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The Integrated Design Process (IDP) – a more holistic approach to sustainable architecture.

Hanne Tine Ring Hansen cand. polyt., Ph.d student[1]
Mary-Ann Knudstrup cand. arch., Associate Professor, Architect maa[2]

[1] Department of Architecture & Design, Aalborg University, Gl. Torv 6, 9000 Aalborg, Denmark, email: htrh@aod.aau.dk
[2] Department of Architecture & Design, Aalborg University, Gl. Torv 6, 9000 Aalborg, Denmark, email: knudstrup@aod.aau.dk

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Summary

This paper presents the Integrated Design Process (IDP) applied to sustainable architecture and available design methods and gives an example of the tools applied. The paper focuses upon the ability to integrate knowledge from engineering and architecture and let them interact with each other in order to solve the often very complicated problems connected to the design of sustainable buildings.

Some of the aspects of the integrated design process were tested on a virtual design project in order to evaluate if the IDP can help achieve sustainable architecture. The aim was to show how different tools related to the IDP can interact in order to enable sustainability to become a natural part of any building project.

The virtual design project gives an example of how a selection of parameters can be weighted and used in a sketching project. The paper thereby discusses an example of how the different parameters and products can interact, and which consequences this would have on a project.

The IDP does not ensure aesthetic or sustainable solutions, but it enables the designer to control the many parameters that must be considered and integrated in the project when creating more holistic sustainable architecture in order to achieve better sustainable solutions, because all the different parameters are considered during the process.

1. Introduction

Issues of global warming and new legislative demands for the energy consumption in buildings have resulted in a need for methods for developing sustainable architecture.
At the moment mainstream architects have difficulties achieving sustainable results in their projects.

The sustainable projects that are completed often achieve their sustainable status by the implementation of solar panels, glassed verandas or low-flushing toilets. However, this does not necessarily ensure sustainability, as the systems in the building do not really work together and often the users do not use the building as intended.

Therefore there is a need for methods which enable more holistic sustainable architecture. Within the last five years new methods have emerged in sustainable architecture. Many of these, however, focus on subsections of sustainable architecture which complicates the implementation of sustainability by mainstream architects. There is therefore still a need for holistic methods in sustainable architecture.

2. Methods

This section presents the background for the paper as well as a description of other methods in sustainable and climatic architecture. This section will also describe how these methods can be positioned when compared to the Integrated Design Process (IDP) developed at The Department of Architecture and Design at Aalborg University, Denmark. *[Knudstrup 2000, 2003, 2004].*

2.1 The Integrated Design Process (IDP) a method for designing Architecture

Designing a building is a very complex process. Therefore the Integrated Design Process is combining knowledge from architecture and engineering in order to solve often very complicated problems connected to the design of buildings. The integrated design process (IDP) [Knudstrup 2003, 2004} works with the architecture, the design, functional aspects, energy consumption, indoor environment, technology, and construction. A process

which can be done by an architect or an engineer but because of the many parameters and the trans-disciplinary approach it would be easier to overcome the many aspects in a team consisting of people with different competences, if it is a larger project.
In the following section the various phases of a design project, will be described to give an insight into the phases of the Integrated Design Process.

2.1.1 The phases of the Integrated Design Process

The design process is a very complex process, so figure 1 is a simplification of the process. However it illustrates the various phases in the process. It is also here very important to be aware that the process is an iterative process.

The Phases are:

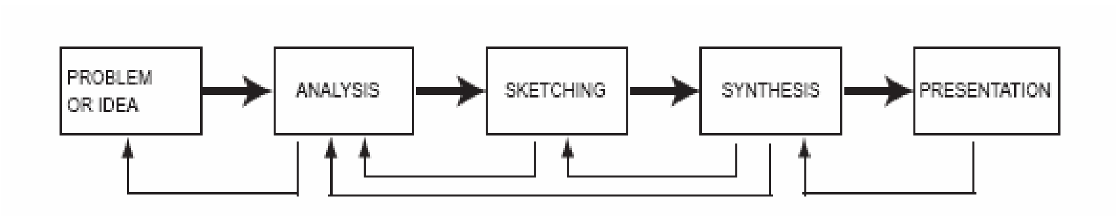

Figure 1 The phases of the Integrated Design Process

Problem formulation or project idea The first step of the building project is the description of the problem or the project idea to an environmental or sustainable building.

