MARKET TRANSFORMATION TOWARDS NEARLY ZERO ENERGY BUILDINGS THROUGH WIDESPREAD USE OF INTEGRATED ENERGY DESIGN

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ABSTRACT

ID is a design procedure that considers the building as a whole system with the aim of optimizing it throughout the lifecycle. ID can be used to reach high ambitions by developing, discussing and evaluating a scheme using a multidisciplinary team from the initial design phases and it is a proven approach for achieving high-performance buildings with good indoor environment without sacrificing architectural quality or result in excessive costs. Integrated Design support designers in delivering buildings which satisfy occupant's needs much more than conventionally designed buildings.
Towards this direction MaTrID project supports the implementation of directive 2010/31/EU by widespread market adoption of ID on the national level. The main targets of MaTrID are:
- Establishing the general understanding on the advantages and requirements of ID
- Improving the know-how basis on ID
- Testing the practical implementation of ID on a large scale
- Development of a common tool-kit for the integrated energy design of NZEB
- Adaptation of the common tool-kit to national requirements
- Implementing EU-wide promotion and dissemination activities
- Drawing conclusions for a further market adoption

The benefit of EU collaboration is to link good practices among leading European countries (including clients, private industry, public sector, etc.). Knowledge transfer among Europe and various actors is the main benefit of MaTrID.

KEYWORDS

nearly zero energy buildings, integrated design

1 INTRODUCTION

Buildings account for around 40% of total energy consumption and 36% of CO2 emissions in Europe. The reduction of energy consumption and the use of energy from renewable sources in the buildings sector therefore constitute important measures which are needed to reduce energy dependency and greenhouse gas emissions. The mitigation potential of emissions from buildings is important and as much as 80% of the operational costs of standard new buildings

can be saved through integrated design principles, often at no or little extra cost over the lifetime of the measure. The recast Directive on the energy performance of buildings (EPBD) stipulates that by 2020 all new buildings constructed within the European Union after 2020 should reach nearly zero energy levels. This means that in less than one decade, all new buildings will demonstrate very high energy performance and their reduced or very low energy needs will be significantly covered by renewable energy sources.
In parallel, Member States shall draw up national action plans for increasing the number of nearly zero-energy buildings (NZEB). These national action plans shall include policies and measures to stimulate the transformation of existing buildings which are refurbished into nearly zero-energy buildings. In addition, by 2015 all new buildings and buildings undergoing major renovation must have minimum levels of energy from renewable sources. The implementation of these policy goals requires a major transformation in the building sector during the next few years.
The design of NZEB requires an interdisciplinary approach. Reducing the energy demand in the design phase demands specifications of the different designers and engineers such as architects, building physics or façade designers. For the demand side concept of a building the best possible heating or ventilation system should be applied. Activating of thermal mass for example requires the interaction between the structural designer and HVAC engineers. Alternative energy systems have to fit to the concept design and the building energy systems. For this reason, the introduction of a design team is compulsory for the design of NZEBs.
In this context the building design phase is of particular importance. IED is a valuable assisting approach to reduce the complexity of the design process, to ensure the implementation of defined, to identify pros and cons of alternative variants of design concepts and to allow decision makers to decide based on transparent facts. Only if IED is applied from the very beginning of the design phase we can assume that a cost-effective solution for NZEB can be identified, because only at the early design phases changes of the general design concept can be implemented at low cost. Therefore, the application of IED is part of the best way towards the intended NZEB at low cost. Experience from several demonstration and pilot projects shows that IED frequently leads to highly energy efficient solutions at least cost over the life cycle of the building, because the integration of all required expertise already in the early design phase brings forward easy and thus cost-efficient solutions.
The objectives of the proposed project have been identified based on an in- depth assessment of barriers for IED resp. on the preconditions which are required for a practical application of the IED approach. Activities are needed on the side of the building owner (developer) as well as on the side of designers. Starting from this, the following specific project objectives can be derived:

- Establishing the general understanding on the advantages and requirements of ID
- Improving the know-how basis on ID
- Testing the practical implementation of ID on a large scale
- Development of a common tool-kit for the integrated energy design of NZEB
- Adaptation of the common tool-kit to national requirements
- Implementing EU-wide promotion and dissemination activities
- Drawing conclusions for a further market adoption

The construction, architects and engineering market is very much focused on regional and local level. Additionally, the state of the art for IED in each country is different. For this reason, the emphasis of the project is on widespread market adoption on national level.

