INTEGRATED ENERGY DESIGN IED
An eldercare centre where regional resources has been used. The building is meeting the Austrian passiv house standards. It has controlled room air shift via earth heating, passive solar energy tank, and in the centre of the building a three story winter garden.
A GUIDE TO INTEGRATED ENERGY DESIGN
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I. Preface

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.
- Architectural quality

Some experts in this rapidly developing field would add related issues such as adaptability, flexibility and operating cost as well as life-cycle cost.

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 indoor environment, without sacrificing architectural quality or result in excessive costs. IED should be a natural and integrated part of any building process.

This guide is intended to assist architects, engineers, clients and developers in designing high performance energy-efficient buildings. The guide focuses mainly on the process of IED, i.e. how the design team may organize their work in order to reach the goals. Thus, the guide will not make the reader an expert in designing energy-efficient buildings, but rather make him/her capable of better understanding the basic ideas of the IED process and its application.

For guidance with respect to technical design issues such as ventilation strategies, etc, the book “Some principles of low energy building design” is provided as an appendix to the IED process guidelines.

It should be noted that the guideline is made on a general level, which means that it may not fit exactly to each individual project. Since every building project is unique, the working methods, the design phases, and the contracts will differ from country to country and from project to project. Nevertheless, we hope that the guide will inspire the reader to further explore the exiting and rewarding process of Integrated Energy Design.

This guideline was developed as a part of the Intelligent Energy Europe project INTEND – Integrated Energy Design in Public Buildings.
Transparent sun shading with solar cells. California academy of sciences. Architect Renzo Piano
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Both available on www.EcoArchWiki.net or www.intendesign.com
2. Integrated Energy Design - Why?

Why IED? In order to explain the characteristics and advantages of the IED process you could ask:

What’s wrong with the conventional design process?

To explain IED, it is useful to start out by explaining the characteristics of the conventional design process. Although there are many exceptions, we can refer to a “conventional” design process as consisting of the following features:

• 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.

Although this is vastly oversimplified, such a process is applied by the large majority of general-purpose design firms, and it generally limits the performance levels achievable, in particular with respect to energy performance.

The conventional design process has a mainly linear structure due to the successive contributions of the members of the design team. There is limited possibility for optimisation during the process, while optimisation in the later stages of the process is often troublesome or even impossible.

The design and performance implications of such a process often include a series of negative consequences, for example:

• The building takes little advantage of the potential benefits offered by solar gains during the heating season, resulting in greater heating demand;

• The building may be exposed to high cooling loads during the summer, due to excessive glazing exposed to summer sun;

• The building may not be designed to take advantage of its daylight potential, due to a lack of appropriately located or dimensioned glazing, or inappropriate glazing types, or a lack of features to bring the daylight further into the interior of the building.
The conventional design process

- **PROGRAMMING**
  - Client Architects
- **CONCEPT DESIGN**
  - Architect
- **DETAILED DESIGN**
  - Architect Engineers
- **CONSTRUCTION**
  - Contractor
- **OPERATION**
  - User

The IED design process

- **PROGRAMMING**
  - Design team
- **CONCEPT DESIGN**
  - Design team
- **DETAILED DESIGN**
  - Design team
- **CONSTRUCTION**
  - Design team
- **OPERATION**
  - User

Student competition. Model of a an idea for a sustainable house. ISES Solar World Congress, Beijing, China. 2007. photo: KS architects
3. Integrated Energy Design - What is it?

IEDE is a new way of achieving high-performance buildings with low energy consumption and good indoor environment.

In the simplest of terms, the Integrated Energy Design (IED) process:
- calls for a different approach from the very early stages of design
- requires a high level of general skills (energy knowledge in a broad sense) and communication within the team
- leads to a high level of integration and synergy of systems, and
- involves modern simulation tools where suitable.

Main design concerns, with sub-categories of design issues.
Adapted from (Steemers 2006).
All of this 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 of a building are higher than construction and refurbishment costs. Experience from building projects applying IED, the investment costs may be about 5% higher, but the annual running costs will be reduced by 40-70%.

