Integrated Design
A State-of-the-Art

A report within the research program
Smart Energy-Efficient Buildings
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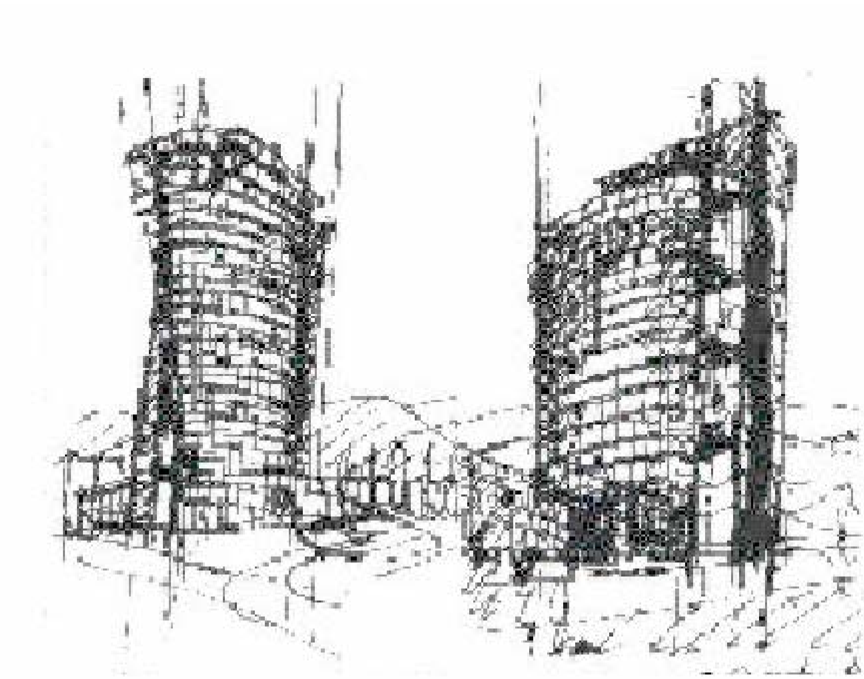

Sketches by Helmut Jahn (Murphy/Jahn Architects - Chicago)

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0 Abstract; "The Integrated Design Process" (IDP)

Increased performance requirements

The global drive towards sustainable development has resulted in an increasing level of pressure on building developers and designers to produce buildings with a markedly higher level of environmental performance. Chief amongst these is energy performance, and current expectations of energy performance pose a definite challenge to designers, in terms of reducing purchased energy consumption and the application of solar technologies, all within the constraints of minimal fees and the time pressure of the modern development process.

Traditional design processes

Nowadays the increased performance requirements cannot be addressed without the efforts of an interdisciplinary design team. The team should be a skilled partner for the client to create a well-balanced, i.e. integrated, design in the concerted action of quality, cost and environment. Particularly in the first stages of the design process important decisions are made, whereas the input of expertise within a traditional design process is limited. Therefore it is recommended to structure the design process in a different way with the goal to apply more knowledge and creativity in the early stages of the process: The Integrated Design Process.

IEA Task 23; The Integrated Design Process

Based on experiences in Europe and North America, the overall characteristic of an integrated design process (IDP) is the fact that it consists of a series of design loops per stage of the design process, separated by transitions with decisions about milestones. In each of the design loops the design team members relevant for that stage are participating in the process. The benefits of the IDP process are not limited to the improvement of environmental performance. The experience of IEA Task 23 members is that the open inter-disciplinary discussion and synergistic approach will often lead to improvements in the functional program, in the selection of structural systems and in architectural expression.

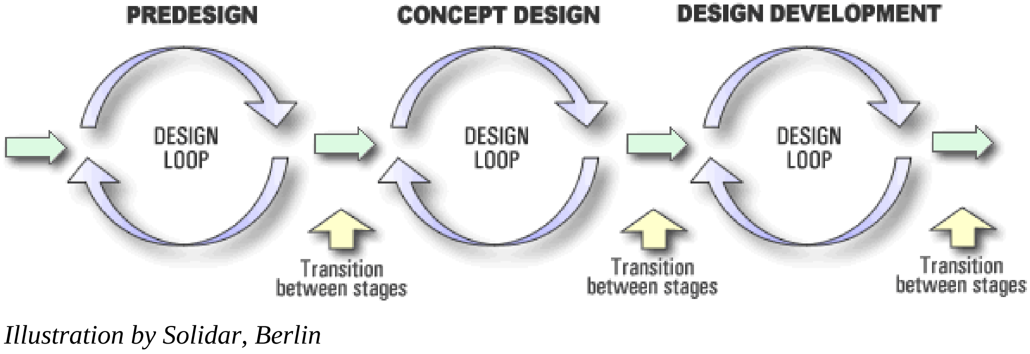


Illustration by Solidar, Berlin

The IDP has impacts on the design team that differs from a conventional design process in several respects. The client takes a more active role than usual; the architect becomes a team leader rather than the sole form-giver, and the mechanical and electrical engineers take on active roles at early design stages. The team always includes an energy specialist, and often an independent Design Facilitator.

The methods and tools developed in IEATask 23 represent the first international attempt to develop a formalised integrated design process that will enable a large number of clients and designers to take advantage of them.

Integrated Design and the Smartbuild project. (NTNU/SINTEF)

The goal of this Work Package; “The Building” is to develop building-integrated and user-friendly solutions and strategies that will reduce the demand for energy and power for heating, cooling and lighting. The solutions should not only be energy- and cost efficient, but should satisfy all user needs with respect to comfort, functionality, aesthetics, etc. The solutions should also be designed to be flexible with respect to future changes, and to have minimum environmental impact in a life-cycle perspective. The work package contains the following tasks:
Task 2.1 Integrated design.
Task 2.2 Building integrated energy systems.
Task 2.3 Lighting systems.
Task 2.4 Building integrated photovoltaic systems.

Every building is unique, due to varying constraints such as building function, client preferences, site conditions, local climate, local context, etc. In order to optimize the design of a smart, energy efficient building, it is therefore necessary to start with the requirements of that specific building rather than with a given set of technologies. That is, it is necessary to use a top-down, or what is called an *integrated approach to building design*.

Such an approach seeks to incorporate all the important aspects in a holistic synthesis. It views the individual systems not as isolated entities, but as closely connected and interacting with the rest of the building and its users. The importance of such an integrated approach has been clearly demonstrated in IEA SHCP Task 13 "Advanced Solar Low Energy Buildings". One of the main lessons learnt there was that "designing new and innovative buildings requires a multi-disciplinary design team" and that "it is necessary to consider the building as a system where the different technologies are integral parts of the whole" (Hestnes 1999). As the various design professions (the architects, engineers, and energy consultants) are not used to working this way, it is necessary to develop the guidelines, methods, and tools that can facilitate such processes.

1 INTRODUCTION

This report is mainly based on three reports from IEA Task 23- Optimization of Solar Energy Use in Large Buildings.

- The last report from fall 2002 named *"Solar Low Enegy Buildings and the Integrated Design Process. An Introduction"*. Author Nils Larsson Canmet Energy Technology, Ottawa, Canada and co-author Bart Poel, EBM-consult , Arnheim, The Netherlands.
- The other main report from June 2002 is named *"The integrated Design Process in Practice. Demonstratin Projects Evaluateed."*. Editors: Bart Poel, Gerelle van Chruchten, Damen Consultants, Arnhem, The Netherlands.
- The third main report from august 2000 is named *"Examples of Integrated Design. Five Low Energy Buildings Created Through Integrated Design"*. Editor Gerelle van Chruchten, Damen Consultants, Arnhem, The Netherlands.

On the IEA web site www.iea-shc.org/task23 the complete results of IEA SHC Task 23 are available and can be downloaded free of charge.

Under Chapter 3 Methods and Tools, we have described some methods and tools for establishing common understanding, vision and main goals, known from Norwegian Projects.

1.1 The need for better performance

Before presenting detailed features of the integrated design process and of the products of the Task, it will be useful to provide a summary of the reasons why IDP is considered an important element of modern building design, especially in projects that require a high level of environmental performance.

The global drive towards sustainable development has resulted in an increasing level of pressure on building developers and designers to produce buildings with a markedly higher level of environmental performance. Although various experts have somewhat different interpretations, a consensus view is that such buildings must achieve measurably high performance, over the full life-cycle, 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 wastes;
- Minimal negative impacts on site ecosystems;
- Maximum quality of indoor environment, in the areas of air quality, thermal regime, illumination and acoustics/noise.

Some authorities in this rapidly developing field would add related issues such as adaptability, flexibility and operating cost as well as life-cycle cost. In addition to a new breadth of performance issues to be addressed, contemporary developers and designers are faced with more stringent performance requirements being imposed by markets or regulation, or both. 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 solar technologies, all within the constraints of minimal fees and the time pressure of the modern development process.

1.2 The Conventional Design Process

Although there are many exceptions, we can refer to a “traditional” 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 as well as basic materials;
- The mechanical and electrical engineers are then asked to implement the design and to suggest appropriate systems.

Although this is vastly oversimplified, such a process is one that is followed by the large majority of general-purpose design firms, and it generally limits the performance levels achievable to conventional levels. The traditional design process has a mainly linear structure due to the successive contributions of the members of the design team. There is a limited possibility of optimisation during the traditional 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 for example for solar buildings often include the following practical consequences:

- The building takes little advantage of the potential benefits offered by solar gain during the heating season, resulting in greater heating demand;
- The building may be exposed to high cooling loads during summer, due to excessive glazing exposed to summer sun;
- The building may not be designed to take advantage of its daylighting 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;
- Occupants may be exposed to severe discomfort, due to excessive local overheating in west-facing spaces or glare in areas without adequate shading.

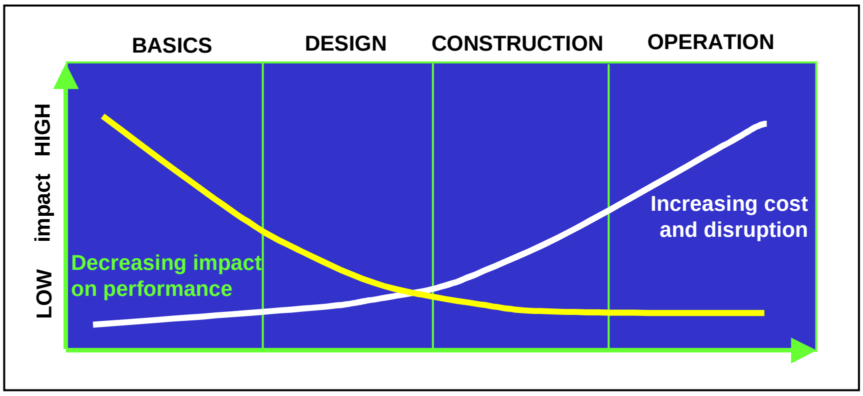
All these features are the result of a design process that appears to be quick and simple, but they result in high operating costs and create an interior environment that is sub-standard; and these factors in turn may greatly reduce the long-term rental or asset value of the property. Of course, since the conventional design process usually does not involve computer simulations of predicted energy performance, the resulting poor performance and high operating costs will come as a surprise to the owners, operators or users.
If the engineers involved in such a process are clever, they may suggest some very advanced and high-performance heating, cooling and lighting systems, but these may result in only marginal performance increases, combined with considerable capital cost increases. The underlying cause is that the introduction of high-performance systems late in the design process cannot overcome the handicaps imposed by the initial poor design decisions.
The problems outlined above represent only the most obvious deficiencies often found in buildings that result from the conventional design process. In summary, the conventional design process is not generally capable of delivering the high levels of broad-spectrum performance that are required in many contemporary projects.

2 THE INTEGRATED DESIGN PROCESS (IDP); CENTRAL CONCEPTS

2.1 IDP involves a different approach of design

The Integrated Design Process involves a different approach from the very early stages of design, and can result in a very different result. In the simplest of terms, the IDP process requires a high level of skills and communication within the team, involves a synergy of skills and knowledge throughout the process, uses modern simulation tools, and leads to a high level of synergy and integration of systems. All of this can allow buildings to reach a very high level of performance and reduced operating costs, at very little extra capital cost.

