DESIGN AND PLANNING PROCESS FOR ENRGY EFFICIENT BUILDINGS - CLIENT'S PERSPECTIVE

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Abstract

The complexity of planning requirements and aims for energy-efficient buildings has significantly risen, however the buildings are mostly planned with traditional planning methods based on sequential planning model. The main hypothesis states that successful energy-efficient and even -producing buildings can be realized only through more integrated, interdisciplinary and life-cycle oriented design and planning processes.
The main research question this paper focuses on is the role of the client within the integral planning process for energy-efficient buildings, and evaluation of the tools for support of investor's decision making process, such as building certificates, life-cycle costs and analysis.
This paper presents the first results of the research of planning processes for energy-efficient buildings from invesotr's perspective, which is a part of an interdisciplinary research project "Co_Be": Cost Benefits of Integrated Planning at Vienna University of Technology in cooperation with several partners from planning practice.
As final result of the project, a 3-module Integrated Planning Guidelines for planers, investors and policy makers will be developed, where as this paper serves as a fundament for Guidelines for Investors.

Keywords: Integrated Planning, Energy-Efficient Buildings, Planning Tools, Life-Cycle Costs

1. Introduction

Buildings count to the one of the largest energy-consumers within the EU – 40% of total energy is used for the heating and increasingly for the cooling of buildings. (Schwarz, 2007) If the current planning and construction practice is focusing on the minimisation of energy consumption through implementation of codes and regulations; the future developments go towards „energy-plus"-buildings.
The European planning practice has already adapted the measurements towards energy-efficient building, for example through introduction of an obligatory energy certificate (Pöhn, 2010) The steps towards unification in building regulations for energy efficiency of building hull have been set – Austrian example is the implementation of OIB-guidelines reflecting the European codes, which already became part of Viennese building code. After the minimisation of energy consumption, future action for the European Union climate protection

and energy supply strategies is based on "post-carbon society" concept, where buildings as "power-plants" play crucial role. (Da Graca Carvalho, 2009) In this sense, much attention has been drawn to the development of technology, construction and standardization of "energy-plus" buildings, little effort has been made to crucially rethink the planning processes for new buildings.
The interdisciplinary research project **"Co_Be":** Cost Benefits of Integrated Planning at the Vienna University of Technology evaluates for the first time qualitative and quantitative life-cycle cost and benefits of integrated planning. The project is carried out in cooperation with partners from Vienna University of Technology as well as from planning practice and funded by FFG (Austrian Research Funding Agency) and Climate Fonds.
The complexity of planning requirements and aims for energy-efficient buildings has significantly risen, however the buildings are mostly planned with traditional planning methods based on sequential planning model. The main hypothesis states, that energy-efficient or even producing buildings can be realized only through more **integrated,** interdisciplinary and life-cycle oriented **design and planning processes**. (König et al, 2010; Kohler, 2007)
Upon this research, a model for best practice integrated planning (IP) process which focuses not only on organizational and technical planning aspects, but also on interaction and communication design of integral planning teams, will be developed and implemented in 3-module **Integrated Planning Guidelines** for planers, investors and policy makers, which is a final goal of the project. Middle-term goal is implementation of strategic steps for integration of climate protection and energy efficiency aims within planning processes through policy but also through growing awareness among stakeholders (investors, users).

This paper presents the first results of practice-oriented research of planning processes for energy efficient buildings, as seen from the investors' point of view; upon which the module **Guidelines for investors** will be build up.

2. Problem Statement

There has been much written and talked about IP, but it is seldom practiced. Despite the fact that the Central-European region is leader in technology and know-how in energy-efficient building -especially Austria and Germany, with the largest density of the passive-house developments worldwide, the knowledge and experience on integrated planning practice is still insufficient or even completely lacking in the region.
The investors have increasingly been requiring after "green buildings" and setting ambitioned planning aims for energy-efficiency, however they are not ready to pay higher fees for planning of sustainable buildings as for the planning of the traditional ones, even though the "green buildings" require more elaborate planning due to its complexity (e.g. thermal simulations).
Further on, bulk of literature implies on **the client as crucial driving force** for the implementation of sustainability aims within integrated planning process. (Trocellini et al, 2006)
The decision making process for planning of sustainable buildings, needs **new tools** for prediction and simulation of future performance due to the complexity of the coherences of different factors such as building geometry, solar gains, Life-Cycle costs and life duration and environmental impact of building elements. Since the early planning phase is crucial for the future performance of the building throughout the building.