The Analysis Phase encompass an analysis of all the information that has to be procured before the designer of the building is ready to begin the sketching process, e.g. information about the site, municipality plans and local plans the architecture of the neighbourhood, topography, vegetation, sun, light and shadow, predominant wind direction, access to and size of the area and neighbouring buildings. Furthermore, it is important to be aware of special qualities of the area and the sense of the place; genius loci.

Through the analysis phase detailed information is procured about the user's demands for space, functionality, logistics as well as criteria for architectural qualities are discussed etc. The user or the building owner goes in as a very important sparring partner for the elaboration of a room program and logistic needs, the architecture demands and a chart of functions and a company concept which can lend inspiration to the design of the building. It is also here decided if the new building is going to have an iconic character at the site or in the urban landscape. Here it is also very important to decide principles for especially targets for energy use; heating, cooling, ventilation, lighting and indoor environmental quality as thermal comfort, air quality, acoustics, lighting quality, of the new building as well as criteria for application of passive technologies as natural ventilation, day lighting, passive heating, passive cooling. These criteria should be developed considering the local climatic conditions and the local energy distribution facilities.
At the end of the analysis phase a statement of aims and a programme for the building is set up including a list of design criteria, target values.

The Sketching Phase is the phase where the professional knowledge of architects and engineers is combined and provide mutual inspiration in the Integrated Design Process, so that the demands and wishes for the building are met. This also applies to the demands for architecture, design, working environment and visual impact, and the demands for functions, construction, energy consumption and indoor environmental conditions. During the sketching phase all defined criteria and target values are considered in the development and evaluation of design solutions. As well as demands for logistics and other demands, which are in the room programme.
New creative ideas and solutions are produced in this phase. It is important in this sketching process, which is also a very complex mental process, to visualize ideas on paper or in physical models, and by using computer-designed models e.g. programmes like Auto Cad" or "Autodesk VIZ 4".
As mentioned above, in this phase the professional parameters of both architects and engineers are flowing together in the Integrated Design Process in interaction with each other. The precondition for designing an energy saving building in an Integrated Design Process is as follows: In the sketching phase the designer must

repeatedly make an estimate of how his or her choices regarding the form of the building, the plans, the room programme, the orientation of the building, the construction and the climate screen influence the energy consumption of the building in terms of heating, cooling, ventilation and daylight – and how these choices inspire each other. Typically the different solutions have different strength and weaknesses when the fulfilment of the different design criteria and target values is evaluated. In this phase the designer makes a lot of sketches to solve the various problems in order to optimise the final and best solution that hopefully will appear in the next closely connected phase, the synthesis phase.

The Synthesis Phase is the phase where the new building finds its final form, and where the demands in the aims and programme are met. Here the designer reaches a point in the design process where all parameters considered in the sketching phase flow together or interact – architecture, plans, the visual impact, functionality, company profile, aesthetics, the space design, working environment, room programme, principles of construction, energy solutions and targets and indoor environment technology form a synthesis. In the synthesis phase the various elements used in the project should be optimised, and the building performance is documented by detailed calculation models.
In this way the project reaches a phase where every item, one might say “falls into place”, and other possible qualities may even be added.
The project finds its final form and expression, and a new building with – hopefully good – architecture, architectural volumes, aesthetic, and visual impacts, functional and technical solutions and qualities have been created.

The Presentation Phase is the final phase, which includes the presentation of the project. The project is presented in such a way that all qualities are shown and it is clearly pointed out how the aims, design criteria and target values of the project have been fulfilled for the new building owner. The presentation to the client will consist of a report a cardboard model and IT-visualisation.

2.1.2 The Interaction of the parameters in the IDP

The complexity of the IDP springs from the interaction between the different tools and products of the process. This was analysed and described in the theoretical master project “The Integrated Design Process Focused on Sustainability and Method” [Hansen, Madsen and Madsen 2003]. Shown here is an example of how the tools and products interact when sketching on the climate screen.