The IED process is based on the well-proven observation that changes and improvements in the design process are relatively easy to make at the beginning of the process, but become increasingly difficult and disruptive as the process unfolds. Changes or improvements to a building design when foundations are being poured, or even contract documents are in the process of being prepared, are likely to be very costly, extremely disruptive to the process, and are also likely to result in only moderate gains in performance. In fact, this observation is applicable to a large number of processes beyond the building sector.

*Early design phases offer opportunity for large impact on performance to the lowest costs and disruption. Illustration: Solidar 2003*
The underlying design philosophy of IED is based on the view that passive energy design has a significant importance to achieving low energy buildings. A way of illustrating such a design strategy is through the Trias Energetica pyramid. Trias Energetica is a three step approach that gives the priorities for realising an optimal sustainable energy solution.

The approach was formally introduced in 1996 by Novem in the Netherlands (Lysen 1996), but the principles have been applied in several low energy building projects around the world based on passive energy design.

The Trias Energetica method contains the following steps:

1. The first step aims at reducing the energy demand, by applying energy reducing measures (efficient building form, plan, orientation and facade layout, good thermal insulation, air tightness, and heat recovery).

2. The second step involves employing technologies for utilizing local renewable energy sources, such as solar thermal systems and photovoltaics, heat pumps, biomass, waste and wind.

3. If there is still the need for some auxiliary energy, then the third step involves using the least polluting fossil fuels in the most efficient way.

Within each of these main design concerns, some subcategories of design issues may be defined, as pictured in the figure at the left.

There are strong interdependencies within these groups of design concerns. For example, the building form – whether terraced or courtyard or deep plan, etc. – will impact on the overall layout, but will also influence the decisions related to the facade design, building fabric and the building services. These considerations will furthermore have a bearing on the choice and design of systems for the mechanical services.

So, how should an IED process be carried out? In the following chapters the IED process is described step-by-step.
Aims for the building is to realizing a „Factor 10“ example, e.g. a building that is using only 10 % of resources and energy compared to a conventional construction, has the highest energy saving standard, are meeting high ecological criteria and have a high user comfort.

A straw bale building was chosen because of
- exceptional building physic characteristics
- compatible for low energy houses and passive houses-income opportunities for agriculture
- good availability
- low cost of raw material
- energy saving function
- market potential for regional economy
Changing Design Paradigms

Before the introduction of mechanical systems, climate — not building style or appearance — was the major determinant of building form. Comfort was achieved through passive means and architectural features built into the design. However, with the advent of new technologies, architects were no longer constrained by the need to ensure that buildings had ample daylight, remained airy and cool in the summer and warm in the winter. Since HVAC systems and artificial lighting could satisfy comfort needs, architects could pursue unrestricted designs without making comfort and energy use part of the architectural design.

These innovations started a design revolution. With the freedom to pursue the architectural design as a pure art form, the architect created a design and then passed it on to the constructional and HVAC designers to “fit” the equipment needed to achieve comfort.

The design process that at one time integrated all design disciplines evolved into a sequential process carried out in separate disciplines. The result was buildings that were not designed to coexist with the surrounding climate. It resulted in development of poor concept design choices, thereby providing sub-optimal performance and buildings that were energy intensive, costly to operate and had a significant effect on the environment.

Today, the construction industry is in the early stages of a new revolution; to reinvent a design process focusing on climate-adapted buildings and involving a wide range of professional skills from the start of the design. The new design process is facilitated by advanced tools offered by modern information and communication technologies. Design teams including both architects and engineers are formed and the building design is developed in an iterative process from the conceptual design ideas to the final detailed design. Building energy use and the cost of technical installations are minimized through an effective integration of the architectural and engineering design. The new design process is called integrated energy design (IED).

