PERFORMING THE TRANSITION - INTEGRATED DESIGN PROCESSES IN CLIMATE CHANGE MITIGATION

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The concepts of "Integrated Design" (ID) and Integrated Design Processes (IDP) is currently gaining importance as the building sector commences its transition towards climate change mitigation. ID and IDP are viewed as management concepts, seeing them as less of systematic knowledge and more of a symbolic device for enabling change, a performance of the concept. Three variants of integrated design globally is presented; Integrated Design and Delivery Solution (IDDS), Integrated Design Organization and Integrated Design Process (IDP). A bottom up perspective is used, looking at ID and IDP's presence in the Danish building industry. The concepts vary on dimensions such as the role of information technology, the relation to lean, forms of collaboration and industry, organization or project focus. Empirically the paper builds on qualitative case studies of four teams bidding for two building projects. It is argued that several ambiguous concepts of IDP co-exist and the architects and engineer struggle with the concepts even when directly involved. Precarious and negotiated consensus has to be created to make IDP perform. Nevertheless the ambiguity of the concepts is viewed not merely as a weakness, but also a condition of possibility for process oriented change in construction triggered by changes in the traditional roles and responsibilities when doing energy design for climate change mitigation.

Keywords: climate change, collaboration processes, Denmark, integrated design.

INTRODUCTION

Transition towards a non fossil economy creates attention to energy consumptions in buildings. Designing clean buildings has become part of this attention, and solutions call it LEED, BREEAM, Active houses, Passive houses, zero carbon, Green Building, or the like, flourish. Design involves meeting the elevated European directive's demands, a task that several studies shows is not simple for the architects and the consulting engineers (Marsh *et al.*, 2010, Hojem and Lagesen 2011). Part of the complication lies with the cacophony of competing concepts for climate change mitigation in building. Clients (and regulators) ask for more, or something, else than just following building regulations, and finding the right synthesis of design criteria becomes a renewed challenge.

One of the central impacts of the need of designing clean buildings is that energy consumption concerns and energy related requirements pushes themselves "upwards" in the design process to the early conceptualization phase. Therefore in this paper the focus is on cases of what would previously have been called programming and would often be organized as "architects competitions", but with the introduction of integrated

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Koch, C and Haubjerg, E (2011) Performing the transition - integrated design processes in climate change mitigation *In:* Egbu, C. and Lou, E.C.W. (Eds.) *Procs 27th Annual ARCOM Conference,* 5-7 September 2011, Bristol, UK, Association of Researchers in Construction Management, 1155-1164.

design (and energy calculations) also involves engineering consultants and for other reasons even contractors. What is in play in other words is a fundamental reorganization of previous linear and "over the wall" fragmented design processes (Brunsgaard *et al.,* 2009). Integrated Design Process (IDP) is here understood as a management and organisational concept. Concepts travel globally, across countries and sectors (Czarniawska and Sevon 1996) and they have to be brought to perform. This is also the case with IDP, and the international variants are identified. Here the interest is the appropriation in a Danish context, and it is assumed that local actors would translate and transform any such organisational and managerial concept, rather than merely mimicking it. The preference in the theoretical framework is therefore given to Danish contributors, identifying three variants.

The aim of this paper is to analyse how Danish architectural and engineering companies interact with the concept of "integrated design processes" as part of their transition into delivering professional services of sustainable buildings. The paper describe one team process yet the empirical material encompass two building projects both aiming at going beyond the EU-requirements for energy consumption. At each of the two projects, two competing project teams, were interviewed addressing architects and consulting engineers. And also referring to clients' and contractors' representatives. Here one team's responses are described to illustrate the process and all four teams responses are encalculated in the analysis.