The IDP 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 results in only modest gains in performance. In fact, this observation is applicable to a large number of processes beyond the building sector.



Solidar, Berlin Germany

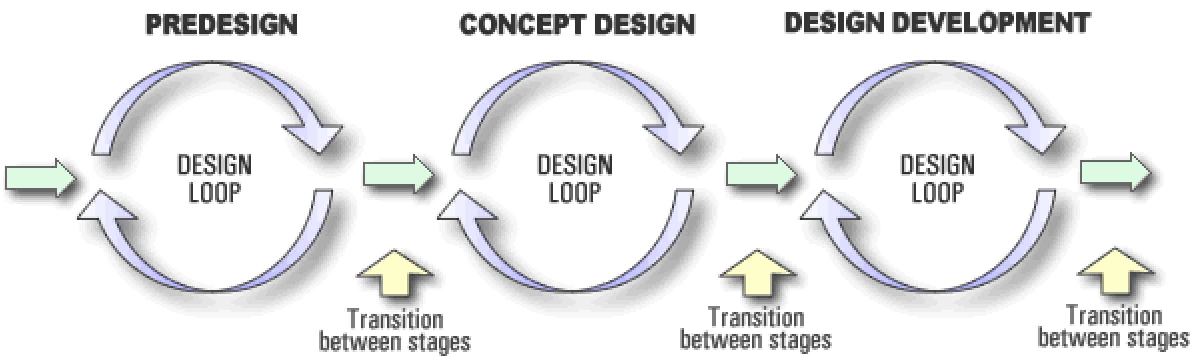
Although these observations are hardly novel, it is a fact that most clients and designers have not followed up on their implications. The methods and tools developed in Task 23, represent the first international attempt to build on these facts and to develop a formalised process that will enable a large number of clients and designers to take advantage of them.

2.2 The IDP includes some typical elements that are related to integration

- Inter-disciplinary work between architects, engineers, costing specialists, operations people and other relevant actors right from the beginning of the design process;
- Discussion of the relative importance of various performance issues and the establishment of a consensus on this matter between client and designers;
- Budget restrictions are applied at the whole-building level, and there is 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 sun shading devices, may reduce costs in other systems, e.g. capital and operating costs for a cooling system.

- The addition of a specialist in the field of energy, comfort or sustainability;
- 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;
- The addition of subject specialists (e.g. for daylighting, thermal storage etc.) for short consultations with the design team;
- A clear articulation of performance targets and strategies, to be updated throughout the process by the design team.
- 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.
- Based on experience in Europe and North America, the overall characteristic of an IDP is the fact that it consists of a series of design loops per stage of the design process, separated by transitions with decisions about milestones. In each of the design loops the design team members relevant for that stage are participating in the process.

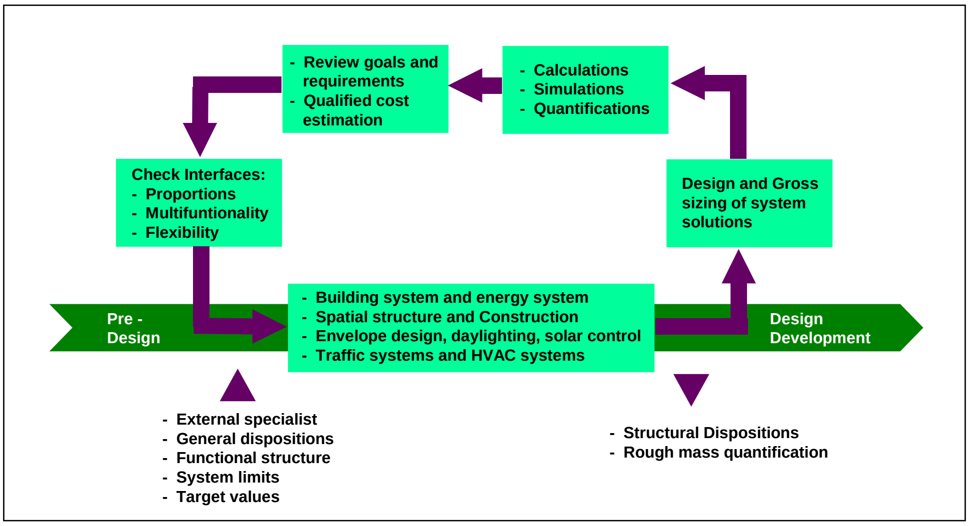


2.3 The design process itself emphasises the following sequence:

- First establish performance targets for a broad range of parameters, and develop preliminary strategies to achieve these targets. This sounds obvious, but in the context of an integrated design team approach it can bring engineering skills and perspectives to bear at the concept design stage, thereby helping the owner and architect to avoid becoming committed to a sub-optimal design solution;
- Then minimise heating and cooling loads and maximise daylighting potential through orientation, building configuration, an efficient building envelope and careful consideration of amount, type and location of fenestration;
- Meet these loads through the maximum use of solar and other renewable technologies and the use of efficient HVAC systems, while maintaining performance targets for indoor air quality, thermal comfort, illumination levels and quality, and noise control;
- Iterate the process to produce at least two, and preferably three, concept design alternatives, using energy simulations as a test of progress, and then select the most promising of these for further development.

As an example a more detailed description of the design loop during the concept design phase is pictured. The central issue in this phase is to define systems in a conceptual way, based on the structure/scheme of the building. In a loop several options are considered, paying attention to the integration in the building as a whole not just restricted to the technical aspects.

2.4 *The Integrated Design Process*



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The IDP process contains no elements that are radically new, but integrates well-proven approaches into a systematic total process. From an engineering perspective, the skills and experience of mechanical and electrical engineers, and those of more specialised consultants, can be integrated at the concept design level from the very beginning of the design process. When carried out in a spirit of co-operation amongst key actors, this results in a design that is highly efficient with minimal, and sometimes zero, incremental capital costs, along with reduced long-term operating and maintenance costs. The benefits of the IDP process are not limited to the improvement of environmental performance. The experience of Task 23 members is that the open inter-disciplinary discussion and synergistic approach will often lead to improvements in the functional program, in the selection of structural systems and in architectural expression.

The Integrated Design Process has impacts on the design team that differentiates it from a conventional design process in several respects. The client takes a more active role than usual; the architect becomes a team leader rather than the sole form-giver, and the mechanical and electrical engineers take on active roles at early design stages. The team always includes an energy specialist, and in some cases, an independent Design Facilitator.

The Integrated Design Process can be used in the Predesign Phase, Concept Design Phase, and for Design Development. See Chapter 2.2.

2.5 Lessons learned

Throughout the design process of the five case story buildings, described in the booklet , *“Examples of Integrated Design. Five Low Energy Buildings Created Through Integrated Design” 2000,* several experiences were found to be noteworthy and useful for future design teams. The following is a survey of these so called lessons learned by the design teams of those five case story buildings. The lessons are arranged by three topics (Team, Process and Techniques).

2.5.1 Team

• Co-operation between architect and engineers has to be very close right from the beginning to achieve good results.
• Close collaboration between the members of the design team is needed throughout a project, especially regarding the most innovative aspects and problems that emerge during construction, when quick decisions are necessary.
• Persistence on the part of the architect can result in success.
• Innovative design and construction require an extra effort on the part of even a very experienced construction team. Conflicts may result.

2.5.2 Process

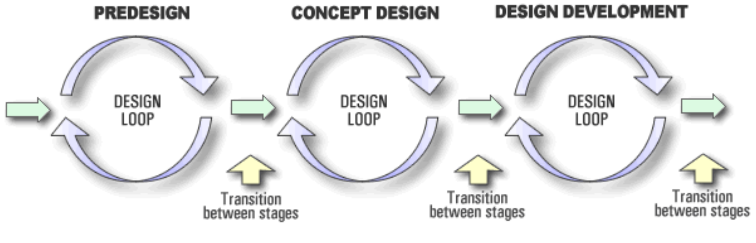
• A design workshop at the start of the project greatly stimulates the development of common ideas on the design and the design process.
• It is advisable to make a guideline for dealing with conflicting goals (for example ’minimise energy consumption’ versus ’optimise daylighting’) and conflicting interests (for example client versus user).
• The integrated design process for the interdisciplinary planning process which was developed in the Canadian project is a valuable instrument.
• One should aim for optimum result, not just for the smallest common denominator.

2.5.3 Techniques

• An energy-efficient building can be built by using relatively non-exotic technologies applied in innovative and effective ways.
• Focus on the building shape, orientation, solar potentials and use before specific installations are considered.
• Implementing products that still have to be designed requires a lot of extra time.
• The most sophisticated technical equipment is of no use if it is not comprehensible.
• Careful design of a daylighting system saves energy, realises an agreeable working climate and leads to improved student performance.

3 METHODS AND TOOLS THAT CAN SUPPORT IDP

In order to optimise the design of a smart, energy efficient building, it is necessary to use an integrated approach to building design. Such an approach seeks to incorporate all the important aspects in a holistic synthesis. That means that we have to consider the building as a system where the different technologies and individual systems are closely connected and interacting with the rest of the building and its users.
The overall characteristic of the design process is the fact that it consists of three main stages; pre-design, concept design and design development.



Within those stages we have a design loop, or an iterative process for finding the best solutions or principles for the problems defined.

Tools, guidelines, methods for integrated and optimal design must consider at least three aspects;

1. Help defining the main objectives for the project, including a smart energy efficient building focus.
2. Facilitate optimization of design solutions where different criteria are considered and traded against each other
3. Help structure and organise the design process in such a way that different specialist, users, stakeholders are able to combine their knowledge.

3.1 Methods and tools for establishing common understanding, vision and main goals.

Early discussions of the project objectives, the clients needs and the functional program with the client, users, architect and engineers are important to establish a common understanding of the project, and also place the importance of smart energy efficient buildings on the map.
To see the different stakeholders goals in connection with the project objectives will increase the common focus for the project.

3.1.1 The Modelling Conference- Enterprise Modelling in the Building Process

The Modelling Conference is a method focusing on common objectives and understanding for a project, and facilitates and structures important discussions about the processes and the main goals. The Modelling Conference is based on;

- All relevant actors in the process should be present or represented in the modelling, like users, owners, architects, consultants, entrepreneurs. In many cases this also may include outside actors like neighbours, governmental and municipal authorities etc.
- The participants primary represent themselves, but are jointly responsible for the content og the conference
- Alternation between group work and plenary work

The conference starts backwards by defining the end product of the building process – the vision and main goals for the project. Then the different processes and products are defined, the connections between the processes and products, and who are the “customers” to the different processes. After identifying the different processes and products that are necessary to reach the main goals, the participants in the modelling conference discuss and define the criteria to those processes, the part products and the end product.

The product of the conference is a process model, which names the main goals, processes, products, roles and performance criteria and highlights certain aspects of the process the participants want to focus on.

The method is used in several Norwegian projects, St. Olavs Hospital in Trondheim, Førde Visjonarium (a pilot project in “Metode for miljørikitge mål og prioriteringer”), Kunnskapsarbeidsplassen (SINTEF 2002) e.o.

Ref
R. Gjersvik *Entreprise Modelling in the Building Process*, Paper CiB W96 Symposium Venice 1999

M. Standal, A. Johansen *Miljøeffektive mål* Metode for miljørikitge mål og prioriteringer 1999 (www.ptl.no)
M. Emery & R.E. Purser *The Search Conference. A powerful method for Planning Organizational Change and Community Action* Jossey-Bass Publishers, San Francisco 1996

3.1.2 Logical Framework Approach (LFA)

The ”Logical Framework” method is a way of structuring the main elements in a project, highlighting logical linkages between intended inputs, planned activities and expected results. Logical Framework Approach can be used not only during initial planning, but also as a management tool during project implementation.
LFA enhances planning, analyses and communication, and helps

- clarify the purpose of, and the justification for, a project
- identify information requirements
- clearly define the key elements of the project
- facilitate communication between all parties involved
- identify how the success or failure of the project should be measured.

The LFA workshop is a major instrument for project planning and analysis, and should include representatives of all involved parties – e.g. client, users, specialists, authorities. The workshop focuses on key aspects of a complex situation in a project.