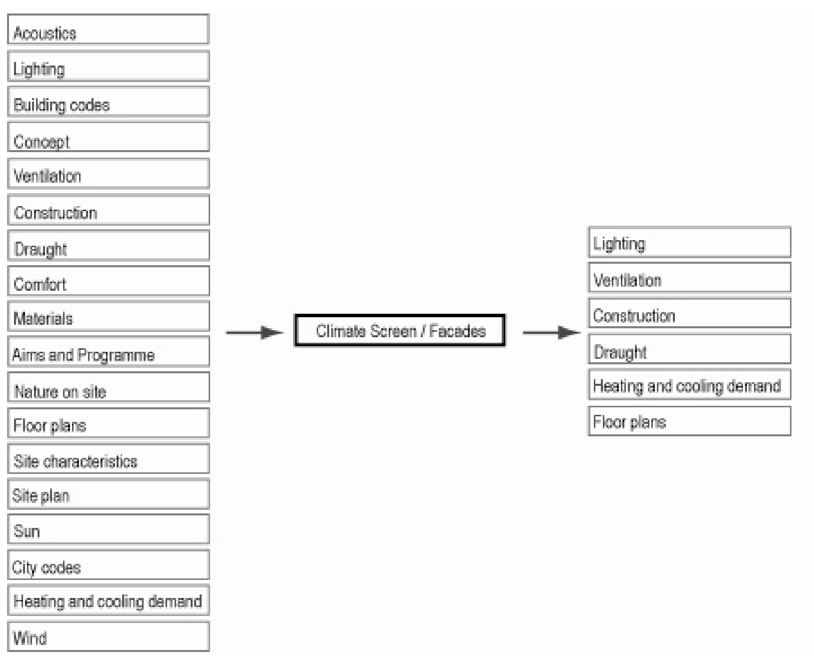

Figure 2 Example of the interaction of the parameters in the Integrated Design Process, when sketching on the climate screen.

This illustration indicates the number of iterations one has to make whenever a decision is made regarding the design of the climate screen. Illustrations like this were made for each parameter found in the Integrated Design

Process when applied to sustainable architecture thereby illustrating the complexity of the design process and simultaneously providing a comprehensive view of the parameters involved in the IDP up to the end of the synthesis phase.

The parameters listed on the left side are the parameters which influence the design of the climate screen, while the parameters listed on the right side are the parameters which are influenced by the design of the climate screen. The project tried to describe which consequences the interactions could have and how it could happen. Furthermore specifications of the technical methods were provided based on material from the technical courses held by polytechnics. This master project provided the theoretical background for the virtual design project which will be presented later in this paper.

2.2 Other methods for environmental architecture

Sustainable Architecture has been of interest to architects and engineers for many years. The interest in climatic architecture can be traced back to Vitruvius' in the 1st century BC in his "Ten Books on Architecture" [Hawkes, McDonald and Steemers 2002].

In the 20th century the interest in green, sustainable, bioclimatic and environmental architecture increased as a result of climatic changes, increased consumption and energy-crises. People like Victor Olgyay, Leslie Martin, Wolfgang Feist, Ken Yeang, Renzo Piano and Norman Forster and others showed interesting results in form of methodologies and sustainable architecture.
The different methodologies and approaches each have their way of creating sustainable architecture some of these will shortly be introduced in the following.

"Design with climate – a bioclimatic approach to architectural regionalism"
In 1964 Victor Olgyay published a book entitled "Design with Climate – a bioclimatic approach to architectural regionalism". The method he presented here has been an inspiration to many of the methods developed and used today. *"The process of building a climate-balanced house can be divided into four steps, of which the last is the architectural expression. Architectural expression must be preceded by study of the variables in climate, biology, and technology"* [Olgyay 1964:11]
The method focuses primarily on the climate and physiology, and not as much on the resources used in the building process. This is probably due to the fact that this method was developed prior to the energy crises in 1973 and 1979. Therefore it deals with the needs which were present at the time; comfort in relation to climate. It also focuses on the cultural influences on the site, which is very much a part of the regionalistic tradition; in fact Olgyay was the first person to use regionalism in relation to climate [Hawkes, McDonald and Steemers 2002].
This method differs from the traditional way of thinking architecture as he begins with climatic and comfort considerations and then later deals with the architectural expression. This also differs from the IDP, where the brief and architectural analyses are made in the initial stage of the analysis phase.
The parameters used in Olgyay's approach are similar to some of the parameters used in the IDP. Olgyay is therefore interesting in relation to the IDP, as he is regarded as a source of inspiration.