METHOD

The theoretical approach is interpretive sociology. The paper starts with identifying internationally articulated versions of IDP, as a background for characterizing three versions of integrated design present in Denmark. This is built on desk study and a selective literature study, both identifying research based and more popular versions of the concept (Koch *et al.,* 2003). The empirical part is case studies of four teams participating in a competition on two building projects with high profile energy demands (Haubjerg, 2010). The choice of cases was done with point of the departure of a collaboration of Haubjerg with a consulting engineering company drawing on its informal network of architectural, engineering and construction firms. The two design competitions of building with energy requirements, each with two teams are covered by interviews of one engineer and one architect from each team, supplemented with two interviews with clients representatives. A desk study was used to complement on knowledge about the two competitions. The names of the two competitions "Zero Carbon" and "Colossus" are fictions. Below the process is focusing on the two teams of Colossus, to be understood as an example. The analysis covers all four teams.

'INTEGRATED DESIGN PROCESS' AS MANAGEMENT CONCEPTS

A management concept can be viewed as a loosely bundled set of ideas, visions, tools (processual and content), exemplary cases and claimed results (Koch *et al.,* 2003). To bring them to 'work' in enterprises they need to be performed, i.e. carried out in emergent processes. This stands in contrast to a belief that concepts used in enterprises would be founded on scientific systematic knowledge, and encompasses well defined and explicit tools (Czarniawska and Sevon 1996). When an enterprise or group uses a concept, it would perform a directed change, realized through symbolic, learning or political processes (Koch *et al.,* 2003). The local context would shape the concept in a characteristic way, making generic definition less useful, including those of the authors.

Integrated Design Processes

Integrated Design concepts have been around for some time and are present both in academic literature and in companies' branding of competences etc. The focus on integrated design (without processes) is for example presented by Moe (2008). He understand integrated design as what architects do, when they incorporate the energy, site, climatic, formal, construction, programmatic, regulatory, economic, and social aspects of a project as primary parameters for design. Moe's concepts are clearly aimed at mitigating climate change and creating sustainable buildings. One example given is the reduction of use of traditional power operated convectors in heating (Moe 2008:7). He moreover characterizes some recent changes in architecture as drivers for integrated design (ibid p7): '…new extended understanding of composition, a broadened understanding of the context and the multivariate assemblage of factors and forces that compose buildings. The composition viewed as a confluence of two salient aspects; the energy milieu of every building site and the social construction of architecture'. Moe places the architect in a central yet changed role (ibid. p8): '…[building] project shifts the power of authorship beyond the twentieth century myth of the singular architect to thoroughly collaborative team structures… Social integration precedes technical integration. All technology is social before it is technical. The role of the architect shifts from individual master to strategic organizer of manifold, often disparate forms of knowledges and processes'. Where Moe places most of the competences and processes of integrative design amongst architects, Löhnert *et al.* (2002) in their internationally based task force of the International Energy Agency (IEA) presents a comprehensive model for IDP, providing roles and iterations for a series of actors. Four phases are proposed: Basic predesign, concept design and design development (Löhnert *et al.,* 2002:39). The committed client and a core team of architects and engineers supplemented with further experts is a core organisational idea. It is claimed that energy design become integrated with architectural design rather than being an external add on. Brunsgaard (2009) claims that the weaknesses of the IEA model are too little focus on architectural quality, and underestimation of cooperation challenges between engineers and architects.

The third example of a integrated design process concept is the International council for Research and Innovation in Construction's (CIB), publication on 'Integrated Design and Delivery Solutions' (CIB 2009). Here integrated design is defined as "Integrated Design and Delivery Solutions use collaborative work processes and enhanced skills, with integrated data, information, and knowledge management to minimize structural and process inefficiencies and to enhance the value delivered during design, build, and operation, and across projects." (CIB 2009:3). The CIB concept combines collaboration, enhanced skills and IT- tools such as Building information Models and knowledge management with process elements from lean (design) (CIB 2009). Apart from the comprehensive process scope, there is also a clear industry transformation focus in the CIB model, it is processes, technology and people of the sector that need to change (CIB 2009: 14).

Summarising, the international variants there are differences is emphasis on which players are to "carry" the integrated design, what role technology and process methods should play and whether the concept is seen as a project approach or an industry approach.

Danish variants of IDP

In a Danish context one can identify three variants of IDP, an architectural-oriented (Hansen and Knudstrup, 2007), an engineering-oriented (Petersen and Svendsen, 2007) and an organisational (Bendixen, 2007). All three variants are embedded in more than one player in Denmark, involving industry companies and universities.