2 PRINCIPLES FOR NEARLY ZERO-ENERGY BUILDINGS

Directive 2010/31/EU (EPBD recast) Article 9 requires that "Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings". Member States shall furthermore *"draw up national plans for increasing the number of nearly zero-energy buildings"* and *"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"*.
A nearly zero-energy building is defined in Article 2 of the EPBD recast as *"a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby"*.
The specific EPBD Concerted Action activities around **"**Towards 2020 - Nearly zero-energy buildings**"** will support the Member States by the exchange of experiences with already existing high performance buildings(ranging from low energy buildings to passive houses, zero-energy and zero-emission buildings, and even to energy surplus houses).
The discussion topics include the most common building and service system solutions**,** calculation methods**,** promotional means, available subsidies and other incentives**,** supporting documents (e.g. guidelines), etc., as well as study tours to interact with experts at national administrations and visits to relevant sites.
The different national applications of the definition of nearly zero-energy buildings are presented and compared: front-runner countries receive a feedback and other countries gather inspiration for their own application.
Through such information exchange, Member States participants furthermore support each other in the development of the national plans for increasing the number of nearly zero-energy buildings**.**
To achieve a suitable definition, related facts and findings need to be seen in a broader societal context and need to be transferred into a practical standard, taking into account financial, legal, technical and environmental aspects. Analysing the implications identified above, it becomes obvious that most of them interact or require the consideration of one or several societal aspects. Consequently, the principles for an nZEB definition should be built on the same broad perspective, should take into account all financial, legal, technical and environmental aspects and should meet the present and future challenges and benefits. Hence, a proper and feasible nZEB definition should have the following characteristics (Thomsen, K.E., 2011):

- To be clear in its aims and terms, to avoid misunderstandings and implementation failures.
- To be technically and financially feasible.
- To be sufficiently flexible and adaptable to local climate conditions, building traditions etc., without compromising the overall aim.
- To build on the existing low-energy standards and practices.
- To allow and even foster open competition between different technologies.
- To be ambitious in terms of environmental impact and to be elaborated as an open concept, able to keep pace with the technology development.
- To be elaborated based on a wide agreement of the main stakeholders (politicians, designers, industry, investors, users etc.).
- To be inspiring and to stimulate the appetite for faster adoption.

Consequently, there are three basic principles, each one with a corollary for setting up a proper nZEB definition, addressing the three main reasons and aims for regulating the building sector: reduced energy demand, the use of renewable energy and reduced associated GHG emissions.

1. Energy demand
There should be a clearly defined boundary in the energy flow related to the operation of the building that defines the energy quality of the energy demand with clear guidance on how to assess corresponding values.
2. Renewable energy share
There should be a clearly defined boundary in the energy flow related to the operation of the building where the share of renewable energy is calculated or measured with clear guidance on how to assess this share.
3. Primary energy and CO2 emissions
There should be a clearly defined boundary in the energy flow related to the operation of the building where the overarching primary energy demand and CO2 emissions are calculated with clear guidance on how to assess these values.

3 THE INTEGRATED DESIGN PROCESS

Integrated design is an approach that considers the design process as well as the physical solutions, and the overall goal is to optimize buildings as whole systems throughout the lifecycle. Firstly, for the purpose of reaching high sustainability performance, the alternative building and technical solutions should be developed and discussed by an *integrated,* multidisciplinary team. ID emphasizes a decision process rooted in informed choices with regard to the project goals, and on systematic evaluation of design proposals. This approach for building design is paralleling the principles of environmental management referred in the international ISO 14001 standards. Here, identifying and prioritizing goals, and developing an evaluation plan with milestones for follow-up, are central issues.
A shift of approach emphasizes that the very early phases need more attention because well informed decisions here will pay off in the rest of the design process as well as in the lifecycle of the building. Well informed planning from the start can allow buildings to reach very low energy use and reduced operating costs at very little extra capital cost, if any. Considering the whole life cycle of a building, the running costs are higher than construction and refurbishment costs; thus, it becomes obvious that it is a shortsighted approach to squeeze the first design phase regarding resources. Experience from building projects applying ID shows that the investment costs may be about 5 % higher, but the annual running costs will be reduced by as much as 40-90 %. The process of ID emphasizes that the performance of buildings should be assessed in a lifecycle perspective, both regarding costs (LCC) and environmental performance (LCA). Figure 1 indicates the importance of the integrated design process at the early phases (Norby, A.S., 2013).