Adapted from P. Heiselberg
The ongoing development of IED

To take maximum benefit from the IED process, you must work with it and continuously learn from your experiences. In this way, the process of IED doesn’t become a static process, but a continually developing process.

NEGAWATT not MEGAWATT

“…The best way of cutting emissions is not to generate them in the first place. Avoiding the waste of energy translates directly into emissions reductions, and cost savings. So instead of “megawatt”, companies should be thinking in terms of “negawatt”, a term thought up by the US environment guru Armory Lovins.

Gary Parke, director of Evolve Energy, an energy management specialist, explains: “The negawatt is, simply put, a megawatt of watt avoided or saved from use on the grid. The most cost-effective option to meet long term emissions reductions, the negawatt can provide a higher and more alternative.”

The returns to be made from energy efficiency are remarkable. The consultancy McKinsey has calculated that, at an oil price of $50 a barrel, a $170bn investment in efficiency would generate more than $900bn in energy savings – or a rate of return of 17 per cent….”

(Financial Times, 2008.11.03).
4. The main steps in the IED Process

Every building project is unique, which means that it is impossible to device a recipe of how to carry out an optimal IED process that will fit all different projects. However, it is possible to identify some main activities that are likely to be useful in most IED processes.

These activities may be summarised in 9 main steps:

1. Select a multi-disciplinary design team from day one, which are skilled in energy/environmental issues and are motivated for close cooperation and openness.

2. Analyse the boundary conditions of the project and the client’s needs and demands and formulate a set of specific goals for the project.

3. Make a Quality Assurance Program and a Quality Control Plan to follow-ups throughout the project.

4. Arrange a kick-off workshop to make sure that all team members have a common understanding of the design task.

5. Facilitate close cooperation between the architect, engineers and relevant experts through co-localisation or through a series of workshops during concept design phase.

6. Update the Quality Control Plan and document the energy performance at critical points (milestones) during the design.

7. Make contracts that encourage integrated design and construction.

8. Motivate and educate construction workers and apply appropriate quality tests.

9. Make a user manual for operation and maintenance of the building.
For building projects with very high energy ambitions, an energy specialist is required. Depending on the project complexity and its goals, there may be a need for one or more other specialized team members (e.g. fire, acoustics, daylight, controls (BMS), etc).

An example of the formation of the design team is illustrated in the figure to the right. In the specific case the architect firm is the Full-Service consultant with an engineering firm as sub-consultant. During the programming and concept design phase the architect and the energy specialist is the core team, responsible of developing the programme and the design.

In a conventional design process this is normally only the architect. Together they have a lot of knowledge and have the capacity to bring in the right experts at the right time; the lightning expert, the HVAC engineer, etc.

After developing the concept design and the project goes into the detailed design phase the energy specialist can be replaced by a more conventional engineer.

Together with the architect they are now the core and the energy specialist becomes one of the experts. The conventional engineer is responsible of developing the mechanical service as HVAC systems, lighting etc and the knowledge from the conceptual design phase is delivered by the energy specialist go make sure that all the systems works together with the design.

The inclusion of a »design facilitator« should be considered, especially in cases where the architect and client lack knowledge of environmental performance issues or where the project has especially challenging performance goals. A design facilitator is a person with skills in the IED process and knowledge of the related energy/environmental issues. This person is contracted separately to guarantee effective coordination and management of the IED process and to avoid and treat problems of goal/interest collisions, communication and assessment of risks.

4.1

STEP 1

Select a multi-disciplinary design team from day one, which are skilled in energy/environmental issues and are motivated for close cooperation and openness.
An example of the team formation during the programming, concept design and detailed design phases. The large circles are the core team and they bring in the necessary experts. As part of the IED process an energy specialist is utilized during the whole project. The majority of his work lies in the programming and conceptual design phases where he is part of the core team.
STEP 2

Analyse the boundary conditions of the project and the client’s needs and demands and formulate a set of specific goals for the project.