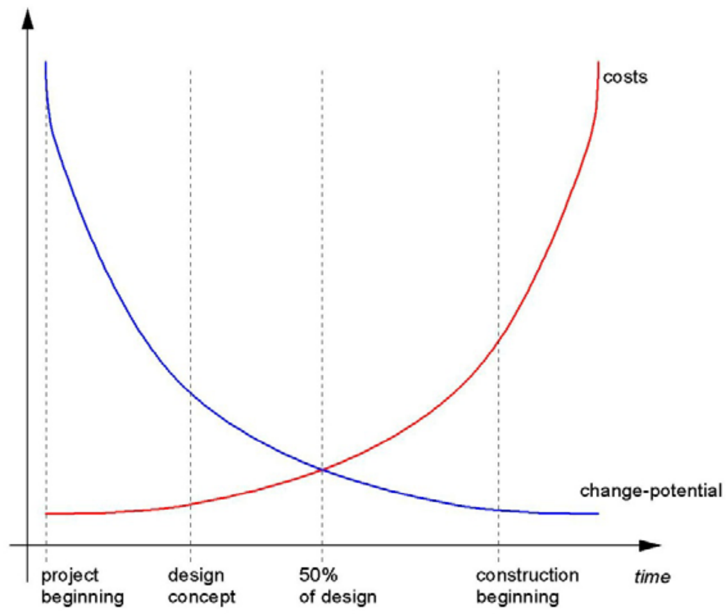

Figure 1: Change Potential versus Costs throughout the planning process

These tools are needed already in the early planning phases, both for planners and clients in order to support the decision making process.
The international building certificates such as e.g. German Sustainability Buildings Society – DGNB (2011), Building Research Establishment's Environmental Assessment Method, UK - BREEAM (2011) or Leadership in Energy and Environmental Design', U.S. - LEED® (2011) offer different sustainability-indicator structures (economic, ecologic and socio-cultural) in form of checklists. In a so called "traffic-light" pre-check procedure a first evaluation of sustainability performance of the building in planning can be obtained in quantifiable form and offer as such a useful tool for investor. However, all further steps require significantly more effort in terms of calculations and simulations, and are hardly manageable without powerful software tools and databases due to the high complexity of parameters.

3. Research Question

The main research question to be handled within this paper is how to support the client's decision making process within the integrated planning process for energy-efficient buildings?
The significance of the decision-making process in the early planning phases on the future performance throughout the Life-Cycle of the building has been demonstrated in the previous chapter. In the early phases of the planning process, such as pre-design phase, there is an infinite universe of possibilities at almost no cost – the planners and especially the investor, who often is not construction or planning professional need customised tools for the early planning phases which would support the decision-making process.
Therefore, the **Guidelines for Investors** should be developed, as a framework for **support and enabling** of investors for development and management of energy-efficient, sustainable buildings, together with **evaluation and recommendation** of tools for decision-making-support customised for the early planning phases.
Further on, the Guidelines should demonstrate the benefits of integrated planning, such as decreasing of life-cycle costs, income stability through higher tenant satisfaction, and tax advantages as one of results of the Co_Be project.

4. Research Method

The research methodology used for Co_Be is based on practice oriented case study, employing descriptive research method. (Dul, Halk, 2008)
For the case study a number of best practice energy efficient buildings (BEEB) are objects of research. The emphasis lies on investigation of planning processes of BEEB, however also the buildings themselves will be documented (plan and photo material, tables with building performance and description of construction and technology, POE).
The methods used for investigation of planning processes are semi-structured expert-interviews (Bogner, 2005) with stakeholders of planning process such as: architects, engineers, investors, facility managers and users. Further on, informal interviews and observation is also employed.
After the first step of investigation and analyses of BEEB a Best Practice Integrated Planning Model (BPIPM) will be developed. The model again will be evaluated by BEEB-experts in order to obtain model-verification.
After optimization, strategies for implementation of BPIPM in the planning practice will be developed in form of Guidelines for Planners, Investors and Policy Makers.