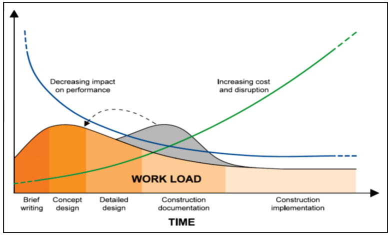

Figure 1. Early design phases offer opportunity for large impact on performance to the lowest costs and disruption. Therefore, a shift of work load and enhancement to the early phases will probably pay off in the lifecycle of the building.

3.1 The benefits

- Higher energy performance
Optimization of building form, orientation and facades is reached through open multidisciplinary discussions and design decisions in early project phases, where knowledge about important conditions is exchanged to inform the design of the building.
- Reduced embodied carbon
Optimized design is given priority before advanced technical systems and control mechanisms. The high embodied carbon of HVAC components are thus reduced.
- Optimized indoor climate
The building and technical systems work together in a logical symbiosis in order to achieve sufficient indoor air quality, temperature control and daylight access/ solar protection
- Lower running costs
Simplified technical systems are more cost efficient, both in terms of investment costs for manufacturing and installation and in terms of running costs and maintenance.
- Reduction of risks and construction defects
Improved planning leads to less building faults. Thus; less claiming, and money saved.
- More user involvement
Early involvement of users and inclusion of user needs in the design process may improve the following performance of the building in the operation phase, as well as increase user satisfaction.
- Higher value
A high performance building can yield higher rental costs which can be compensated for by a lower energy bill thus the sales value of the building will increase.
- Green image and exposure of the building
A green image can benefit the building owner or tenant organization.

3.2 The barriers

- Conventional thinking
The building sector is known for being slow accepting new ways of working. ID calls for decision processes and design methods that challenge familiar habits, and require high communication skills. Professionals on both sides of the table must practice in collaboration, and maybe adjust their working habits.
- ID seems to costs too much
Developers traditionally pay more attention to construction costs than lifecycle costs (LCC). However, when energy consumption and maintenance is included in the calculations, it usually supports investments in planning for high performance and robust solutions.
- Time constraints in initial design phase
Often developers underestimate the value of thoroughly planning, and expect high speed in conceptualizing a building. It can be challenging to convince the developer that the initial phase is crucial, and that giving time for design iterations often pay off in better concepts.
- "Skills tyranny"
As the ID process requires more collaboration between stakeholders who may have diverging goals, conflicts could be accentuated. It is therefore necessary that the team members do not insist on ultimate demands within their fields of expertise, but rather endeavour to work with a holistic approach.

3.3 The principles

Six steps can be identified for a successful integrated design implementation (Figure 2):

- Project development: this includes the discussion of the project ambitions and challenge initial client presumptions, initiating ID process and preferably make partnering contracts
- Design basis: selection of a multi-disciplinary design team, including an ID facilitator, motivated for close operation, analysis of the boundary conditions. Also refine the brief and specify the project ambitions, preferably as functional goals
- Iterative problem solving: facilitate close operation between the architect, engineers and relevant experts through workshops etc. Use of both creative and analytical techniques in the design process. Discussion and evaluation of the multiple concepts and finalise optimised design.
- On track monitoring: Use goals/ targets as means of measuring success of design proposals, make a Quality Control Plan, evaluate the design and document the achievements at critical points/milestones
- Delivery: Ensure that the goals are properly defined and communicated in the tender documents and building contracts, motivate and educate construction workers and apply appropriate quality tests, facilitate soft landing. Make a user manual for operation and maintenance of the building
- In use: Facilitate commissioning and check that the technical systems etc. are working as assumed, monitor the building performance over time regarding e.g. energy consumption, user satisfaction etc.

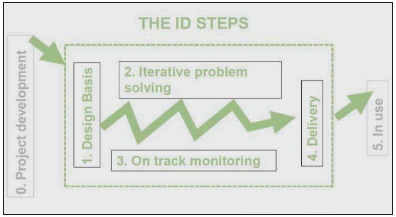

Figure 2. Overview of the ID process.