During the planning exercise the participants make a step-by-step analysis of the prevailing situation and what measures should be undertaken. The result of the LFA planning process is the project matrix. This matrix is then used as a starting point for formulating the technical part of the formal project agreement as well as the detailed plan of operations. It will serve as a major point of reference throughout the life of the project, particularly for monitoring and evaluating the project. In connection to this framework, a set of criteria has been developed for qualitative judgement of environmental, economic, social, technological and other consequences.

An LFA specialist should facilitate the Logical Frame Approach, and a workshop can last from 1-2 days to 6 days or more.

The method has accomplished widespread international distribution and has been used by a number of different organisations. LFA has also recently been tested in the project ”Metode for miljøriktige mål og prioriteringer” for Økobygg (1999 – 2002), to establish and develop environmental goals and means in a complex project (Kvadraturen vid. Skole, Kristiansand).

Ref

K. Samset. *The Logical Framework Approach (LFA).* Norwegian Agency for Development Cooperation, 1996 ISBN 82-7548-160-0.

3.1.3 Main objective analysis

The intention of a main objectives analysis is to clarify the purpose and goals for the project that focus on a holistic view where specific topics are natural integrated on the same level as the other aspects. The analysis is a step-by-step process for identifying, developing and defining a project objective hierarchy and main objective, and the project framework early in the process.

It is also important that the objectives are defined and described in a way that they can be used further in the planning, and when you come to priority between different aspects.

The method is a planned and managed group process involving parties with different competence, perspectives and interests in the project. The step-by-step principle is not limited to the use of special planning techniques and tools, several methods and techniques from project management, total quality management, change management and other management literature can be used.
The method contains of 4 steps;

- project status
- main goals or objectives
- part objectives
- specifying and consensus of the objectives described

It is important that the objectives are identified and structured, and the properties of attributes connected to them are defined. The attributes should be measurable, operational and understandable.
The participants in the group work must have the experience and the knowledge needed to achieve relevant information and criteria related to the special topics you want to bring in to the project.
A resource group should not be bigger than necessary, depending on the objective of the analysis is supporting decisions or establish clarity and acceptance of the project objectives in the organisation.

Ref
M. Standal, A. Johansen *Målanalyse. Miljøeffektive mål* Metode for miljørikitge mål og prioriteringer 1999 (www.ptl.no)

3.1.4 Other workshop methods – NABU (Norwegian Architects for Sustainable Development)

The task of changing society towards sustainable paths of development requires active participation by people at many levels. The issues are complex, and require cross-disciplinary integration. Technology alone is no solution; environmental solutions must be ”owned” by those who are to implement and manage them, so all the parties must be involved in the processes. This implies using cooperative working methods to find ”win-win” solutions that create common goals and perceived benefits for all stakeholders.

Workshops are dynamic and interactive processes. They can be applied for purposes such as concept design for specific projects, local economic development, participatory planning, conflict solving, as well as for expert education on themes such as energy design or natural ventilation. Since its inception in 1994, NABU has organised workshops of various kinds, at locations all over Norway. The Norwegian Research Council has funded the project for development of workshops as a particular tool for sustainable development in architecture and planning. NABU has taken initiative to publish a handbook about these techniques.

This handbook shows different well-known methods based on basic principles partly by using the same techniques in different combinations. The handbook intends to give the reader a fundament tailored for different situations. The handbook also gives a summary of new planning theory, references to pedagogical theory and to many elaborating method books. (Creative problem solving /Forsth 1991, van Gundy 1985, Westhagen et al 1995, LFA -

metodic / Samset 1996, PLA-metodic / Aune, Foss, Skåra 2001, Search Conference / Emery & Purser 1996).

Ref
Asle Farner. *Verksted som verktøy i plan- og utviklingsprosesser.* Kommuneforlaget, 2003

3.2 Methods and tools for developing and establishing performance criteria for the project

To achieve the goals for the project and for the organisation occupying the building, it is important to develop and establish performance criteria focusing on the users needs, national codes and standards and the project framework, d.e. site, time, cost, resources.
Establishing performance criteria is both a process and a systematisation of the information. Several checklists have been developed helping structuring the different criteria. The following is a brief summary of some of these. Se also (Andresen 2000) chapter 3.4.

3.2.1 Peña´s Information Index Matrix

Peña presents an Information Index Matrix that serves as a checklist for information categories generic for each design problem. The matrix of key words is meant to be used to seek out appropriate information in the programming phase. The matrix contains 4 main categories of criteria; Function, Form, Economy and Time.
For each of those four categories there are 3 sub-categories. Those issue categories are crossed with the five steps of programming;

1. Establish goals
2. Collect facts
3. Uncover concepts
4. Determine needs
5. State the problem

The Index matrix is used both as a checklist form important issues for the project, and as a framework for structuring the information.
The method described suggests a combination of interviews and workshops during the programming. The workshops are important to verify and exemplify the client’s decisions.

Ref.
W. Peña, *Problem Seeking*, AIA Press Washington 1987

3.2.2 Architectural Programming, Duerks model

Duerk proposes typical design teams of currant interest in a project. The teams may vary from project to project. Relevant teams to this issue are energy efficiency, environment considerations, flexibility, maintenance etc. The model is a matrix that connect and discuss the different teams against the 5 categories; Facts, Values, Objectives/goals, Performance criteria and Concept.
Duerk divides the programming into four main steps;

1. Develop main objectives
2. Develop minor and secondary objectives
3. Develop measurable performance criteria
4. Develop concepts

To succeed, it is important to have a main objective describing what is important ton achieve in the project. The minor objectives must express the qualities, and the objectives must be given priority. The result or the final project must be measured against the performance criteria defined in the programming phase.
An important part of Duerks model is the focusing on future situation. The developing of concepts is a tool to illustrate the ideal and wanted organisational relations.

Ref.
D. p. Duerk, *Architectural Programming,* Van Nostrand Reinhold, New York 1993

3.2.3 The Norwegian Standard NS 3455 Building Function Table

The Building Function Table helps identifying the different aspects and performance criteria and structure the information into four main groups; general information about the project and organisation, project framework, user requirements and specifications concerning technology. The most important aspect of this table/matrix is to identify the different functions and activities, and the functional requirements to the following areas;

0 Function
1 Room
2 Transport / Traffic
3 Supply (energy, water, air etc)
4 Information
5 Climate
6 Security / safety.
7 - 8 Open
9 Special

The Building Function Table is used in several new projects for governmental and municipal authorities, and is linked to other Norwegian Building Standards (costs, building elements and products). A systematic structuring of the information is important if you want to do benchmarking.

The Building Function Table is a useful tool in order to structure the information needed, but does not focus on special important topics or objectives.

Ref
NBR 1993, NS3455 *Bygningsfunksjonstabellen* med veiledning.

3.3 Methods and tools for generation of alternatives for smart energy efficient buildings.

The generation of good alternatives is important if the design process is to be effective. It will be wise to start out with a wide range of possibilities, and test the extremes of the criteria. Generation of alternatives is mainly a task for the experts and consultants in the project, and is above all a craft, an exercise of creativity and experience. The methods described here are generic methods useful on different subjects. See also (Andresen 2000), chapter 4.1

3.3.1 Brainstorming

Brainstorming is a technique that originates from Alex F. Osborn (Osborn 1957) and it is based on the stimulation of one person´s mind by another´s. The main guidelines of brainstorming are summarised as follows (Dell´Isola 1997);

- Rule out criticism Withhold adverse judgement of ideas until later. There exist no bad ideas.
- Generate a large number of possible solutions. Set a goal of multiplying the number of ideas in the first rush of thinking by five or ten.
- Seek a wide variety of solutions that can represent a broad spectrum of attacks on the problem
- Watch for opportunities to combine or improve ideas.

A typical brainstorming session takes place with a group of people sitting around a table and spontaneously generates ideas designed to solve a special problem. During the session, no attempt is made to judge or evaluate the ideas. Evaluation takes place after the session has ended.

3.3.2 Delphi

The Delphi technique is an approach for eliciting opinions from a group of experts. A Delphi process involves a series of successive questionnaires, where each questionnaire after the first, the respondents receive feedback information about the outcome of the preceding round without learning which option was contributed by whom.

A starting point for a session can be the performance criteria defined for that special issue, where each participant of a multidisciplinary team is asked to list ideas for meeting the criteria defined. The team or group then discussed the different ideas, organise random ideas into packages and focus on ideas having significantly more potential than others.

The second cycle of the Delphi begins with individual team members excluding ideas from further consideration and developing new alternatives. Then the team discusses a list of alternatives that meet functional criteria.

By the third and final iteration, the team members begin to agree on key points seeing the various ideas and alternatives in comparison to each other.

The method has been employed in many cases all over the world, covering divergent subjects from educational reform to design options for health care centre. The method can be useful focusing on special issues in a project, for example heat pumps and energy-efficient buildings.

Ref.

S.J. Kirk and K.F. Spreckelmeyer, *Enhancing Value in Design Decisions*, Evergreen, Colorado 1993

3.3.3 Synetics

Synetics is a formalised creative technique that encourages the use of metaphors and analogies to spawn inventiveness in problem solving. Synetics means joining together different and apparently irrelevant elements to form new and effective ideas and schemes. The purpose of Synetics is to multiply ideas by stimulating the imagination through four types of analogies; symbolic, direct, personal and fantasy.

The problem is formulated in just one sentence starting with how? The owner of the problem explains why it is a problem, and what he thinks is the “optimal” solution. The rest of the group then explores the problem, finding new perspectives, ideas, alternatives etc.

The participants then list three or more attributes that are positive by the idea, and one main concern.

After discussing possible solutions, the problem owner rates on a scale from 0 – 100% how new the idea is, how good it seems, and how possible it is to implement it. If the rating on those three aspects are 50% ore more, it is likely to implement the idea.

Ref.
W:J:J: Gordon, *Synetics: The development of Creative Capacity*, New York, Harper, 1961.

3.4 Methods and tools for performance prediction

Performance predictions is carried out to find out how well a proposed solution satisfies the objectives, and is the basis for evaluating and choosing design solutions. Thus, the performance prediction has to produce means to measure the relative goodness of a design compared to the performance criteria.
In the design process, there are a wide range of questions and problems to be solved, related to different aspects of the building. There are a large number of tools available to the designers, including handbooks, simple calculation methods, and computer simulation models for quantitatively estimating the performance of smart energy-efficient buildings.

These methods and tools focus on one or few aspects, there is no tool that can predict the total performance of a building. We will recommend to search in the other State-of-the-Art reports within the research program Smart Energy-Efficient Buildings to find relevant methods and tools for your area of interest.
A comprehensive overview of 251 energy related software tools may be found at http://www.eere.energy.gov/buildings/tools_directory/

3.5 Methods and tools for performance evaluation

The objective of performance evaluation is to test if potential solutions meet the design and the project objectives, in order to select the most promising design. Within the building industry, there is no practice for multi-criteria evaluations. It is necessary to analyse the results of applying the different methods and tools and compare these to each other. In this report we describe some methods that focus on multiple and qualitative aspects. See also (Andresen 2000) chapter 6.2.

3.5.1 Peña´s Quality Quotient Model

This is an evaluation technique based on quality measurements. For each of the main issues or forces; Function , Form, Economy and Time, the magnitude is determined empirically using a scale from complete failure (1) to perfect (10). By using the same value measurement scale to respond to individual questions covering each of the four categories, the final values can be determined more easily. The results are presented in quadrilateral diagrams that are a good way to immediately perceive a situation. The scoring diagram used presents the results of the evaluation in a very illustrative way. They give a picture of the overall score of the design, and at the same time showing the scores on the individual criteria.
The model shows a way of performing an evaluation that starts out with qualitative measures and converts them into numerical values.

Ref.
W. Peña, Problem seeking. *An Architectural Programming Primer*, AIA Press, Washington 1987

3.5.2 The Synthesis Model of Kirk and Spreckelmeyer

This is a model for comparing design alternatives, where the performance of individual systems or components is measured against design goals. The model may be used during different stages of the design process, from evaluating building layouts to special components. The defined aspects are measured with respect to the main design goals.
For a building layout it could be flexibility of space, capital costs, owning and operating costs, energy conservation, image and visibility etc. The performance scale ranges from “poor” to “excellent”. In addition to showing performance scores, the model also can show the weighting of the criteria and the aggregated weights and scores for all the alternatives.
The graphical display of this model gives a good overview of the performance evaluation as a whole, while showing the individual performance measures that have been carried out.