"Bioclimatic skyscrapers"
The Malaysian architect Ken Yeang has been engaged in bioclimatic design in connection with Skyscrapers since 1981. [Yeang 1994]. Working in Malaysia presents him with climatic problems, as he works in a tropical climate with small changes in temperature and a large cooling-load due to high external temperatures and a humid climate. To develop his designs Yeang insists on doing research to update his knowledge during every project thereby improving the architecture. Over time he, thus, integrates more and more sustainable measures in his architecture, which also enables him to reflect on the effectiveness of his solutions. He calls this method RD+D (Research Design and Development). The application of this method has over the years resulted in the development of more and more sustainable principles used in his buildings.[Yeang 1994]. *"At the heart of the principles are the first and dominant concerns of energy reduction and buildings as open systems – interactive inside and outside in response to the seasons. In essence the fundamental propositions are very simple, but the overall, global effect of their consequences represents an optimistic and progressive vanguard of potential that is crucial to the effort towards a sustainable future world"* [Yeang 1994:14]. "*The overall arrangement abandons traditional geometry and responds to the dynamics of climate, sunpath, wind direction and the issue of lifestyle: openness – including breezeways, verandahways, transitional spaces that relate to the society they serve*" [Yeang 1994:15]. Malaysia used to be a British colony until 1957 and therefore there was no vernacular architectural tradition when Yeang began his career. The architectural tradition in Malaysia was up until then

influenced by a European tradition. Thus Yeang has tried to establish an architectural tradition based on the Malaysian culture and climate through out his work. [Yeang 1994].
Yeangs approach to sustainable architecture is interesting because of the principles he uses, as these are similar to the tools used in the IDP. His approach is not as process oriented as the IDP but the fact that he uses the RD+D method indicates that he uses a process, with an analysis of research material, an implementation phase and an evaluation phase.

"The Selective Environment – An approach to environmentally responsive architecture"
The Selective Environment presents a terminology developed at the Martin Centre at Cambridge University, U.K. *"Selective design, as opposed to exclusive design, aims to exploit the climatic conditions to maintain comfort, minimising the need for artificial control reliant on the consumption of energy. This manipulation of climate, to filter selectively positive characteristics of the environment, is achieved through architecture. A building's form is probably the most significant consideration with respect to the selective potential of a design. (…) Solar gains, daylight and natural ventilation are three aspects where climate can provide useful support to minimise the use of energy for heating, electric lighting and fan power respectively. (…)The degree to which a building can be selective is dependent on the very first strategic considerations in its design."[*Hawkes, McDonalds and Steemers 2002b:123].
"In its original definition, the characteristics of a 'selective' building were defined by the following parameters:
initial environment; built form; orientation; fenestration; and energy sources.
In adapting these principles to the global context, these may be redefined (…). The primary aim remains the same: to seek to achieve the maximum use of ambient energy sources in the creation of internal environments that are, as far as possible, naturally sustained, and in which comfort conditions are related to the climate of the location. It is also assumed that there will be spatial and temporal environmental diversity and that the operation of control systems will be primarily in the hands of the buildings' occupants." [Hawkes, McDonald and Steemers 2002b:12].
If this method is compared to the IDP we find that the methods use many of the same parameters in the design process. The main difference between the two methods seems to be:
The Selective Environment is a development of the LT-method [Baker & Steemers 2000], which can be regarded as an engineer method, thus, the development of The Selective Environment has gone from an engineer method towards an architectural method.
The IDP started as an architectural method adapting to an engineering method.
The end results of the two methods have many of the same basic parameters and goals, but the development of the two originates from two different approaches to science, i.e. the positivistic and the hermeneutic.