The architectural oriented variant is developed at the Department of Architecture and Design at Aalborg University, Denmark (Hansen and Knudstrup, 2005). It is based on a holistic architectural approach and advocates a close collaboration between architects and engineers, where the building is designed through an interdisciplinary approach. The approach advocates a common language between the architects and engineers. Hence, they must carry an interdisciplinary profile which incorporates skills from both professions, which enable them to design jointly. One of the fundamental tools in this approach is a comprehensive parametric analysis that allows the engineers to be more proactive in the design phase. The approach operates four phases: Analysis, Sketching, Synthesis and Presentation. Joint decision making and cooperation between all professions in all phases should be exercised.

The engineering oriented variant is developed by Petersen and Svendsen (2007) at the Technical University of Denmark (DTU). It is based on designing rooms before buildings in a “space of solutions” where each room is analyzed in accordance to predefined goals regarding energy performance and indoor environment by the engineers. The architect can then design the building by combining the rooms in various ways based on the performance of the rooms (Petersen and Svendsen, 2007, 2010). It is thereby possible to design various buildings that automatically fulfil the predefined performance goals. This approach decreases the trial and error design element, emphasising conscious decisions. The space of solutions is not intended to control the design but to set the boundary condition. The approach is based on the assumption that indoor environment differ from room to room according to the specific orientation and internal load etc., hence, it is argued that it makes no sense to analyze indoor climate on building level in the design phase. The approach is less depended on joint decision making than the AAU method above as the engineers and architects can work more individually (Petersen and Svendsen, 2007). According to Petersen and Svendsen (2007, 2010), integrated design involves four stages with particular roles (in paranthesis):

1. Establishing design goals (building owner and design facilitator (DF))
2. Establishing design proposals for rooms and sections (building owner and DF)
3. Generating proposals for rooms and sections (architects, experts, DF)
4. Selection and optimization of final building design (building owner, DF, experts)

The design facilitator is a role that Petersen and Svendsen (2007) share with the IEA concept discussed above. Also Petersen and Svendsen advocate the use of a specific IT-tool for handling the data on rooms in the building, ‘iDbuild’ (Petersen and Svendsen 2010). This is a building simulation tool developed by Petersen and Svendsen for generating design advice for a goal-oriented design processes (see Petersen and Svendsen 2010). According to Petersen and Svendsen (2010), it relies on the power of building simulation tools in design. And with the intention to push performance evaluations into the early phase in the building design process to reduce costs. Brunsgaard *et al.* (2009) analyse seven cases of use of IDP in a series of passive house projects. They find that most of the cases position themselves within the "extremes" of the engineering and architectural variants, whereas two adopt a more traditional design process (Brunsgaard *et al.,* 2009:4). IDP causes different problems within the consortiums (Brunsgaard *et al.,* 2009):

- Unclear boundaries compared to a traditional design process. Who does what and when?
- Different understanding of the same decision
- The design teams focused so much on the technical aspects, that they forgot the architectural qualities
- Constraints disabling the architect to design good architecture
- The engineer felt constrained because the architectural aspects were too fixed.

It follows that changes in the traditional design approach engender new ways to work as a team. Unclear roles and goals, ineffective communication, increased constraints and unfamiliarity with each others' processes prevailed in the cases - issues which emphasize the utilization of IDP. However, it should be noticed that these experiences are based on an entire project process and not the competition phase alone.