Ref.
S.J. Kirk and K.F. Spreckelmeyer, *Enhanching Value in Design Decisions*, Evergreen, Colorado 1993

3.5.3 Post Occupancy Evaluation

Post-occupancy Evaluation is the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some times. Post-occupancy Evaluation focuses on building occupants and their needs. POE is based on a set of performance criteria derived from the values of the evaluators and clients, and is both of quantitative and qualitative character. Three elements of building performance can be identified and treated hierarchically in their application to the POE process:

1. Technical elements: Health, safety and security aspects of building occupancy
2. Functional elements: Occupant's ability to operate efficiently and effectively
3. Behavioural elements: Psychological and social aspects of user satisfaction and general well-being

POE uses a broad spectre of methods and tools from interviews, walk-through, observation, to more diagnostic methods and analysis.

Post-occupancy Evaluation categorises the approaches to building evaluation by describing three levels of POE effort - indicative, investigative, and diagnostic, each differing in terms of time, resources and personnel needed.

Ref.
W. Preisser et.al. *Post Occupancy Evaluation*, Van Nostrand Reinhold Company, 1988

3.5.4 “Green Building” Assessment Tools

The GBTool was developed within the Green Building Challenge ´98 project, and is a framework and software tool for assessing the energy and environmental performance of buildings. GBTool is structured hierarchically in four levels with the higher levels logically derived from the weighted aggregation of the lower ones:

1. Performance Areas
2. Performance Categories
3. Performance Criteria
4. Performance Sub-Criteria

A scoring scale ranging from –2 to +5 is used for assessing all criteria and sub-criteria.

The performance level required to achieve a certain score is based on the level 0 being the reference or industry norm level where –2 is significantly inferior and +5 is a score/level that is difficult to reach.
Within the Green Building Challenge documentation a series of criteria is offered as a basis for developing appropriate weightings for different areas. GBTool does not compare or assess groups of issues between criteria, nor does it assign importance to synergies. This is a limitation also to this method, recognising that smart energy-efficient buildings are about integration of systems and strategies.

Ref.
N.Larsson and R. Cole, *Green Building Assessment Tool – GBTool 1.3. A Second-Generation Environmental Performance Assesment System for Buildings*, CETC Buildings Group, CANMET; Ottawa 1998
GRIP, *Environmental design of Buildings (Miljøriktig bygg-prosjektering)*, Oslo 1998

3.6 Methods and tools for multi-criteria decision-making (MCDM)

Multiple Criteria Decision-Making methods include Multiple Objective Decision Making (MODM) methods and Multiple Attribute Decision Making (MADM) methods.
The MCDM methods are structured approaches that seek to identify the decisionmakers´ values with respect to multiple criteria in order to help them find the most suitable choice. They seek to make value judgements explicit and may in this process reveal values or biases that would otherwise have been overlooked. In this way they may promote understanding and learning and ease communication between design team members.

There are a wide variety of MCDM methods described in the literature, here only one of the most simple ones is described. For an overview of MCDM, see (Andresen 2000) chapter 6.3.

3.6.1 Simple Additive Weighting (SAW) Methods

This method seems to be the simplest and most intuitive approach to aggregating values and performance measures. The method helps to structure the design work, to focus on the most important issues, and to promote understanding and communication among the participants in the project. The simple additive weighting methods use all attribute values of an alternative and apply regular arithmetical operation of multiplication and addition, and the attribute values must therefor be numerical and comparable.
Maasam (1988) describes the basic procedure for such models in six steps;

1. Define the set of alternatives, interest groups and criteria
2. Obtain impact values for the criteria for each alternative and convert the raw data into standardised values
3. Determine how the values are aggregated to give final utility value for each alternative.
4. Determine the utility value for each alternative
5. Undertake a series of sensitivity tests to examine the effects on the utility values.
6. Justify the sensitivity test in the context of the planning exercise, and incorporate the result into later planning process.

Experiences have shown that it yields goods results even though it is not applied on a strict axiomatic basis. However the method needs to be adapted to fit the special needs of building design, and to be able to use effectively in a building design framework.

Ref.
K.P. Yoon and C.L. Hwang, *Multiple Attribute Decision Making. An Introduction,* Thousand Oaks, Sage Publications 1995

3.7 Methods and tools for Environmental Management Systems (EMS)

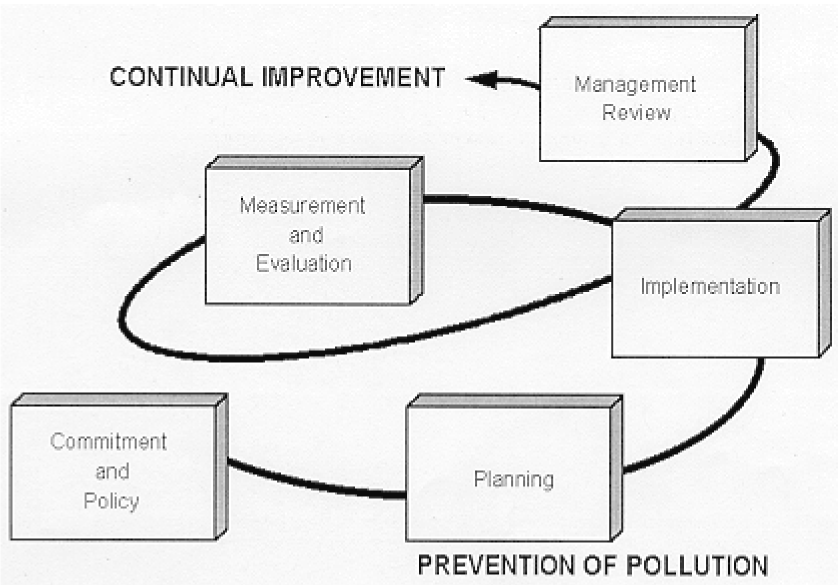
3.7.1 Overview - what is an Environmental Management System?

In a world growing increasingly dependent on science and technology, tomorrow's architects, engineers and scientists must be prepared to be leaders in more than just their chosen professions. They must also be leaders in environmental excellence. In this field, there are developed different tools and systems for environmental management.

An Environmental Management System (EMS) is an organized and formal approach to managing environmental issues within an organization. Development of an EMS is a voluntary approach to improving an organization's environmental performance.

An EMS is a set of management processes and procedures that allow an organization to analyse, control and reduce the environmental impact of its activities, products and services and operate with greater efficiency and control.

An EMS is appropriate for all kinds of organizations of varying sizes in public and private sectors and encourages an organization to continuously improve its environmental performance. The system follows a repeating cycle, like below.



An EMS provides the means for effectively managing:

- Compliance with regulatory requirements (hazardous materials/waste management issues, reporting and record keeping, employee training programs)
- Worker safety requirements (regulations, health and safety training)
- Prevention of pollution (spill prevention, emergency response)

- Emergency preparedness and response plans (emergency planning, employee training, improved management of hazardous and bio-hazardous material storage areas and mitigation of environmental impacts from emergency situations)
- Continual environmental improvement: (minimizing wastes, cost savings through energy and solid waste reduction, health and safety improvements)

Usual benefits of proactive EMS's are:

- Cost savings
- Reduced impact on the environment
- Improved public image
- Improved relationships with regulatory agencies
- New national and international business opportunities
- Increased environmental awareness
  - and leading to a positive global impact on the environment

3.7.2 EMS Basic Elements

The EMS integrates the environment into everyday business operations, and environmental stewardship becomes part of the daily responsibility for across the entire organization, not just in the environmental department.

Typical basic elements in an EMS are:

- Reviewing the organization's environmental goals
- Analyzing its environmental impacts and legal requirements
- Setting environmental objectives and targets to reduce environmental impacts and comply with legal requirements
- Establishing programs to meet these objectives and targets
- Monitoring and measuring progress in achieving the objectives
- Ensuring employees' environmental awareness and competence
- Reviewing progress of the EMS and making improvements

An EMS helps organizations address its regulatory demands in a systematic and cost-effective manner. This proactive approach can help reduce the risk of non-compliance and improve health and safety practices for employees and the public.
An EMS can also help address non-regulated issues, such as energy conservation, and can promote stronger operational control and employee stewardship.

Personnel evaluate the processes and procedures they use to manage environmental issues and incorporate strong operational controls and environmental roles and responsibilities into existing job descriptions and work instructions. They set objectives and targets for managing their environmental issues. They monitor and measure and evaluate their progress in environmental performance both in areas that are regulated and areas that are not.

EMS's can improve an organization's compliance, pollution prevention and overall environmental performance and hopefully build greater confidence with local stakeholders.

EMS's provide a number of benchmarked tools to manage environmental risk effectively and offer great potential for continuous improvement in compliance and other areas of environmental performance.

An EMS is not intended to be a substitute for regulatory requirements nor does it offer regulatory relief from the law.

EMS's are proactive programs that identify and address the root causes of potential compliance problem areas. Senior management plays an active role in the EMS, monitoring and measuring the organization's progress toward its environmental goals, and continually looking for ways to improve environmental management.

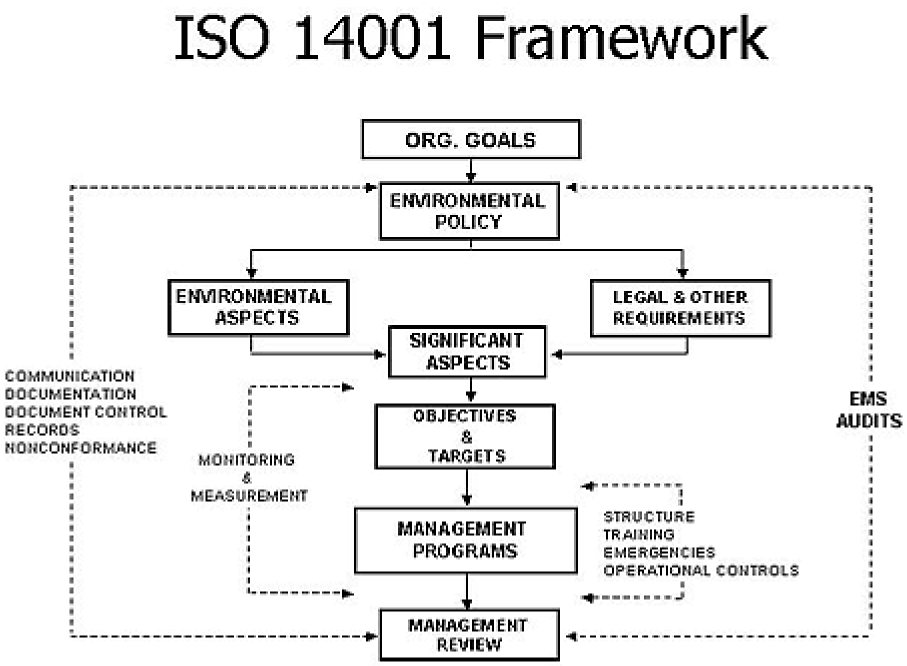
There are mainly two international EMS's on the market; ISO 14001 and EMAS (Eco-Management and Audit Scheme). In addition, there are national and local EMS's, in Norway we for example have a system called environmental lighthouse ("miljøfyrtårn"), first and foremost adjusted to small public and private enterprises.

In the last five years or so, there are established a sort of EMS that we in Norway call MOP (Miljøoppfølgingsprogram) that can be translated to "environmental following-up program". These EMS's are used on several huge Norwegian development- and building projects like Fornebu, Telenor and Pilestredet Park in Oslo.

3.7.3 ISO 14001, EMAS and MOP

ISO 14001

One of the most commonly used framework for an EMS is the one developed by the International Organization for Standardization (ISO) for the ISO 14001 standard.



ISO14001 is a widely accepted international standard for the certification of environmental management systems. Three of the key requirements are summarised below:
The organisation shall identify and assess the significance of the impact its activities can have on the environment. These impacts are described as environmental aspects.