"Passive House"
The idea of the passive house was suggested by professor Bo Anderson in 1987. Since then it has been developed further by Dr. Wolfgang Feist [www.dcue.dk 2001]. The European countries each have their standards for sustainable buildings. Amongst these standards the passive house concept is regarded as one of the more successful approaches, which is why many countries are now looking towards Germany to learn how to achieve similar results. [Gauzin-Müller 2002]

The heating load must not exceed 15 kWh pr. m^2 pr. year. In order to achieve this, the following guidelines can be applied:

- *"Compact form and good insulation: All components of the exterior shell of the house are insulated to achieve a U-factor that does not exceed 0.15 W/(m²K) (0.026 Btu/h/ft²/°F).*
- *Southern orientation and shade considerations: Passive use of solar energy is a significant factor in passive house design.*
- *Energy-efficient window glazing and frames: Windows (glazing and frames, combined) should have U-factors not exceeding 0.80 W/(m²K) (0.14 Btu/h/ft²/°F), with solar heat-gain coefficients around 50%.*
- *Building envelope air-tightness: Air leakage through unsealed joints must be less than 0.6 times the house volume per hour.*
- *Passive preheating of fresh air: Fresh air may be brought into the house through underground ducts that exchange heat with the soil. This preheats fresh air to a temperature above 5°C (41°F), even on cold winter days.*
- *Highly efficient heat recovery from exhaust air using an air-to-air heat exchanger: Most of the perceptible heat in the exhaust air is transferred to the incoming fresh air (heat recovery rate over 80%).*
- *Hot water supply using regenerative energy sources: Solar collectors or heat pumps provide energy for hot water.*

- *Energy-saving household appliances: Low energy refrigerators, stoves, freezers, lamps, washers, dryers, etc. are indispensable in a passive house."* [www.passiv.de 2005]

Passive House is mostly applied to dwellings, more specific single-family houses and low-rise apartment buildings, which is why the principles for the concept are few and simple to apply. The principles do not set any demands or present any method on how to ensure architectural quality in the buildings, and it could therefore be regarded as an engineer method as opposed to the IDP which represents an integration of both engineering and architectural principles. Even so the parameters applied in this method are relevant for the development of sustainable projects.

Let us return to the challenge of the work with-in the Integrated Design Process where a lot of parameters from architecture and engineering are combined and taken in. It is obvious that the IDP leads to other solutions – other types of buildings and new designs – when the technical disciplines are included in the design process. On the sketching level the projects become better defined than they use to be in the more "artistic" architectural setting, as the indoor environmental conditions and the energy frame of the building are clarified. This clarification is also important for the comfort, and for a good working environment for the coming users. From an economic point of view the operating costs can be kept to a minimum when the climate screen of the building is optimised, thus, saving energy for cooling and heating, and the passive ventilation principles employed also reduce energy expenses.

3. Virtual Design project

The IDP was tested in a virtual design project entitled "Citylife" [Hansen, Madsen and Madsen 2004]. The result was a master plan for an eight acre plot, from the master plan a building unit was selected for detailing. The aim of the project was to achieve a sustainable development on an industrial area of the harbour front in Aalborg/Noerresundby. The old industry of this city area was closing and the focus of the project was what to do with the devastated site that could reintroduce prosperity in the city area.

The following parameters from the IDP were used in the project:
Analysis phase:

- Site analysis (history, architecture, genius loci, green structures, infrastructure, functions in the area, age of inhabitants etc.)
- Comfort analysis (based on CR 1752)
- Climate analysis (Solar calculations of altitude and azimuth, temperatures, rainfall, humidity, Wind roses etc.)
- Analysis of the legislative demands (Building codes and municipality documents)

Sketching phase:

- Site plan
- Solar studies of site plan in a computer programme (Bsim2002), to investigate shadows from buildings.
- Green roofs
- Green corridors
- Consideration of daylight levels in the middle buildings and the risk of glare.
- Optimization of U-values (Insulation thickness)
- Calculation of the heating and cooling load
- Ventilation strategies (Natural ventilation, Placement of windows)
- Atriums in relation to entrance area in the dwellings
- Open floor plans
- Construction system (stability)
- Physical models
- Virtual models

Synthesis phase:

- Ventilation strategies (Natural ventilation, Placement of windows)
- Calculation of the heating and cooling load
- Choice of internal materials based on room acoustic calculations in the office area
- Choice of materials based on LCA profiles
- Calculation of a structural detail (The four storey corbel towards the fjord)
- Calculation of minimal ventilation rate and the opening area of the windows to ensure this.
- Physical models