Integrated Design Organization

Bendixen (2007) studied a consultancy engineering company who in a period, roughly 2004-2006, organised an internal grouping of 15 employees, around an integrated design concept of the building envelope. The organisation occurred as part of larger restructuring of the company's organisation. The group encompassed facade engineering, structural engineering, indoor climate and building physics engineering competences including experiences with more concepts and issues, such as natural ventilation, passive houses, molds. The formation of the Building Envelope Group was sanctioned by management and marketed externally. The groups providing specialist services were supposed to sell their services both internally to standard projects and externally as an independent service. The group leader adopted integrated design as the central unifying idea. The group leader regarded the group as an opportunity for interactive creations of new services and project solutions through mutual inspiration and integration of different engineering competencies, and involvement at an early stage in projects. Upon formation, the group and its manager started looking for a major project to act as trailblazer for their concepts. Meanwhile only a few members worked on the same project, whereas most worked on many small one-man projects or providing a few hours of assistance to other projects. The expert engineers were highly self-sufficient as they had a more or less continuous portfolio of projects with core clients and/or through their internal and external networks. Many members of the group had more than ten projects running at the same time. Most time was spent desk working or at meetings and sometimes people with similar engineering expertise approaches each other for advice or discussion. The group leader took initiatives to consolidate the group and promote its overall objectives arranging various workshops. A reconstruction project involving more members of the group was considered as the trailblazer project. And eventually after roughly six month a project with the potential for realising the group's ideas came along. The process in this project encompassed interacting with a client, other engineering consultancies and with architects. However the project failed to materialise as the client withdraw. After a further period of a "many project" portfolio the group ceased to exist. Not so much due to requirements to adhere to strict procedures of project economy (Koch 2004). On the contrary the formation and development of the initiative has been quite "organic" and voluntary. It was particularly 'small projects, large in number' that drained the initiative. The company later mobilised integrated design in other contexts drawing on the experiences made in the group.

Summarizing three variants of IDP have been discussed in a Danish context, illuminating different emphasis on architectural and/or engineering competences and approaches to processes (see also Löhnert *et al.,* 2003), with different emphasis project versus organisation and little emphasis on IT or lean principles. The two "profession variants" alludes to the buildings sectors difficulties in creating common (mental) spaces for collaboration, and the organisation example underlines that IDP-projects does not occur as "islandic" vacuums but should be viewed as linked to the development of the project based companies in the sector.

CASE: A TEAM DOING IDP

We now turn to the empirical material developed in Haubjerg (2010). In the following the one of the two building projects and its energy ambitions is first described, followed by a description of the process of one of the teams, and the analysis of all four teams (both Colossus and Zero Carbon).

Colossus

Project Colossus concerns a large scale building project (30.000 + m2). The client invited selected companies to a Design/Build competition with duration of approximately 3 months. The project's requirements concerning energy performance was tighter than required in the regulations, although there were no specific initiatives on IDP. Two of the prequalified teams were chosen. When the interviews were conducted the competition was still ongoing. The project teams consisted of the Design/Build contractor, a main architect, a main consulting engineer, and various sub contractors, consultants, and specialists. The interviewees were the main architect and the main engineer from both teams and a contractor from one of the team. Furthermore, the client was also interviewed. The client announced the competition, first a prequalification round and then five selected teams developing a proposal. Each project team could involve other consultants in order to secure the quality of the proposal, which the two studied teams at Colossus did. The energy ambition had, similar to Zero Carbon, two dimensions. First the building should be able to obtain a class 1 level compliant with EPCB (European Commission 2003), which at the time of announcement equalled 50% lower than the Danish Building regulation. Secondly the occupants should be actively involved in reducing the behaviour oriented energy consumption. The Colossus client asked for the use of integrated energy design (EID), using a design process focused on climate, user appropriated design and a planning of internal functions with a view to optimizing energy consumption.

The process of team 1, Colossus

As the client demanded the use of integrated energy design, it was beyond debate. This was interpreted as an advantage, enabling the project team to focus (Engineer team 1). As expressed by the architect of team 1:

'When we got the program we evaluated the winning parameters… And one can easily see that Integrated Energy Design, among other things, is of great importance. And we do adopt that, because it is an important part of this process and the contractor paid it a lot of attention, hence, ...we discussed [it] every time' (Architect team 1)

However in contrast to EID, the architect saw IDP as more of an engineer's concept:

'The engineer had a method/process they adopt into a project: first we do this, and then we do that. And of course we looked into that, but we're at a point where many strings need to be tied together, so IDP is only a part of the many processes we are trying to coordinate. It's not a model that we are familiar with, so I cannot really tell how it worked out' (Architect team 1)