Objectives and targets designed to reduce the organisation's environmental impact shall be established and a programme for achieving these objectives and targets shall be in place.
The company's environmental policy must contain a commitment to continuous improvement, prevention of pollution and a commitment to comply with relevant environmental legislation, regulations and other requirements.

ISO14001 certification helps keep the organisation focused on reducing the environmental impact of our operations. However, experience has shown that good environmental management not only yields financial savings, but also leads to efficient business practice.

An organisation’s main impacts on the environment can for example be classified into eight key groups, which are independent of local organisation or location.
These elements are:

- fuel, energy and water
- waste
- transport
- emissions to air
- procurement
- product stewardship
- local impacts
- benefits

EMAS
EMAS - the Eco-Management and Audit Scheme, the other main framework, is a voluntary initiative in the European Union designed to improve companies’ environmental performance. It was initially established by European Regulation 1836/93, although this has been replaced by Council Regulation 761/01. Its aim is to recognise and reward those organisations that go *beyond minimum legal compliance and continuously improve their environmental performance*.

In addition, it is a requirement of the scheme that participating organisations regularly produce a public environmental statement that reports on their environmental performance. It is this voluntary publication of environmental information, whose accuracy and reliability has been independently checked by an environmental verifier, that gives EMAS and those organisations that participate enhanced credibility and recognition.

Environmental management has become a core business issue for many organisations. Minimising the amount of waste that is produced, reducing energy consumption and making more efficient use of resources can all lead to financial cost savings, in addition to helping to protect and enhance the environment. EMAS is strongly backed by Government and the environmental regulators - organisations who participate are recognised as making strong commitments to the environment and to improving their economic competitiveness.

EMAS requires participating organisations to implement an environmental management system (EMS). The EMS must meet the requirements of the International Standard BS EN ISO 14001. Many organisations progress from ISO 14001 to EMAS and maintain certification/ registration to both.

MOP - example from The Pilestredet Park Urban Ecology project in Oslo

Pilestredet Park, the former national hospital area in the heart of Oslo city, is a large urban renewal program where state and municipality are cooperating in a pilot ecology project with quite ambitious environmental goals. The Pilestredet Park project covers the total renewal of this area. The importance of the processes of change which lead towards sustainable development in building and planning, including the need for new knowledge, attitudes, methods and organisational structures are underlined. The importance of cross-disciplinary work is highlighted.

Covering over seven hectares, it is a very complex urban area with all the old hospital buildings which were built there over the last hundred years or so, in many different styles, different types of construction, a large range of technical infrastructures, and in various degrees of quality or decay. The buildings comprise over 110,000 square metres of floor space today. Approximately half of this is to be demolished, and there will be about 85,000 square metres of construction plus about 50,000 of renovation of existing buildings. Of this, about 60% is to be housing, the rest offices and commercial premises of various sorts. The outdoor areas are to be landscaped as public spaces. It was decided in 1997 to make this into a pilot project for urban ecology, in a collaborative project where Statsbygg and Oslo municipality are the main actors. An urban ecology program for the area was developed at an early stage by Statsbygg and Oslo municipality to clear out the ambitions and goals.

Planning and building codes only lay down minimum standards required for insulation, water use, noise levels and so on. And there are various bits of environmental legislation which again, only give minimum requirements for pollution control, waste management, safety, or user information. These are not enough when one wishes to implement a project with a strong, innovative ecological profile.

The MOP is an obligatory agreement which is part of the contract of sale to the developers. The main themes included in the MOP are;

- Selective demolition including sorting, recycling and minimum transport of wastes
- Maximum reuse of existing buildings, including specific projects with re-used materials
- Environmental architecture including energy design, healthy materials, climate control etc.
- Energy conservation throughout, including renewable energy and strict consumption limits.

For those parts which Statsbygg itself is going to build, it will be binding too. It defines, firstly, a considerably higher level of ecological ambition, and it stipulates procedures to be followed in the process which ensure good environmental planning and quality control.

The MOP, therefore, is the concrete tool for achieving the environmental targets. It also stipulates sanctions. It is a binding contract with developers. The important principle that we should note is that it is thus a legal agreement which operates on the level of civil law, not public regulation. This may be more effective than conventional public tools such as area plans and building codes

Such a program can only be based on consensus between Statsbygg – representing here the environmental ambitions of the state – and the marketplace. When the terms and conditions of the MOP were drawn up, and the first properties put out for sale, there was worry about whether major property developers would object, or simply that the bids received would be very low. In that case there would have been real trouble. However many of the big property companies are themselves actively interested in environmental skills and market profile these days. It came as a surprise, and a relief, that not one of them raised objections to the demands in the MOP, and high sale prices were obtained.

3.7.4 Environmental and Business Benefits of EMS

Environmental credibility is also becoming a factor in national and international competitiveness. Implementation of EMS and subsequent certification can facilitate progress towards increased competitiveness through measurement and innovation, leading to increased profit, more efficient processes, reduced costs and a more credible image.

Market pressures are calling for a better understanding of the environmental costs and benefits of products and services. Percy Barnevik, President & CEO of ABB said as long ago as 1995 (at the Environment North Sea conference in Stavanger) *"There is still, in many places, a general perception that eco-efficiency means higher costs, lower profit – a sort of sacrifice you must do with respect to shareholder interests. However, if you look at the real world you find among companies a strong and positive correlation between being at the forefront of eco-efficiency and being profitable and generally successful. It is not a contradiction, it is a correlation."*

The fear of the initial cost of implementing an EMS can be discouraging to some organisations especially smaller companies. The fact is, however, that many organisations already employ some form of environmental management and find that implementation of an EMS according to the Standard means that they do not have to start from scratch. Those that have not started to even consider how they might implement an EMS may find that their competitors are leaving them behind.

The real concern for managers should be that environmental problems cause a lack of control over business operations. An EMS can give even managers who are not particularly motivated by environmental issues more control over the destinies of their enterprises. Such systems are useful because they help organisations comply with complex (and often ambiguous) rules, ensure that reports and permit applications are submitted in time and improve communication of environmental requirements throughout the organisation. The presence of an EMS helps companies to protect themselves against legal liabilities.

Ref

- ISO 1400/ISO 14001 Environmental management Standard Web-site: WWW.iso14000-iso14001-environmental-management.com
- EMAS - the Eco-Management and Audit Scheme. Web-site: http://www.europa.eu.int/comm/environment/emas
- A.E. Bratset, T. Tollefsen, C. Butters: The Pilestredet Park Urban Ecology Project Oslo Norway, Article in UIA Newsletter no. 6/2002.

3.8 Methods and tools produced in IEA Task 23 - IDP

Task 23 has produced guidelines, methods and tools to help designers to implement the IDP process. The complete list of Task 23 deliveries is given in Chapter 7, Appendix.
Here is the short version:

3.8.1 An introductory Booklet

An Introductory Booklet *"Solar Low Energy Buildings and the Integrated Design Process. An Introduction"*, (fall 2002) is providing a short explanation of the characteristics of an Integrated Design Process an introducing the results of Task 23. Author is Nils Larsson, Canmet Energy Technology, Ottawa, Canada and co-author Bart Poel, EBM-consult , Arnheim, The Netherlands.

3.8.2 The IDP Guideline

The IDP Guideline, is a comprehensive description of the philosophy, rationale and features of the IDP process, and of the companion IDP Navigator. The Guideline provides interactive access to background information, including key issues and recommendations in a checklist format.

3.8.3 The IDP Navigator

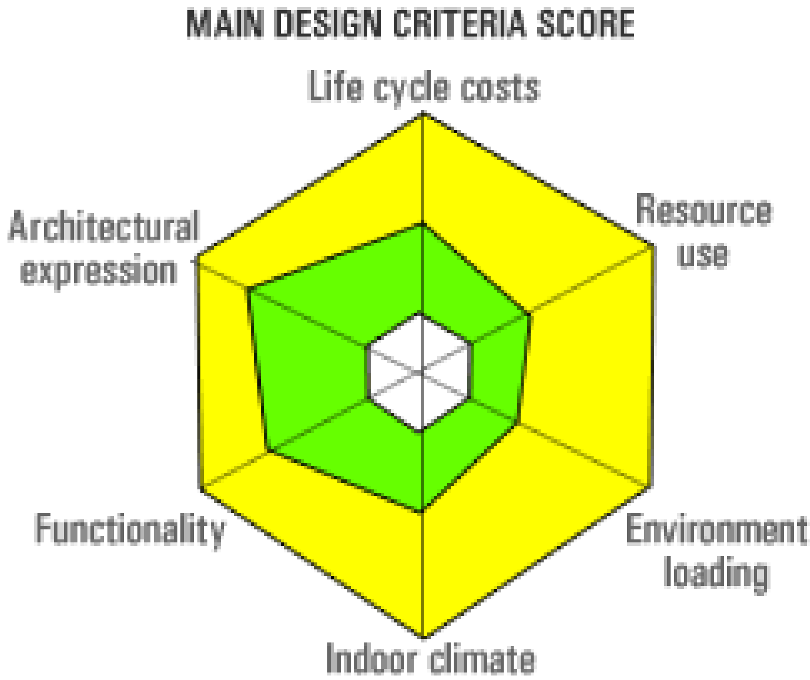
The IDP Navigator; an information source containing important process related and technical issues that are crucial for IDP, produced as a software package. Users can navigate through the information using an interface that is structured according to the steps in the design process. It provides detailed support to users in identifying the elements and inter-relations between steps in the Integrated Design Process. The structure and contents of the Navigator are consistent with the IDP Guideline, but the knowledge base can be modified according to the needs of a specific user. A user manual and presentations on how to use the IDP Navigator are also available.

3.8.4 A Blueprint for a Kick-off Workshop

A Blueprint for a Kick-off Workshop as a basis for the organisation of a design team workshop right at the beginning of the IDP. The main objective of the workshop is to create common understanding at the beginning of the design process. The blueprint is a separate part of the IDP Guideline mentioned above.

3.8.5 The MCDM-23

The MCDM-23, a Multi Criteria Decision Making method with an accompanying software tool; intended for use both in normal building design processes and in competitions. The name reflects the fact that the evaluation of several alternatives is a multi-criteria decision making process. The method assists the team in the selection of and in the prioritisation of design criteria, and in the evaluation of alternative design solutions. In design competitions, the method can assist in developing the program and to select the best design amongst several alternatives.
The MCDM-23 software tool automates many of the tasks involved in using the method, and also produces worksheets, bar charts and star diagrams. A user manual and a booklet on how to use the MCDM 23 together with an MS-PowerPoint presentation are also available.

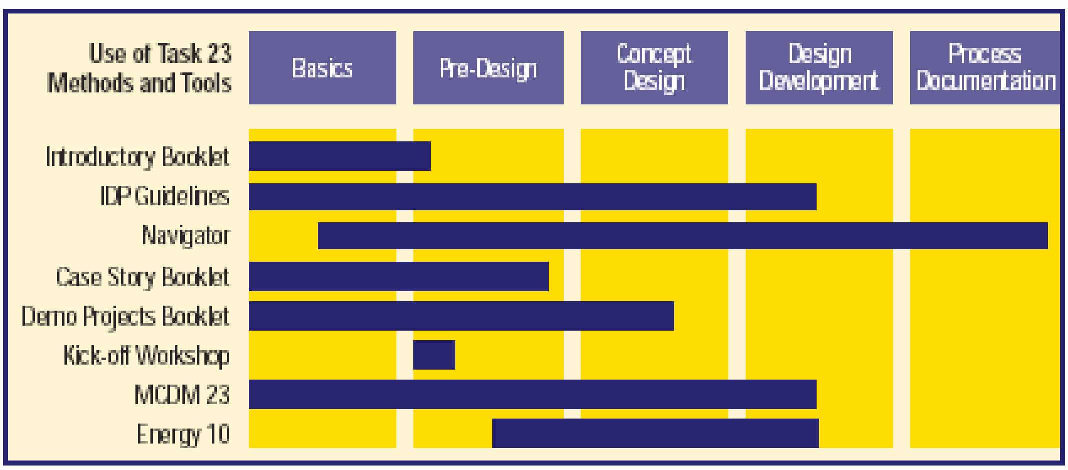


3.8.6 Energy 10

Energy 10; a user-friendly energy simulation system that provides predictions of operating energy performance and identifies the most effective design strategies in reaching this performance level. Energy 10 is being continuously improved and now offers users an economical and highly effective simulation process for early design support.