- Virtual models

The different parameters were integrated in the design process at different stages as tools instead of obstacles. The green area of the site was very important in the project such as the new standards which were suggested for the sociality of the inhabitants in the new area.
The parameters became a natural part of the project and some of them merged. The design of the facades and the floor plan were influenced by the strategy for the ventilation and daylight considerations and the placement of the different storeys in the office area were decided based on the penetration of daylight and the risk of glare, in order to be able to avoid shading on the facades. Just as the design of the site plan was influenced by the site analysis, the green corridor, the simulation of light and shadow in a computer model.
The site plan and the scale and expression of the building were also greatly influenced by physical models which laid the foundation for the computer simulations.

The master plan was inspired by the urban structure in the area, and therefore consisted of two types of building structures; long rectangular buildings towards the waterfront and u-shaped building blocks facing the city. A large green area was placed between the two building types. The green area was developed as a continuation and an enlargement of the green corridors on the site and the functions envisioned for this area were those of an interactive city park with different types of leisure activities.
The functions in the buildings on the site were a spa, an arcade, a gym, small shops, a restaurant, business centres with new innovative working environments and dwellings.
The project presents a new way of living in the city, as the project group wanted to go against the antisocial development of the urban inhabitants. The green area was therefore an area for both the inhabitants of the buildings on the site and in the area, just as the entrance areas to the dwellings were made as unofficial meeting points in the building in order to enable closer relations between the inhabitants.
The project resulted in a master plan and a building design with environmental considerations incorporated into the master plan and in the choice of materials, ventilation systems, daylight strategies and heating and cooling strategies in the building. The aim of the project was to revitalise the area into an urban breathing space which could reunite the inhabitants of the area and create prosperity in a shrinking city area.

4. Conclusions

The IDP can be used for environmental or sustainable projects but there is still a need more specific methods, e.g. related to a particular function in a specified climate. By looking at the development of methods in environmental and sustainable architecture in general one can conclude that others have reached the similar conclusions that specific methods in sustainable architecture are important, as most methods focus on subsections of sustainable design. These are important but a more holistic method is also needed which embraces all the subsections and completes the sustainability of architecture.

The IDP does not ensure aesthetic or sustainable solutions, but it enables the designer to control the many parameters that must be considered and integrated in the project when creating more holistic sustainable architecture in order to achieve better sustainable solutions, because all the different parameters are considered during the process.

The virtual design project only reached an early stage of the sketching phase; therefore the degree of sustainability in the project could be improved further if allowed. The main concern is the integration of the many different parameters, as this is regarded as the key to creating more holistic sustainable architecture. The control and integration of so many different parameters in a project ensures a better interaction of systems and therefore also a building where the degree of sustainability seems to be better.
As the virtual project has never been completed there is no way of telling how the systems would actually work, even so the aim to test the Integrated Design Process was succeeded, as the discussion of the integrated design process in the workgroup eased the communication and thereby the design process.
The workgroup consisted of three students doing their master thesis in Architecture at The Department of Architecture and Design. In spite of the similarity in their background they had different preferences and different head competences, which is similar to the trans-disciplinary workgroup. The group had one major advantage; due to their common education they had achieved a common language based on the same terminologies and they had a previously defined approach to sustainable architecture and theory of science from the theoretical master project “The Integrated Design Process Focused on Sustainability and Method” [Hansen, Madsen and Madsen 2003].

5. Discussion

People involved in sustainable building design need to adapt to trans-disciplinary teamwork which calls for new means of communicating. Some engineers and architects have already reached this goal but most mainstream architects would not know where to begin which is a problem, as most if not all future architecture needs to be sustainable if we are to fulfil the Kyoto agreement.
Problems with communication often arise because architects and engineers seem to be different species as they have different approaches to architecture as their approaches belong to different philosophies of science. The architect belongs to a humanistic tradition whereas the engineer belongs to a positivistic tradition. This creates problems when working as a team, as the communication between the different parties relies on a common language and in this case the languages are very different. The architect focuses on senses and subjectivity where the engineer focuses on measurable results and objectivity. One of the main issues of the communication in teams seems to be to find a common language it is therefore strictly necessary to involve all the parties of a project from the project formulation phase.

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