Every building project has a set of boundary conditions and contextual issues that will affect the project design goals. These boundary conditions should be identified and analyzed at the start of the project. The boundary conditions will usually include the following issues:

Location and site

The location of the project and the specific site conditions will have an influence on what types of building concepts that may be applied. Issues to be analyzed include:

- Integration into urban environment, local architecture and surrounding landscape
- Orientation of the site; solar access and wind conditions
- Natural resources on the site or in the close vicinity; solar energy, geothermal energy, sea/lake water, etc.
- Surrounding traffic, noise, and air quality
- Infrastructure – transportation and energy supply (e.g. district heating system) etc.
Exner architects and Esbensen engineers, Denmark.
Analyzes of the boundary conditions.
Trends and Market

The intentions of the client are always influenced by the trends and market developments, which are formed by governmental policies and socio-cultural conventions. Issues to be considered include:

- What are the expected future energy prices?
- What are the expected future environmental regulations for buildings (e.g. carbon-taxes, labeling systems, codes, etc.)?
- What are the expected future user demands with respect to environmental performance and building quality?
- What are the expected technological advances that may influence the environmental performance of buildings (e.g. information and communication technologies)?

Analysis of needs, demands and wishes

A clear articulation of energy/environmental performance targets is a prerequisite of an effective IED. Most often, a clear, well thought through set of requirements that correctly reflect what the client really want, is rarely present in the beginning. Nevertheless, some idea of what is wanted is available. The design team must translate the broad initial demands of the client into clear performance goals and design criteria. The importance of having the team translate and specify criteria is to foster the development of a common mission for the design team, and to have an agreed upon reference for evaluating the performance of the design. The client, however, is a key player in the goal-defining team, and his commitment to supporting measures for high-performance is imperative.
Example of a daylight access study.
At an early state of the design phase it is investigated how the individual shape of the three buildings is affecting the daylight access on the facade. The three buildings are all part of DnB Nor new Headquarter in Oslo, Norway. Architects are A-lab, Norway, MVRDV, Nederland and DARK, Norway. Daylight simulation is done by Esbensen Consulting Engineers, Denmark.
Examples of questions that may be posed to the client to help the development of goals are:

- What is the overall environmental policy?
- What image should the building convey?
- What are the commercial goals of the client?
- What are the economic constraints or profit demands (e.g. payback time, investment cost, etc)?

Attempts should be made to influence the client toward seeing the long-term advantages of a high-level environmental performance. A presentation of Life Cycle Costs is an effective way of leading a client away from a focus on short-term profit.

- What are the requirements with respect to indoor environment (lighting, air quality, temperatures and noise)?
- What are the priorities with respect to conflicting goals (e.g. cost vs quality)?

Tools in the programming phase:

- Solar/shading diagrams or tools
- Wind diagrams
- Environmental assessment tools
- Environmental programming tools
- Forecasting/scenario tools
- Multi-criteria decision-making tools
What are the requirements with respect to indoor environment (lighting, air quality, temperatures and noise)?
The output of this phase is a Quality Assurance Program, which describes the overall goals for the building. The values have to be described both as goals and demands. It may also be useful to weight the goals or rank them. It is important that the Quality Assurance Program is deeply rooted in the decision makers of the project and it should be given the same status as the budget and time schedule for the project.

The Quality Assurance Program has to be followed up by a Quality Control Plan. This plan is a tool for the project team and a document that makes it possible for the building owner to control and follow up the goals. The quality control plan defines goals and related sub-goals, defines milestones through the planning and construction phases, and specifies who is responsible for each task.