All of these Task 23 products are downloadable from the IEA SHC Task 23 web-site (www.iea-shc.org/task23) except for Energy 10.

The following diagram provides suggestions for the most useful points of intervention for the Task 23 methods and tools. (Solidar, Berlin Germany)



Solidar, Berlin Germany

3.9 Organisational Models to enhance the Integrated Design Process

The contacts in traditional projects are focused on risk and responsibility, and not so much on co-operation and the project's objectives. The way a project is organised, managed and carried out will be different from project to project.
A model to undertake a building project will contain of 4 elements;

1. Organisational model
2. Enterprise model
3. Contracting model
4. Contract form

In the last years new models for building project have been developed. These models focus more on co-operation to find the most optimal physical and technical solutions, and a more optimal building process. In international literature partnering is used to describe this model. *"Partnering is a structured management approach to facilitate teamworking across contractual boundaries. Its fundamental components are formalised mutual objectives, agreed problem resolution methods, and an active search for continuous measurable improvements"* (Construction Industry Board 1997).

Key words here are common objectives and goals, co-operation, competence, low conflict level. Several models have been developed in different countries, based on these thoughts. For more information, see references.

Ref.
K. Tennebø. *Arkitekten og samspel*. NTNU 2002
J & W Management. *Partnering.* J & W Management (WEB) Sverige 2002
A. Kadfors. *Förtroande och samverkan i byggeprocessen.* Chalmers tekniske högskola, 2002
B. Scott. Partnering in Europe. *Incentive based alliancing for projects.* Thomas Telford Publishing. London 2001.

3.10 Building Performance Contracting and Performance Based Fees (PBF)

3.10.1 Contracting and fees - established practice

Usually there are no incentives for energy efficient design or installation when architects and engineers are contracting a new project.

Design fees are usually either a percentage of the total construction budget or a flat rate. This has the effect of emphasizing speed and 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 costs or energy costs.

Contractors have little incentive to insure that building systems are installed to operate efficiently. For example, fans can be wired backwards thereby doubling their energy consumption, lights that should be programmed to go off at night can be left on, and economizers are often improperly installed so that free cooling is wasted. As long as the occupants don't complain, everyone is happy, except the owner, who is stuck with an exorbitant utility bill.

3.10.2 Performance Contracts - Incentives to save Energy

There are possibilities and well-known solutions for developing incentives to save energy from energy services companies (ESCOs) in US, who have successfully implemented performance contracts at thousands of existing buildings. (Charles Eley, Eley Associates).

First there have to be developed an energy target with a computer model. The model should represent a reasonably efficient building. For example, it could represent minimum compliance with an energy code. Include the energy target in the contracts with the A/E and/or the Contractor but leave it up to the A/E to determine the combination of energy measures that meet the target at the lowest cost.

Second the proposed building has to be modelled at specific stages during the design process to make sure it will meet the target. If the building is off target, the A/E must improve the design. Pay the A/E a bonus for achieving the target at the construction document stage (optional).

At last actual energy use has to be monitored in the second year of occupancy. Adjust the energy target for factors beyond the A/E and Contractor's control (e.g. plug loads, occupant schedules, and weather). If the building uses less energy than the adjusted target the owner pays the A/E or Contractor a pro rated bonus (up to a maximum amount). If the building uses more energy than the adjusted target the A/E or Contractor pays the owner a pro rated penalty (up to a maximum amount).

It’s natural that professionals will be cautious about implementing these “new” ways of entering performance contracts, often based on a common team performance contract. This means that the whole design team; the architect, HVAC engineer, structural engineer and electrical/daylighting designer work together on bringing the actual themes into the process, developing the project until it satisfies all the goals and demands given.

This group approach encourages creativity and varying degrees of experience of the design team invigorates, educates, and challenges those involved. Architects and engineers will need to work together to show building owners that any increase in design fees are a small investment toward decreased operational costs, improved occupant satisfaction and performance, and conservation of materials and natural resources.

3.10.3 “Green was not a goal, it was a solution!” The North Clackamas High School in Oregon as an example.

Computer and physical modelling of The North Clackamas High School indicate that it is one of the “greenest” schools in the US. The 265,355-square-foot school opened April 3, 2002. The North Clackamas High School project began in the mid-1990s and involved numerous entities, including RMI, BOORA Architects, CBG Engineers, Eley Associates, ENSAR Group, the Northwest Energy Efficiency Alliance, Portland General Electric, the Energy Foundation and, of course, the school district. North Clackamas educators had heard about the effects of natural lighting and ventilation on student and teacher performance, and investigated. (Cameron M. Burns and Huston Eubank, Rocky Mountain Institute)

Bill Dierdorff, Business Manager with the North Clackamas School District says that the district was not interested in green design for it's own sake. *"The district was interested in an excellent educational environment that would be cost-effective over the 75 to 100 year life of the facility. Green was not a goal, it was a solution!"*

The school is organized into building "bars" along an east-west axis for optimum natural lighting and ventilation, the school employs natural and recycled content materials such as natural linoleum, ceramic and quarry tile, brick, recycled rubber flooring, recycled upholstery and recycled acoustical tiles. These themes follow principles of environmental sensitivity, simplicity and efficiency. Divided into four academic houses, the building provides small-scale learning environments with emphasis on flexibility, integration of instruction, technology as well as spaces for social interaction and community use.

Architect Heinz Rudolf in BOORA Architects of Portland says that the emphasis on high performance glass and skin permitted a reduction of the mechanical system.

A DOE-2 computer energy model anticipates savings over typical designs of 275,000 kWh in lighting, 315,000 kWh in fans and pumps, 150,000 kWh in cooling and roughly 27,000 therms (2.7 billion Btus) in heating. An indigenous landscaping design that includes preserving and enhancing an existing six-acre wetlands area complements the building. The wetlands will be used to retain and purify stormwater runoff.

To test their design ideas about lighting and natural ventilation, the architects and students built two full-scale classroom mockups. The first of these was at the Seattle City Light's Lighting Design Laboratory, where they were able to hone critical aspects of their daylighting and electric lighting design. The second was built by the students on the site of the new school and used to test natural ventilation components of the heating and cooling design.
The total energy savings are expected to be 44 percent better than the Oregon Energy Building Code requires (and much better than the American Society of Heating Refrigeration and Air Conditioning Engineers, Inc. energy code recommendations). The school will save roughly $75,000 to $80,000 annually on its energy bills, and the total capital cost was a mere $118.70 per square foot.

3.10.4 Performance based fees (PBF) - not a rocket science!

The North Clackamas High School is unique not only because it is one of the greenest schools in US, but also because of the use of performance based fees (PBF). As the name implies, PBF's link a portion of the compensation of project architects and engineers to the savings derived from high efficiency designs. The greater the savings in electricity, natural gas, liquid fuels and other resources, the more these professionals earn.

With funding from the Energy Foundation, RMI worked closely with Eley Associates to create set of PBF guidelines. *"PBF's aren't rocket science, but using them requires considerable foresight and planning."*

Charles Eley of Eley Associates wrote in the primer on Energy Performance Contracting for New Buildings. *"The value of starting early cannot be overemphasized. Retrofits and late design changes are usually limited to HVAC equipment selection, lighting equipment changes and possibly glass type. These measures save energy, but they have a relatively low rate of return. The most cost-effective measures happen early on, and affect characteristics like building orientation, window size and placement, shading, space planning. Many of these* *measures cost nearly nothing - sometimes they even cost less than the base case - but each has the potential of saving a lot of energy."*

Performance-based fees can get lost in the complexities of building and development project processes, especially when there are many change orders. In this project, however, the PBF's survived and even helped steer the process. The money saved through energy efficiency will be split between the designers and the school fifty-fifty for the first two years, with the school's share going into the general fund to offset the increasing cost of energy.

"The PBF's were important simply because they allowed us to spend the extra time and effort required to create a first-class school. The extra compensation allows us to do extra research, evaluations and testing so that we can develop cost-effective systems, especially passive systems. What is equally important is the fact that once a contract for the extra compensation is in place, it serves as tool to commit everyone to accomplish specific goals, as opposed to slightly increasing the professional fees without the specific expectations". (Architect Heinz Rudolf in BOORA Architects.) Rudolf also imply that the run-up in energy prices last summer might have a very positive effect on the performance- based fees, and how this has highlighted the importance of energy savings for this project.

The school has been a hit locally as well as regionally. Several other school districts are working on high schools that will use similar technology, including the Salem-Keizer School District and the City of Oregon School District.

Ref

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4 Interaction with IDP and other Smartbuild strategies and technologies. Examples.

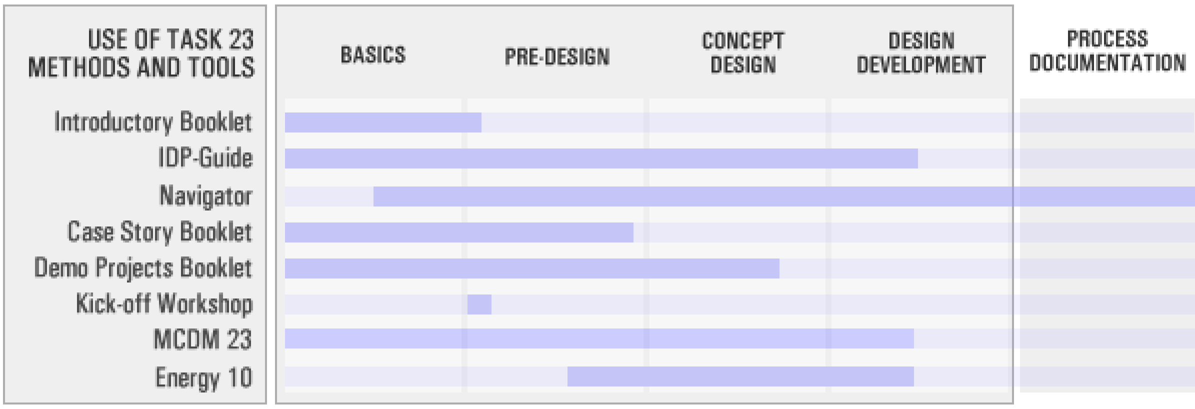
This Chapter is mainly based on two reports from IEA Task 23- Optimization of Solar Energy Use in Large Buildings.

- The last report from fall 2002 named *“Solar Low Energy Buildings and the Integrated Design Process. An Introduction”*. Author Nils Larsson Canmet Energy Technology, Ottawa, Canada and co-author Bart Poel, EBM-consult , Arnheim, The Netherlands.
- The other main report from June 2002 is named *“The integrated Design Process in Practice. Demonstration Projects Evaluated.”*. Editors: Bart Poel, Gerelle van Chruchten, Damen Consultants, Arnhem, The Netherlands.

4.1 Optimum combination of technologies in each specific case

To significantly reduce the total energy use in large buildings, it is necessary to use several technologies such as energy conservation, daylighting, passive solar, active solar and photovoltaics, in combination. The designers of these buildings therefore need to find the optimum combinations of technologies for each specific case. This requires an integrated design approach, where the different low energy and solar technologies to be used are considered integral parts of the whole. (The main objectives of SHC Task 23 are to ensure the most appropriate use of solar energy in each specific building project for the purpose of optimising the use of solar energy and also of promoting more use of solar energy in the building sector. SHC Task 23 focuses primarily on commercial and institutional buildings).