So where, the architect distinguish between EID to IDP, the engineer maps them one to one. The established project organisation scheduled a number of deadlines and meetings. But according to the engineering consultant, things got more fluid, where it was a strength that the architects firm managed to keep a partner (high level manager) onboard in the process, to enable joint decision making. Also a steering group was formed which acted more like a quorum. All specialists were 'placed' outside the steering group and/but involved whenever needed. The project organisation operated in a similar manner. At weekly status meetings the contractor was updated on the progress. Some called for a standardized process, however the engineer contended that

'…. it is a problem because it locks things. ... Our method is to design the process in relation to the specific project....We are focused on how we organize ourselves, how we control the process, how do we ensure everyone has a good process without no one dominating, so we don't have to spend time on identifying who is in charge. The size of the project is also important in regards to which methods and tools we utilize. And that we have to deal with every time.… But an IDP is never perfect and each one is different. It is about being good at navigating in chaos.' (Engineering Consultant)

The process of designing energy was becoming a stronger synergy than normally. All rooms were analyzed by the engineers with regards to the internal load in relation to air change, so the architect could prioritize the locations of the room according to that. As expressed by an engineer:

.. .In a previous project we had a very bad process, so we were a little reluctant regarding how much we wanted to dominate the process with IED. So we had some strategic considerations about ... the best project ... also sells on the architecture, because it might become a hindrance to the architect. … We put a lot of efforts in preparing the details before the architects came to the part.' (Engineering Consultant).

The architects felt that the engineers were not able to contribute in that process, as they were too slow in decision making:

'In several occasions the engineer was sitting here. But actually it was somewhat unnecessary, because of the fact that it takes quite a long time for them to arrive at conclusions. When we had discussed an issue for 15-30 minutes, they sat down by their computers and typed in the parameters and didn't really need us anymore and we couldn't get more out of them, since they first had to compute' (Architect).

The architect saw the problem was with the engineer's IT tools;

'And sometimes I do not think that you need to compute it, but just use common sense ... In regards to explore and try new things in terms of the facade they held back a little. And it may relate to that if you do not possess the knowledge then it is difficult to approve it because... their role is ... to be able to document the project' (Architect).

A few tensions occurred relating to making contradictory demands meet. A ceiling design needed a compromise between thermal design and acoustics. The process was a good experience, even if it could have been more interactive (Engineering consultant). This team's energy design was evaluated by the competition committee to be excellent, as it was at the active house level, being able to produce energy. The overall synthesis was less convincing than the winning project (from team 2).