Example of a Quality Control Plan concerning energy efficiency

<table>
<thead>
<tr>
<th>No</th>
<th>Goals, sub-goals and requirements to achieve the goals</th>
<th>Responsible</th>
<th>Milestones</th>
<th>Proposed solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Max. annual energy budget 140 kWh/m² net energy per heated floor area. Conditions: Occupancy 12 hours a day, 5 days a week for 52 weeks</td>
<td>Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Space heating &lt; 15 kWh/m²/yr</td>
<td>Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1</td>
<td>Compact building form, not excessive window area</td>
<td>Arch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2</td>
<td>Thermal zoning</td>
<td>Arch/Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.3</td>
<td>Well insulated and air-tight envelope. U-values &lt; 0.15 W/(m²·K), minimized thermal bridges ψ &lt; 0.01 W/m²·K, n50 &lt; 0.6 ACH</td>
<td>Arch/Building physicist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Space cooling = 0</td>
<td>Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.1</td>
<td>Efficient shading, g-value &lt; 0.2</td>
<td>Arch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.2</td>
<td>Night free cooling by natural ventilation, utilization of thermal mass, efficient control</td>
<td>Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.3</td>
<td>Minimized thermal loads from lights and equipment, utilization of daylight, occupancy control</td>
<td>HVAC/Arch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project example – Headquarter of the Assurance Company Storebrand, Oslo Norway

Main topics in the Quality Assurance Program:
1. **Comfort**
   - Indoor Air Climate
   - Logistics
2. **Sustainability**
   - Energy budget of 125 kWh/m²
     *(Norwegian energy labeling B)*
   - Use of renewable energy
   - Use of sustainable materials
   - Waste management
   - Transport
   - Water efficiency
3. **Functionality**
   - Flexibility
   - Life cycle costs
4. **Accessibility**
5. **Aesthetics**
STEP 4

Arrange a kick-off workshop to make sure that all team members have a common understanding of the design task

“Communication competence, willingness to cooperate and openness must be required of all team members. A “kick-off”-workshop in the early design phase is recommended to explain the nature of IED and to support the team spirit” (Poel 2002).

The main objective of the workshop is to create common understanding at the beginning of the design process with regard to three important notions:

- understanding the integrated design process
- a clear perception of the design task
- a cooperative and open attitude towards the other members in the design team

In case the design team is not experienced in IED, an introduction on the integrated design process by an expert is an appropriate means of knowledge transfer. If integrated design is executed for the first time, it is advisable to make use of a facilitator to coach the team and provide the necessary information. For more information, see ”A Blueprint for a Kick-off Workshop” (Poel 2002).

Make a plan for follow-up
The final task of the workshop should be to make a plan for further work and future workshops. Issues for further investigation should be identified, along with persons responsible for carrying out the work. This should be implemented in the quality control plan.

Summarize workshop results
The results of the workshops should be summarized in a report and distributed to all relevant stakeholders.

Suggestions to an agenda to a kick-off workshop:

1. Presentation of the overall goals for the building by the developer
2. An introduction of Integrated Energy Design by an expert of this issue
3. Discussion of how the design team can get the most out of everybody’s knowledge and how to cooperate in an IED process
4. Discussion of the projects main challenges and how to cope with them
5. Decision of important milestones for the projects and the follow-up on those
Hamnhuset, Gothenburg, Sweden
White architects
photos: www.ecobox.no
Architects and engineers have different kinds of languages when visualising their design ideas. Architects tend to use pictures and drawings to illustrate the whole building concept, while engineers like to use numbers, graphs and flow diagrams to illustrate the effectiveness of individual systems.

In addition, architects and engineers have different ways of working. The engineer likes to have a precisely defined problem as a starting position. He then typically works his way analytically and stepwise through the problem-solving process, until a solution is reached. The process is almost linear and the need for developing alternative solutions is often neglected.

The architect, on the other hand, starts with a scarcely defined problem and a complex variety of possible solutions. The working process is characterized by a series of circular movements rather than a linear sequence. This will take him from a preliminary idea based on his individual experience through an iterative analysis of related impacts. The solution and the problem are investigated simultaneously.

In order to cooperate more efficiently, the architects and engineers need to adapt their working methods and to change the way they communicate. The architects need to make their conceptual ideas more explicit and explain them to the engineers at important decision points.

