can contribute to energy optimized design in these buildings. The implementation of these tools and methods will result well functioning buildings – in terms of comfort levels, energy efficiently, employed renewable energy sources, low energy consumptions and buildings that are demonstrably improved,

4. European Internet Database on Sustainable Buildings

In order to spread the knowledge and experience of buildings of high- energy performance, sustainable and ecological design and spread the results of the project a European Internet Database has been created (a link to the database will be added at www.intendesign.com).

The Database has been developed based on the "wiki" concept. A wiki enables documents to be written collaboratively, in a simple mark up language, using a web browser [6]. The entire body of pages in a wiki are highly interconnected via hyperlinks. A wiki is essentially a database for creating, browsing and searching information. The wiki offers a great advantage, which is the ease with which pages are created and updated. This is the reason why it was decided to create the Database as a wiki so that it is more flexible and stay "alive", being constantly updated even after the end of INTEND project.

The Database can be navigated by the specified groupings[7]:
1. Projects: The name of the building)
2. Typology: Residential, office, education, sports, culture, health and commercial
3. Location: Western, Eastern, Central, Northern and Southern Europe
4. Technology:
   - Passive design measures (e.g. daylighting, thermal mass, solar chimneys etc.),
   - energy efficiency measures (e.g. insulation, high efficiency boilers),
   - energy generation (Solar thermal panels, Photovoltaics, Wind turbines),
   - sustainability (e.g. Sustainable and renewable resources, low embodied energy, area and transport, green spaces, indoor environment/comfort, reduction of construction waste, water saving equipment/actions, waste and drainage systems),
   - process (e.g. if IED process has been used)

Each project is illustrated by pictures, designs, graphs etc. At the end of each project the public can make a comment or vote in order to rate the overall thermal, visual and acoustic environment of the building.

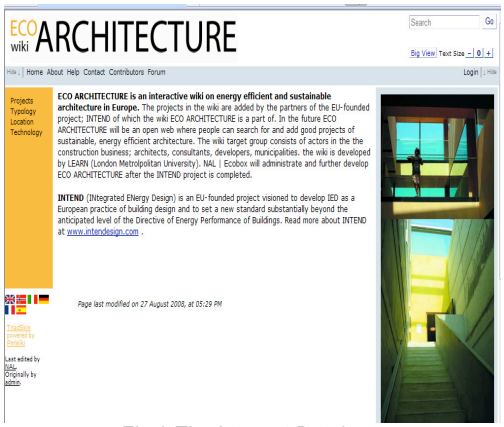

Fig 6.The Internet Database

5. Conclusion

The results of an ongoing project called INTEND focusing on Integrated Energy Design have been presented. The notion of Integrated Energy Design has been analysed pointing out its main principles. Tools and methods for practicing IED have been developed and are presented. A European Internet Database has been created based on the "wiki" concept to spread knowledge and experience of low –energy buildings and sustainable projects.

It is expected, that the outcome of the project will clearly demonstrate awareness of the usage of IED as an important design concept. It will be demonstrated, that the IED-cooperation within the team of architects, engineers, building owners and investors can provide outstanding results regarding energy efficiency, renewable energy sources and indoor climate.

6. References

1. Material from the preparation of the proposal for the Intelligent Energy Europe (IEE) programme, the EU INTEND project with the project ref. no. EU Contract no. EIE/06/021/SI2.448295 - INTEND.
2. Larsson, N. and B. Poel (2003) "Solar Low Energy Buildings and the Integrated Design Process – An Introduction", http://www.iea-shc.org/task23/.
3. The Trias Energetica method. [Online] Available: http://triasenergetica.com/
4. Report on "Mapping of previous integrated energy approaches". [Online] Available: http://www.intendesign.com/
5. Introduction to Integrated Energy Design- a guideline to the process. [Online] Available: http://www.intendesign.com/
6. Wikipedia [Online] Available: http://en.wikipedia.org/wiki/Wiki
7. INTEND Deliverable 17: Internet Database report