Figure 2: Co_Be work plan

A quantitative and qualitative analysis and evaluation of traditional, consecutive planning processes and integrated planning was carried out on hand on role-playing experiment. The experiment took place within the course "Building Process Management" for students of fourth semester of civil engineering together with higher semester architecture students. The building task included design of self-sustained, energy-efficient, temporary smoothie-bar, built out of renewable materials (wood). Planning teams including four roles of an architect, civil engineer, client and business advisor were split into two clusters: cluster of traditional planners (CTP) and cluster of integrated planners (CIP). In CIP team-members were grouped together and worked on the given assignment simultaneously. In the CTP the roles, instead of teams were grouped together, and worked on the assignment consecutively - scripts for temporal scenarios were herby developed e.g. as follows: client briefs the architect, the structural and heating, ventilation and air-conditioning (HVAC) engineering concept may follow only after architectural concept is completed, the business advisor comes in the end after the complete structure if finished. In the evaluation, the designs were judged upon the preset criteria: design, construction, energy-efficiency, cost-efficiency.

For the particular research focus of this paper – integrated planning process for energy efficient buildings from investors' perspective; the qualitative and quantitative research and evaluation was carried out. As the qualitative research the open-ended interviews with investors were conducted within the case study of planning processes for BEEB.

The quantitative research concerned evaluation of the tools for decision making process.
The tools that were chosen for evaluation were the Life-Cycle Costing (LCC) and Life-Cycle Assessment (LCA) Methods from the building Certificate DGNB. (DGNB, 2011)
These tools have been chosen because they are relatively simple, so the calculations can be executed without additional software tools, also the benchmark data is available from the certificate-association.
The DGNB certificate was chosen since it is an international certificate and therefore of interest for both private and institutional investors, also because it is the only certificate that considers detailed calculation of Life-Cycle costs. For the evaluation the public domain of DGNB certificate was chosen – so called BNB (2011) system - Evaluation system for Federal Buildings (Bewertungssystem für Bundesgebäude) due to the data availability.
In the evaluation process of DGNB method, a winning design of the smoothie-bar from the Role-Playing Student Competition was chosen, and was calculated on LCC and LCA.

5. Qualitative Evaluation – Investor's perspective

Both literature and practice identifies investor as the driving force for the implementation of sustainability aims. Therefore, special attention has been paid on the one hand research of planning process as seen from investor's point of view, and on support and enabling of investors to act in terms of sustainability.
The qualitative research by means of open-ended interviews focused on three main questions for investors:

1. Describe the planning processes you are taking part in, your role within them and difficulties
2. Describe the ideal planning process for you
3. Identify the key-indicators for success of your "green building"

Through the open-ended interviews deficits of planning processes were identified, main difficulties for realisation of the energy-efficient buildings for investors, as well as potentials and investors' needs.

The interviews resulted with development of following typology of investors:

1. Private investors
   1.1. Professional private investor
   (Developer for Bank, Fond, Construction company, etc.)
   - builds seldom for own use
   - builds mostly speculatively – sells or rents the buildings

   1.2. Non-professional private investor
   - "builds once in lifetime" - for own use
   - gets very involved and committed to the sustainability task
   - manages the building

2. Institutional Investor
   Builds professionally, however represents public interests and is obliged to regulations for commissioning of public buildings such as architectural competition and Federal act on planning tenders (Bundesvergabegesetz). Often manages large stocks of buildings, is experienced and has lots of data on benchmarks. Often does facility management herself, even though seldom builds for own use – always for rent however often in subsidised, or non-profit sector.

Due to the public character, the protection of public interests has highest priority, such as climate protection and minimisation of CO_2 emissions.

For the survey, three institutional and one representative of private investor were interviewed. The private investor's intention was to build *"…for very long time"*. He did organise an invited architectural competition, however the outcome of competition was *"…it became clear, that investor did not do his homework"*. The clear, quantifiable planning aims concerning sustainability were lacking. Through integrated planning process together with the general planner it was possible to identify the clear aims and even to develop a relationship of *"…long-lasting friendship"*.

The one of the institutional investors clearly identifies the obligatory open architectural competition as hindering. *"Bundesvergabegesetz actually hinders me to get the planners I really want…"*. *"The main difficulty in communication with planners represents Bundesvergabegesetz…"*.
Open architectural competition is identified as further difficulty:
"Competition-phase is especially critical one…"
"It is very difficult to motivate the architects to actually fulfil the task as described in architectural competition…!"
The phase before the competition, as the phase where the investor clearly has to define her wishes for the competition is very difficult for the client:
" … to make a competition call, the client has to know the functional and spatial programme, as well as the energy-performance goals – this is the main task of the client." and *"…in order to do this a planning-team for task-definition is already necessary."*
This is especially difficult, since not very many public, but also private investors are ready to invest in planning teams for task-definition – also known as briefing or programming process.
Even if briefing is contracted, the same planning team will due to the Bundesvergabegesetz not be able to actually take part or win the competition, so a new planning team has to be contracted – this is seen as the major bottleneck within the process.