The following diagram provides suggestions for the most useful points of intervention for the Task 23 methods and tools. (See www.iea-shc.org/task23)
(Solidar, Berlin Germany)



Following the time axis of the design process the following instruments can be applied:

4.2 Stories of Integrated Design. Examples

The five demonstration projects evaluated within Task 23 are presented individually in *“The integrated Design Process in Practice. Demonstration Projects Evaluated.”*. All projects aim for a better energy performance than usual, considering the use of solar energy, and most of the projects have the objective to design a sustainable building with extra attention for the

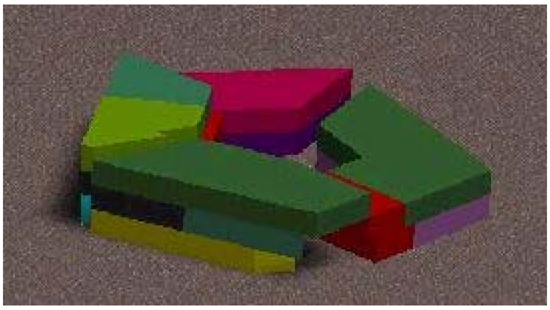
indoor conditions. A common characteristic is also a very explicit choice for an Integrated Design Process (IDP), in line with the principles developed within IEA SHC task 23.
The following projects are included in the booklet:
- Canada: School in Mayo a one storey building providing a high quality educational environment (floor area 3.400 m2).
- Denmark: Community Centre in Kolding a sustainable community centre for all age groups and social stratums (floor area 1.058 m2).
- Germany: Headquarters Deutsche Post in Bonn the headquarters of the Deutsche Post, a 43 storey building (floor area 66400 m2).
- The Netherlands: Brigade staff building 'De Ruijter van Steveninck' Barracks in Oirschot a sustainable office building with a high level of functional flexibility (floor area 4.200 m2).
- The Netherlands: Bank office in Zierikzee a flexible low energy building with two storeys, an inviting building for the public (floor area 1.950 m2)

Canada: Mayo School, Mayo, Yukon
The integrated design process stimulates to go further than standard solutions.

Denmark: Community Centre, Kolding
The client considered that the resulting good indoor climate and reduced energy operational cost were a direct result of using the IDP process.

Germany: Office building Deutsche Post, Bonn
This prestigious, forty-three story building provides a supportive working environment, individual control and operable windows, which could only be realised by an integrated design process.

Netherlands: Office building Rabobank, Zierikzee
The design team focussed on minimising the HVAC-system by an adequately designed building envelope. This resulted in a design with an estimated reduction of energy consumption of about 30%.



. **Netherlands: Brigade staff building Royal Dutch Army, Oirschot**
An inspiring actor appeared to be crucial for the design process

A description of the building design, the design process and the experiences of the design team are presented in the publication The Integrated Design Process in Practice./IEA Task 23

It is obvious that there is a rich variety between the projects. The projects differ in building size from 1.058 m2 floor area for the Danish project up to 66.400 m2 floor area for the German Post Tower. Accordingly the structure of the design team was more complex in the German case. Also the experience of the actors in the design teams with IDP showed a wide range. Both the Danish and the German design teams were already experienced in integrated design, while in the case of the Dutch project, the teams had little expertise and an IDP facilitator was added to the team. Within the scope of IEA SHC task 23 special methods and tools were developed, to support the IDP. In three of the five demonstration projects described the design team used the design process guidelines and the MCDM, and in two projects Energy 10 was used. In some projects the IDP was supported by the use of other instruments, but with a similar function, because at that time the task 23 instruments were not yet available or actors were more familiar with these other tools that were a good alternative. The differences between the design processes are of course related to the specific needs of the client and the expertise of the actors in the design team. Apart from that, also the national context differs from country to country. Especially regulations, building codes and the conventional way the design process is organised gives a diversity in the projects. We will give a couple of examples before we examine the findings and experiences from the five projects.

4.2.1 School in Mayo, Yukon, Canada

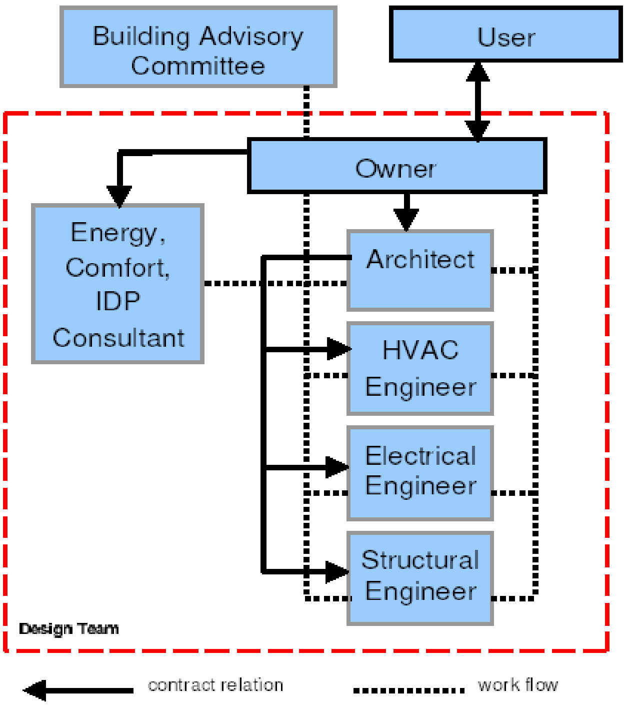
Reasons for construction
The existing school was undersized, in a state of deterioration, and generally functional deficient. For the school in Mayo client needs were formulated like a high quality educational environment and a building adaptable to broader community needs e.g. community gathering and adult education. But also a high level of environmental and energy performance, which should be in accordance with the Canadian C-2000 Program for Advanced Buildings, and a fixed budget including site development were requested. So, the conventional construction budget asked for cost effectiveness.

Contracting
The core process for the development of a school in Mayo was normal, e.g. a client selected the architect and engineers on a semi-competitive basis, and the contractor was selected on a competitive cost basis. The energy engineer / design facilitator was retained directly by the owner.

Facilitator
The energy, comfort, sustainability and integrated design process consultant acted as the design facilitator in addition to his pure engineering task. The consultant had previous experience with the design team on a C-2000 project and was paid partly by the client and partly by the C-2000 program. The architect and the other consultants had successful previous experience with a C-2000 project as well.

Responsibilities
In Mayo, in accordance with IDP principles, the design team participated as a unit in high level decision-making, although the owner was initially not fully integrated or on-side in this process. Once general design directions were determined, the team solved specific design issues within their disciplines, with iterative interdisciplinary consultation as required.

Actors relations
The client actually consisted of two entities: the owner, i.e. the Yukon Territorial Government (YTG), and the user, i.e. the Yukon Department of Education (DE). The Building Advisory Committee (BAC) was a local community group with individual knowledge of sustainability. The BAC was a key motivator in moving the project in the direction of sustainability. The architect was the lead consultant and he retained the structural -, the HVAC - and the electrical engineer. The energy/comfort/IDP consultant was retained directly by the owner to work as an integral member of the design team, but at the same time was representing the owner's interests.



C-2000 Program for Advanced Buildings
C-2000 technical requirements cover energy performance, environmental impacts, indoor environment, functionality and a range of other parameters. In the C-2000 Program, financial and technical assistance is only provided for the design process. The C-2000 Program now focuses on providing advice on the design process at a very early stage.

Experience
The use of an integrated design process was initially requested by the owner in accordance with sustainability mandate, but the true initiative was provided by the architect and energy/comfort/integrated design process consultant. Through the integrated design process, they expected to enhance the probability of attaining functional and sustainability goals as well as cost management. An integrated design process was introduced during the schematic design stage. The expectations were high, based on previous experience, tempered in some cases by concerns regarding extra design effort. But the expectations were met. All project objectives were achieved within the design team tolerance levels for effort. There was some initial resistance from the Department of Education. The primary argument was cost, complexity, and public perception of the building being too elaborate. But as the project progressed, the owner became more receptive. There were some initial conflicts between the owner and the design team, especially with respect to the disposition of an energy program performance incentive paid to the owner, but these were solved by ongoing management of the relationship. These problems were unique to the project and not related to the integrated design process. All C-2000 performance criteria were met, or a valid argument was presented for the modification of certain criteria from their original office-building-based framework. The project also met all project criteria for budget and function, and the completed building reflects a superior level of architectural quality. Without the use of the integrated design process, the Department of Education would probably have implemented one of their “ stock” building plans. After the initial resistance to the high-performance approach, the general trend was for enthusiasm to grow within the design team and the client. All actors were ultimately satisfied with the process, and the resulting building is definitely different, both in performance and appearance. The design team remained committed throughout and, as a result, the team members will use an integrated design process definitely in their subsequent projects. The ultimate overwhelming success of the project resulted in a subsequent groundswell of sustainability initiatives within the owner’s organisation.

Tools
In Mayo the design team used the design process guidelines as specified by C-2000 criteria, including C- 2000 process/decision reporting software, DOE 2.1e energy simulation and Superlite lighting/daylighting analysis software.

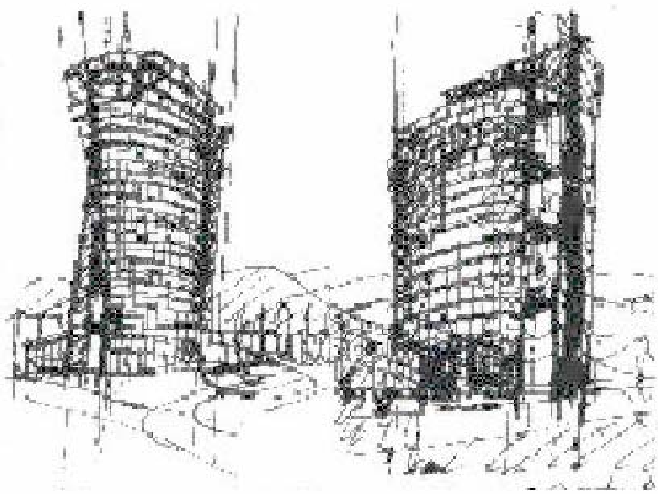
Time frame
Initiative 1999, Design completed 2001, Construction Completed 2002, Hand over 2002.

Trade-offs
In Mayo the management of the numerous performance trade-offs which arose during the design of a building in a cold climate, was an inherent part of the design process, with analysis provided predominantly by the DOE simulations. A typical overriding trade-off is the balance between envelope articulation, massing, day-lighting, and passive solar gain vs. heat loss associated with envelope and fenestration area. This trade-off is essential for IDP because it touches both building and system design and therefore enables whole building optimisation.

4.2.2 Headquarters Deutsche Post in Bonn, Germany

Reasons for construction
The headquarters of Deutsche Post AG were already located in Bonn. The city of Bonn was very interested to keep the about 3000 direct working places in the city and convinced the

Deutsche Post to stay in Bonn. Therefore a high rise building with more than 40 stories was possible. On the other hand public pressure was very high to build a low energy building, which already reaches future planned low energy standards. Therefore the client required a representative building with a human-determined working environment, individual control and access, operable windows in a high rise building and an energy saving of 25% below the existing code.



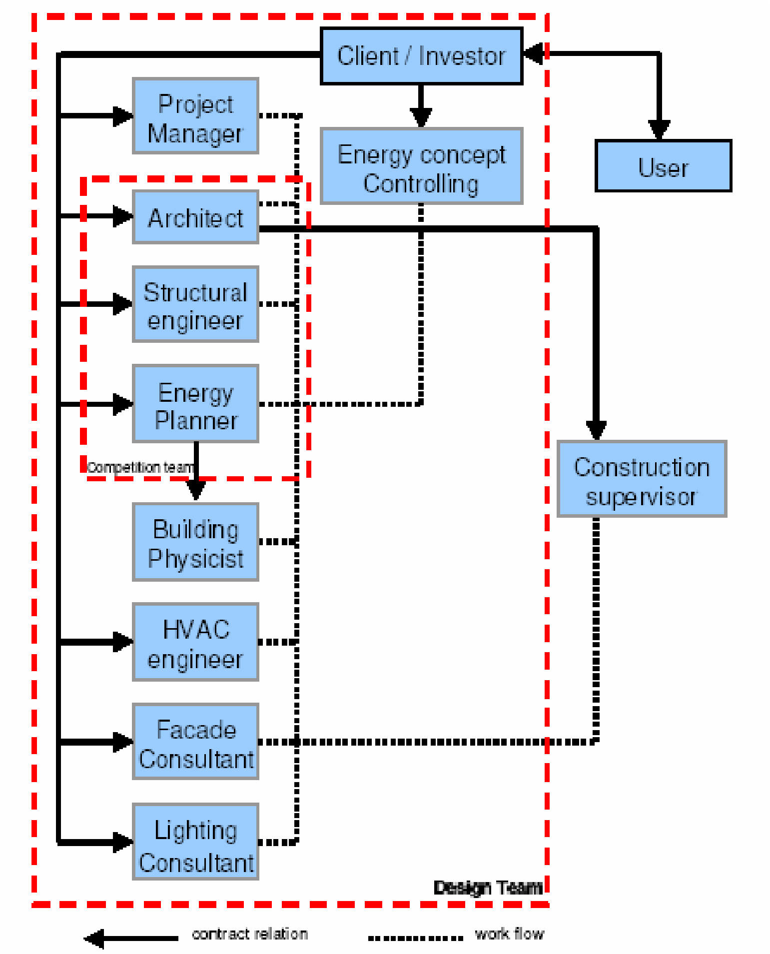
Sketches by Helmut Jahn (Murphy/Jahn Architects - Chicago)

Contracting
The client retained project management and a concept controller to control the decisions of the complex organisation. The project management was helpful in engaging additional external experts.