4 THE MATRID PROJECT

MaTrID aims to support the implementation of Nearly Zero Energy Buildings by 2020. In this context the building design phase is of particular importance. Integrated Energy Design (IED) is a valuable approach to reduce the complexity of the design process and facilitate the interactions between the members of the design team. IED allows them to provide the best solution for the whole building. MaTrID's targets are harmonized with the integrated design process as described in the previous section (.Leutgöb, K. 2012)

4.1 Objectives

The objectives of the proposed project have been identified based on a holistic IED approach. Activities are needed on the side of the building owner (developer) as well as on the side of designers. Starting from this, the following specific project objectives can be derived:

1. Establishing the general understanding on the advantages and requirements of IED at the side of real estate developers and building owners: In this context, the project aims at convincing opinion leaders of builder's associations, big property developers or other multipliers that IED is the way to be chosen for the design of cost-efficient NZEB.
2. Improving the know-how basis on IED: The application of IED requires practical know-how on the developer's side as well as on the designers' side. Therefore the project aims at developing practical tools, such as specific text modules for client briefs as well as for IED related contracts and remuneration models.
3. Testing the practical implementation of IED on a large scale thus setting best practice examples which can be easily copied and multiplied
4. Development of a common tool-kit for the integrated energy design of NZEB
   - Clients brief for NZEB
   - IED-related model contracts
   - IED-friendly remunerations models
   - User-friendly IED guideline
5. Adaptation of the common tool-kit to national requirements
6. Implementing EU-wide promotion and dissemination activities
7. Drawing conclusions for a further market adoption of IED in the years after the end of the project including also practical recommendations on possible policy instruments that may support the widespread use of IED on daily design practice.

4.2 Focus area

The construction, architects and engineering market is very much focused on regional and local level. Additionally, the state of the art for IED in the participating countries is very different. For this reason, the emphasis of the project is on widespread market adoption on national level. National activities are country specific and reflect the respective demand.

4.3 Benefits

The greatest benefits are provided only if applied in the earliest stages of the project, when changes to the design are still easy to implement. The benefit of EU collaboration is to cross-pollinate good practices among leading European countries (including clients, private industry, public sector, etc.). Knowledge transfer among Europe and various actors is the main benefit of MaTrID.

4.4 Outcomes

The outcomes of the project can be summarised as follows:

- A general understanding on the advantages and requirements of IED on the part of real estate developers and building owners as well as on the designers' side.
- Practical tools – such as specific text modules for client briefs as well as for IED related contracts and remuneration models – which can be directly applied in daily practice.
- Successfully tested pilot projects with practical implementation of IED on a large scale. Examples can be easily copied and multiplied.
- General acknowledgement of IED beyond the limits of the participating countries.
- Conclusions for a further market adoption of IED in the years after the end of the project including also practical recommendations on possible policy instruments that may support the widespread use of IED on daily design practice.

A specific award will give European visibility to outstanding ID processes. This award will contribute in spreading the ID approach, in highlighting its advantages and in showing possible and feasible ways to reach advanced building targets.

5 CONCLUSIONS

The European Union (EU) aims at drastic reductions in domestic greenhouse gas (GHG) emissions of 80% by 2050 compared to 1990 levels. The building stock is responsible for a major share of GHG emissions and should achieve even higher reductions of at least 88% - 91%i. Therefore, without consequently exploiting the huge savings potential attributed to the building stock, the EU will miss its reduction targets. More than one quarter of the 2050s building stock is still to be built. The energy consumption and related GHG emissions of those new buildings need to be close to zero in order to reach the EU's highly ambitious targets. The recast of the Energy Performance of Buildings Directive (EPBD) introduced, in Article 9, "nearly Zero -Energy Buildings" (nZEB) as a future requirement to be implemented from 2019 onwards for public buildings and from 2021 onwards for all new buildings

Integrated Design (ID) is necessary in managing the complex issues arising from planning buildings with high energy- and environmental ambitions. In these processes, emphasis is on collaboration in multidisciplinary teams as well as on clear goal-setting and systematic monitoring. In the early design phases, the opportunity to positively influence building performance is great, while cost and disruptions associated with design changes are very small.

The guiding strategic objective of the MarTrID project is to contribute significantly to a widespread market adoption of integrated energy design of buildings. IED should become the standard way of European building design within 2020. As a result real estate industry will find it easier to cope with the challenges coming from energy and climate change policy by producing sustainable buildings with very high energy performance in a cost-effective way, calculated over the life cycle of the building.

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