They need to open up for input from the engineers and specialists and to wait for feedback before moving forward. The engineers have to work in a more dynamic interaction with the architect, simultaneously evaluating and suggesting ideas and solutions as the design evolves. He needs to present his ideas and recommendations without using many professional terms, figures or diagrams, but rather visualising the consequences of his suggestions on the whole building level.

At an early stage the engineer should use simple “table-tools” to give immediate feedback to the architect’s different outlines, instead of complex tools where the result takes many days to get. As a team, the architect and engineers have to present their proposed solutions and related consequences to the client.

Ideally, the entire design team should be working in a close day-to-day cooperation, facilitated by physical proximity (e.g., project office). However, this is not always possible in practice. In any case, the project will benefit from an ongoing series of workshops during the design process.

Following the kick-off workshop, an initial design workshop should be arranged that includes the participation of the client and the architect, as well as specialists in energy, building physics, HVAC, lighting, IAQ, costing, landscaping and operation & maintenance.

At the start of the initial design workshop, the energy engineer should present an initial proposal for an energy budget, based on an analysis of a reference building with given constraints and in the given context (climate, surroundings). In addition, specialists may be invited to present short overviews of issues of their speciality relevant to the project at hand.
Examples of the different »languages« of architects and engineers. An architect's visualization of a sustainable building at right, and an engineer's visualization of an energy efficient building at left.
During the following design process, several smaller and more focused workshops should be arranged between the different professionals. The client should be invited for major decisions. The discussions may identify the need to acquiring additional specialized support, who may be invited into the workshops. The design workshops may include the following tasks:

**Discuss and develop alternative building concepts**

Hold an open discussion on schematic options relative to performance targets and priorities, costs and other implications. Discuss how the different schematic options may be improved with respect to energy performance and what other implications this may lead to. Use the Trias Energetica design strategy to gradually improve and test out different energy technologies and strategies.

The discussions should include integrated considerations of (see also Steemers illustration on page 12):

**Urban planning issues** (compact vs open structure, energy infrastructure, solar access/shading, wind conditions, noise, pollution).

**Building form and layout** (efficiency of space use, compactness, thermal zoning, daylight access, ventilation strategies, passive heating and cooling, air distribution).

**Facade design** (glazing area, window size and placement, solar shading, daylighting systems, ventilation openings).

**Building fabric** (thermal mass, emissions, maintenance, embodied energy)

**Mechanical service** (heating, cooling, ventilation and lighting system design strategies).

### Tools to support collaboration

An essential challenge for the design team is control of the extensive information flow. The use of internet platforms can link different design and construction disciplines so that drawings can be created from a common database that can be shared.

In each phase, visualisation and simulation tools explore, document and support decisions related to design, performance and cost. Close design collaboration supported by advanced computer tools enables easy refinement of opportunities, quantifies cost savings, and optimizes design trade-offs.

Thus, issues of energy, indoor environment, cost and architectural quality can be viewed together rather than independently, so that a design solution can be optimized with respect to all criteria.

### Tools in the concept design phase:

- Reference buildings, case studies
- Scale models and mock-ups
- Rules of thumb (locally adapted)
- Energy and indoor environment design tools/simulations
- Daylight design tools
- Environmental assessment tools
- LCC-tools
The facilitator must master to operate the many aspects a building project offer and in order to build good low-energy buildings he should at least consider:

- Design issues by Steemers
- Design philosophy, Trias Energetica
- Welfare

Other important aspects to put into the blender are typically economic, timeframe etc. Some aspects are correlated while others are contrary to each other but all have a contribution to the design. Every aspect is considered several times until an optimal integrated solution is found.
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-wheels«. 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
5) make corrections if needed.

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.

After the design phase, it is of course important to follow up the intentions in the construction phase. The Quality Control Plan also has to include the construction phase.

At defined milestones during design and constructions phases the team has to perform checks that energy performance requirements or goals are met during design and construction.