Design process set-up
The project is a result of an international competition. The initiative for an integrated design process was taken by the architect and the energy consultant. The architect (and design team) had successful previous experience. The participants of the competition remained. In fact, the integrated design process started with a kick off workshop at the beginning of the competition. The design process of the competition was followed by the formal process of the project. Additional designers were introduced and had to become familiar with the effects like double use, reduced safety buffers, clear demands and expectations. The building would have become different without following the integrated design process (a standard central ventilation system, taking up an additional floor, would have been the result). Without these savings the screen facade would have been in danger to be cancelled for cost reasons.

Actor relations
Arthur Andersen got the project management. The architect was Murphy/Jahn architects based in Chicago. Since 5 years Mr. Jahn co-operates with some mainly Germany based engineering companies in the field of structure, energy concept and HVAC-planning. This team was already entering the international, open competition. The structural engineer has been the design partner of Murphy/Jahn for several years. The climate engineer is a consulting company working for integrated energy concepts in building design for ten years. The building physicist is responsible for the thermal and acoustical building protection envelope and the room acoustics: a sensitive approach in this project with open concrete ceilings. The traditional HVAC engineer transforms the concept into pipes and ducts. The lighting

consultant developed his proposals into light fixtures in close relation to Mr. Jahn and developed the lighting layout together with the architects. Because of the innovative ventilation and comfort concept, the client engaged an additional consultant, the concept controller, for a check of the proposed and evaluated concept. From weather data analysis, via simulation with Trnsys, Fluent and Radiance to component and 1:1 test, all different kinds of tools have been used during the integrated design process.



Experiences

In Bonn the team was motivated to develop a new type of high rise building, based on their earlier experiences in other common projects with integrated design. The architect and the energy consultants took the initiative. The integrated design process was already introduced in the competition. The reaction of the actors was mostly openminded. If actors opposed they used objections like deviations to standard working methods, internal irritations and a more time consuming process. In those cases discussion and clear decisions are necessary. The actors expected that integrated design would bring a synergy effect and as a result a low energy and high comfort building. These expectations have been mainly fulfilled with strong input of some participants, supported by the project management and the client. Developing a building for a known end user instead of an anonymous user, is always a better situation, because this end-user can decide to go new ways and to take some risks, an investor would not take risks for an unknown client. With a strong architect and an open-minded client the signals were positive in the beginning and were verified during the design process.

Intensive exchanges in the early planning phases have led to irritations with the client and project management. After explaining the backgrounds this problem has been solved.

However, the result has been: longer discussions about additional planning costs and a low acceptance of integrated design. With strong support of the architect, and by convincing the project management it resulted into a finally good process. These kinds of problems are related to the integrated design process. Not the experimental character but this planning philosophy needs additional explaining.

The specific achievements of the integrated design process in this project are a final concept with the integration of the ventilation concept already in the building form. This could only be achieved by an integrated design process. In addition, the compensation of higher investments in the building facade, which are partially compensated by savings in the technical equipment, could only be argued in an integrated design process. Parts of the concept components were not available before this project started, but were developed and finally installed. The basic concept, developed in the design team (mostly in the competition) determined strongly the building form and effectiveness.

The client is satisfied with the process and the building performances of low energy use and high comfort. The team has learned about the potentials of the integrated design process. In spite of the additional time needed the team members definitely will use the integrated design process in further projects.

Time frame
Initiative 1999, Design completed 2001, Construction Completed 2002, Hand over 2002.

4.3 Overview of findings

4.3.1 Introduction findings

Considering the various demonstration projects some important experiences related to the Integrated Design Process (IDP) appear. A detailed description is given in the booklet *The integrated Design Process in practice. Demonstration Projects Evaluated.*, chapter 4 and 5. In this chapter, these findings are summarised in a more general way. The author says that this chapter is not meant to be a complete set of points of attention regarding the IDP. The findings are limited to the evaluation of the five demonstration projects. Extensive information on IDP can be found in both the “Integrated Design Process Guidelines” and the “Navigator” developed within Task 23. The design processes in the five projects show a rich variety, due to differences in the design task, the composition of the design teams and the specific context for each of the projects.
For instance:

- there were differences in the function of the building (one school, two offices, one community centre and one bank building);
- the size of the buildings varied from 1.000 m2 floor area up to 66.000 m2;
- two of the projects started as a design competition;
- there was a deviation in the level of the client’s expertise;
- some teams were familiar with IDP, for others it was their first experience.

4.3.2 General findings

The demonstration projects proved that an Integrated Design Process is considered to be very beneficial and can be managed successfully if integration aspects are dealt with in an explicit way. The products developed by IEA SHC Task 23 turned out to be very effective. The first stages of the design process may be a little more time consuming and costly, but inefficiencies in the following part of the design process will be avoided and the overall cost performance ratio of the building improves.

The demonstration projects in their diversity showed that the Integrated Design Process is a general approach for various design tasks in different contexts. This means that an IDP can be applied in a wide range of projects. It is important to understand that IDP is not a rigid approach but should be adapted to the specific circumstances of a project, in fact a rigid attitude is in conflict with the basics of integrated design.
Crucial for a successful IDP is:

- an adequate composition and structure of the design team
- competent and motivated team members
- a clear design task
- a process structure that stimulates integration
- good project management

These points may seem trivial statements but they are not. The fact that we are dealing with an IDP and not with a traditional design process makes the difference. It means that the IDP opposes special requirements for the team, the description of the design task and the design process that are not obvious.

4.3.3 Findings regarding the design team

- In many cases the initiative for IDP is not taken by the client but by the architect or a consultant. Attention should by paid to the fact that the client has to understand the essence of IDP. The client has to be motivated and involved to use this approach and he should provide the conditions in terms of structure of the team and the process.
- A proper selection of the members of the design team is elementary (an incompetent member can frustrate the entire process). Discuss IDP with them in advance and assure that they are motivated and have an open attitude.
- If the team is not familiar with IDP it is recommended to add an IDP-facilitator to the team. The facilitator’s role can also effectively be combined with a consultancy role, like consultancy in the field of energy, comfort or sustainability.
- Changes to the team should be limited to those who are absolutely necessary. If changes are unavoidable, take good care of the new team member integrating well.
- It is important to have at least one or two inspiring core members in a team.
- The roles of the team members should be well defined; not in terms of separation but in terms of a mutual responsibility for an optimal end product.
- The client’s representative should have a clear mandate, so decisions can be made without the risk that they are overruled.
- The fee structure of the team members and budget allocation of building cost should not block but stimulate integration. Shifting budgets from HVAC-systems to shading devices and low energy appliances, in order to avoid a cooling system must by inherently stimulated in the budget structure as well as in the fee structure.
- Quality of communication is of great importance for a successful IDP. Based on enthusiasm and an open attitude the actors in the team should learn to communicate actually beyond the borders of their own discipline; a common language will be developed.

4.3.4 Findings regarding process

- The Integrated Design Process typically consists of a number of design loops resulting in products that are milestones functioning as decision documents at transition moments in the design process from one phase to the next.
- Multidisciplinary work sessions are Central activities within a design loop, in order to generate, discuss and judge design options.
- Integration is a very important issue in the first stages of the design process. In the final design phase the process has a more conventional character. In case innovative technologies are part of the design, integration remains a strong issue up to the construction phase and exploitation.
- The design task should be clearly described but not in an unnecessary level of detail. It must be possible to discuss modifications that lead to a more optimal building. These discussions on the design task should be well located in the process in order to manage them effectively.
- After establishing the team, a Kick-off Workshop proved to be an effective way to make a sound start with the design process. A Kick-off Workshop can establish a clear understanding of the client's needs, a common view on IDP and at the same time it stimulates enthusiasm and makes expectations clear about the role of the different actors in the team.
- It is important to prepare the Kick-off workshop properly because it should be an inspiring event.
- A common understanding of the client's needs and expectations, is a necessary condition for an IDP and can even be considered as a preliminary design loop. Understanding the design task not only means studying the brief (program of requirements) but also discussing it together with the client and assimilating and commenting the client' s expectations.
- Integration should be managed just like the conventional aspects such as activities, time, and cost. Special attention is needed for the exchange of information and the quality of communication.
- The MCDM 23 method turned out to be a powerful and effective means of evaluating and discussing whole building performance.
- Energy simulation tools like ENERGY 10 proved to be useful in judging energy concepts and measures in the early design stages, and it supported the communication between the members of the design team.

5 Integrated design and SmartBuild

5.1 General

The overall aim of the planned Program ***Smart Energy Efficient Buildings*** is to develop new knowledge, integrated solutions, and technologies that will make it possible to cover our building-related energy needs with substantially less harmful environmental emissions, while still satisfying the whole range of end-user needs such as comfort, aesthetics, costs, operability, reliability and functionality. The knowledge, technologies, and products developed in the Program will serve as a basis to strengthen education, research, economic growth, and sustainable development of Norwegian industry, community and individuals.

The main area that needs further research is how to integrate the different tools and methods into the design process. Also, many of the methods and tools that exist, are quite complicated and time consuming. However, in a constantly more complex building process, there is a need to make simplifications and straight forward guidelines on how to cover the most important aspects in an effective way.

Also, the motivation for including environmental aspects and integrated design for the different actors and stakeholders in the building project, needs to be elaborated. This may be done in collaboration with task 1.1 user needs and task 1.4 Implementation strategies.

The end-product may be a framework that may be used in building projects (or in educating the actors in the building process), describing procedures for when to do what, by whom and how.

The road to this end-product involves testing out different tools, methods and theories in actual building projects. Also, it would be useful to involve one or several companies that are interesting in developing and implementing a strategy for integrated design for smart-energy efficient buildings.

6 Literature, central R&D institutions, and industry

6.1 Literature related to the IEA Task 23 project:

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- *"Solar Low Energy Buildings and the Integrated Design Process. An Introduction"*. Author Nils Larsson Canmet Energy Technology, Ottawa, Canada and co-author Bart Poel, EBM-consult , Arnheim, The Netherlands. fall 2002

- *"The integrated Design Process in Practice. Demonstration Projects Evaluated."*. Editors: Bart Poel, Gerelle van Chruchten, Damen Consultants, Arnhem, The Netherlands. june 2002

(For more information in IDP-Tools and methods, see www.iea-shc.org/task23) .

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- http://www.klimabuendnis.org (Climate alliance of European Cities
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- http://www.formas.se (Swedish Research Council for Environment, Agriculture an Special Planning, Formas)
- http://www.arkitektur.no (NABU Norske Arkitekter for Bærekraftig Utvikling)
- http://www.dcue.dk (Dansk Center for Byøkologi, Århus)

6.5 Central R&D institutions

- Swedish Research Council for Environment, Agriculture and Special Planning, Formas
- CANMET, Canada

6.6 Industry

- Statsbygg
- Telenor Eiendom
- Forsvarsbygg
- SINTEF
- Byggforsk
- Dansk Center for byøkologi
- NABU
- Arkitektkontoret GASA AS
- Selmer Skanska AS
- Veidekke AS