ANALYSIS

The analysis cover four cases, Colossus team 1 and team 2, described above, but also the other case of the Zero Carbon team 1 and team 2. The actors have difficulties defining what integrated design "is" even after having participated in a process claimed to follow such a concept. The consulting engineers have adopted integrated design further than the architects. One company (Engineering Consultant team 2 Colossus) has implemented IDP internally. Another (Engineering Consultant team 2 Zero Carbon) have developed their version of integrated energy design, also as part of their business strategy, and claims identity between IED and IDP. In all four teams actors struggle with the meaning and content of IPD, including what new roles and behaviour is needed. For example in Colossus team 1, the engineering consultant views EID as IDP, whereas the architect distinguished between them. In team 1, engineers appear to stick to evaluation through IT-models of the ideas of the architects. There is thus a relatively weak performance of IDP. Possibly IDP 'works' more through providing a philosophy of interactive collaboration. The understanding of intensified collaboration among engineers and architects appears to be the core of the actor's appreciation of IDP. In the processes investigated, three out of four aims at collaborative and interactive decision making, whereas one openly prefers to have the architects as decision makers and the engineers as information suppliers (ZeroCarbon team 2). The imagined participants and the timing of participation also varies as most refer to early interaction between engineers and architects, whereas one player, emphasizes a tripartite collaboration (Architect ZeroCarbon team 1). Another interpretation views energy engineers and architects as prime collaborators, whereas other engineers play a more peripheral role (Architect ZeroCarbon team 2). Central enabling factors for the process are the clients demand for it, previous collaboration, a 'good feeling for each other', and an organic project organisation enabling interaction and iterations. The organisation is flat with little emphasis on the steering group level, and more emphasis on joint workshops with many participants. IT tools for calculating energy features of the building are contested as enablers. Some players see the tools as necessary to get the necessary valid calculations, whereas others, predominantly architects, sees the IT tools as constraining the interactive process, and ask for sound judgment instead (Architects Colossus team1 and ZeroCarbon team 2). Petersen and Svendsen (2010) similarly notes that engineering energy design IT-tools are evaluative, rather than prescriptive, which appears to handicap the engineers in early phase design. Also scheduling is seen as an ambiguous tool: the process has to be creative and interactive but is also short (3 months) (ZeroCarbon team1). Another contested element is how engineers manages their new role; Both the architects and the engineers points at the need of a more open minded approach towards design opportunities, rather than problem solving. Most of the Architects asked here, evaluate the engineers as underperforming in this respect, even if the interviewed engineers claimed to be focusing on these competences. This mirrors the fundamental differences between the professions and their perception of each other. The barriers for IDP currently seem to be the limited experience of most players, resource limitations, team recruitment and tools. The resource limits of the projects where the IDP was attempted carried out were significant and hindering process innovation (Koch 2004). For six out of eight companies, IDP is still to be adopted as a business strategy. By recruiting professionals with IDP experience and/or doing internal training the companies would enable the processes also beyond cases where building requirements and clients would require it (see also Hojem and Lagesen 2011). The lack of tools and procedures to support the enforced interaction is remarkable. None of the reviewed concepts are in play. Mobilizing stereotypes between architects and engineers appears to be a part of the solution to the role insecurity in the new situation occurring at IDP. Loosemore and Tan (2001) understands stereotypes as both instrumental and detrimental for collaboration. A stereotype of a player helps tackling the occurrence of new and unknown cooperation partners. One can act according to experience with the role and profession a new player represents. This includes the architects understanding of IT tools and scheduling as being too rigid for an interactive process. And the engineers viewing the architects attempt to take control of the process through rhetorical means. The very flexible projects processes become a barrier when trying to implement new organisation, new roles and new ways of interacting. At the presentation of both the designs, after the competitions, the energy features were highly flagged: At the Colossus competition, team 1 actually provides the strongest proposal with a design were the house as such can be built with a positive energy balance. This is characterised as excellent design by the evaluation committee. Team 2 wins the competition however, with a better balance between given design criteria; including the (other) user requirements. It was subsequently announced that the building would comply to EBPD level 1 requirements, and with active involvement of future users in changing energy consuming behaviour. There was however no mention in the competition evaluation of future higher levels of EU-regulation, but merely a reference to contemporary Danish regulation. At the Zero Carbon competition, the winning project (team 2) designed a building actively producing energy, with energy neutral dwellings, and simultaneously healthy, with good indoor climate and quality of life. The client's consultant observed that some teams had not assured consistency in their proposal, despite the calls intention of close collaboration (client consultant Zero Carbon). The cases studied represent clients going beyond present day building regulation, and consulting enterprises with competences needed. This is in contrast to Hojem and Lagesen (2011) observing that most consulting engineering companies studied in Norway prefer to stick to existing building regulation (which is probably parallel to most Danish consultants). Going beyond the building regulation implies that the design teams embark on less defined ground in designing the environmental level and balancing it with other criteria such as cost. In the Colossus case, synthesized design appeared to master this balance better than energy focused design.

CONCLUSIONS

The analysis shows that there are several ambiguous concepts of IDP, and the architects and engineer shape the concepts when directly involved. Precarious and negotiated consensus has to be created to make it perform. The various players agree that an increased interdisciplinary interaction in the design team is necessary in order to tackle the increased complexity of sustainable building design. This tendency changes the traditional roles and responsibilities in the design process which leads to misalignments of expectations in the team. The cases studied, represent clients willing to go beyond present day building regulation. This implies that the design teams, when performing the climate transition, embark on less well defined ground, in balancing the environmental design with cost and other criteria.

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