Typical milestones where the team has to update energy calculations and the developer has to accept the solutions:

- End of Concept Design
- End of Detailed Design
- When entering contracts with the contractors
- When the primary constructions are erected and the building envelope is completed (test of thermal bridges and air tightness)
- End of Construction Phase
- Building and HVAC System Commissioning
The main phases in IED with the most important IED milestone
Usually there are no incentives for energy efficient design or installations when architects and engineers are contracted for a new project. Design fees are commonly either a percentage of the total construction budget or a flat rate. This has the effect of discouraging additional work such as improvements to overall building performance.

Architects and engineers fear litigation from non-standard or undersized design. From the mechanical engineer’s point of view, it is a good idea to grossly oversize a system since there is no incentive for saving equipment or energy costs. Also, contractors have little incentive to ensure that building systems are installed to operate efficiently.

Integrated energy design and construction may be encouraged by alternative ways of contracting. Various new models for contracting in building projects have been developed. These models focus on co-operation to find the most optimal physical and technical solutions, and a more optimal building process. One such contract model is Partnering.

Partnering is a structured management approach to facilitate teamwork across contractual boundaries. Its fundamental components are formalised mutual objectives, agreed problem resolution methods, and an active search for continuous measurable improvements. Key words are common objectives and goals, co-operation, competence, and low conflict level.

A partnering model may include some sort of Performance contracting. Such a contract may work in the following way:

First, an energy target for the building is developed and agreed upon. The energy target is included in the contract with the design team and the contractor. The proposed building is then modeled at specific stages during the design process to make sure it will meet the target. If the building is off target, the design team must improve the design.

Finally, energy use is monitored in the second year of occupancy.

The energy target is adjusted for factors beyond the control of the design team and the contractor (e.g. plug loads, occupant schedules, and climate). If the building uses less energy than the adjusted target, the owner pays the design team or contractor a pro-rated bonus (up to a maximum amount). If the building uses more energy than the adjusted target, the design team or contractor must pay the owner a pro-rated penalty (up to a maximum amount).
Feldkirch Textile Passive House, Austria.
Architect Walter Unterrainer
photo: Erlend Seliskjer
It is important that the quality requirements set during the design phase is followed up in the construction phase.

Special IED-related items to be aware of in the construction phase include:

- The pre-selection of the invited bidders should include a review of sustainability-related experience.
- Tender and contract documents should require contractors and subcontractors to verify and document specific high-performance goals during construction.
- Motivation and education of workers about crucial construction operations (e.g. thermal bridges, airtightness) should be ensured.
- Spot checks and partial commissioning during construction with corresponding quality tests (e.g. blower door, thermal photographs) are recommended for the validation of energy or environmental performance at crucial points in the progress and in case of unexpected events.
- Every change and alternative solution should be checked on a conceptual level; the risk of introducing contradictory details or components should be carefully avoided.
- Technical performance parameters of core components relevant to energy matters (e.g. efficiency of heat exchanger, SFP-factor) must be documented because of their central influence on the energy performance.

**STEP 8**

Motivate and educate construction workers, and apply appropriate quality tests
After completion of construction, the design data should be updated in order to provide concrete information for future facility management.

A monitoring program of the experimental parts of the systems should be recommended to the client/owner. The operating staff and the user should be educated and familiarized with the operation of the systems.

The following ecological and energetic measures have been incorporated into the Solar Community Centre.

- Building integrated PV-system
- Natural/hybrid ventilation
- Daylighting
- Passive cooling
- Passive solar heating
- Solar heating for domestic hot water
- Ecological insulation materials
- Usage of rainwater for flushing
- Visualisation and monitoring program
Novartis head office, Stockholm Sweden. 1999
Architect: G. Anjou, Lund & Valentin ark. AB

5. References


Norwegian Wood project Marilunden, Stavanger, Norway.

Architect Eder Biesel, Noncon form

Photo: Per Anda

Net energy usage: 105 kWh/m²
Energy source: Heat pump (air to water)
COP 3.45 for room heating and hot water.