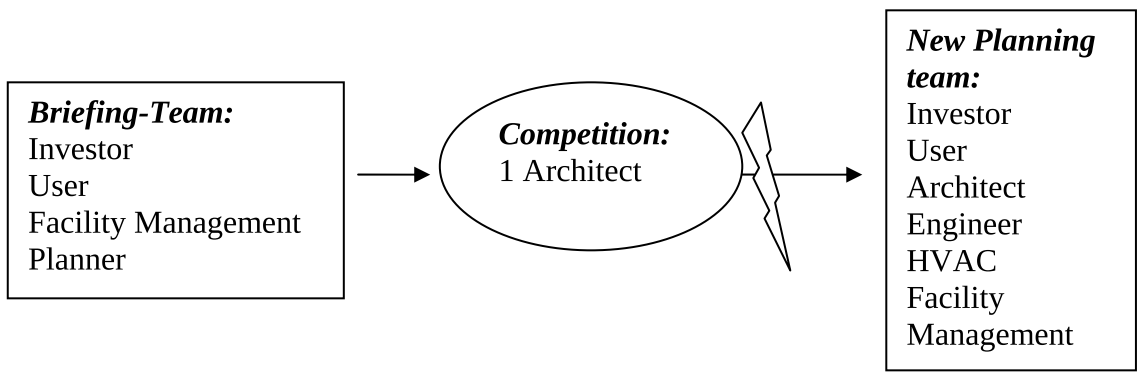

Figure 3: Bottle neck in planning process

The clearly stated necessity was to contract one planning team all over the planning and design process, or at least to be able to contract the whole planning team through the competition instead of only architecture.

All of the interviewed parties agree that the point of team-formation is critical for project-success – "…at pre-design phase all team members must be appointed. From here on everybody must work together. It is much more difficult if one member joins later."
"It is important that the team is formed till beginning of design phase in order to avoid costly and time intensive changes, herby the architecture plays crucial role in the team."
The topic of costs and planning fees – "…the higher the cost and time pressure – the higher the pressure in team and the related problems. The lower the planning fees, the higher the difficulties, since the reduction of the effort goes on account of the other team members".
For decision-making process the investors clearly require tools. "The decisions that are met are mostly based on qualitative declarations which are then translated into quantities, from which € is the most important one – costs decide in the end." But: "...there has to be tools beyond €!"
The complex planning processes and the issues of sustainability are difficult to comprehend for investors – "…the question is, how do I bring a decision?"
Simulation has been identified as an important tool for decision-making support, also allowing development of different scenarios and option-based decisions.

6. Quantitative Evaluation – Tools

Based on the result of role-playing experiment, one of the winning projects was taken for the simulation and evaluation of LCC and LCA. The BNB certificate criteria and methodology was chosen, since it does not require additional simulation software, and due to the data availability from the public domain of the BNB certificate.
The aim was to test the method for suitability for implementation in the early planning phases, as support for client decision-making process, based on quantitative, option-based evaluation.

The project itself – a temporary, mobile smoothie bar, build of mostly renewable resources (wood) and to be operated largely through renewable energy (solar gains) - is in the stage between pre-design and design phase through the detailing grade. The smoothie bar itself was conceptualised to be used for 5 years, mainly in the summer months. Throughout the winter-months the bar had to dismantled and stored in the storage – both of which is connected with extra costs.

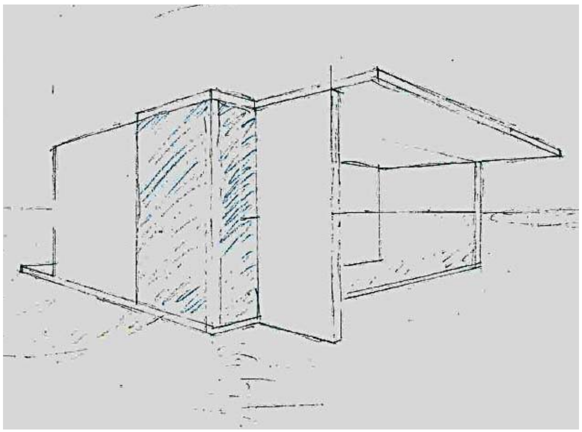

Figure 4: smoothie bar project

6.1 Life-Cycle Cost Calculation

The costs-calculation method is based on cost-estimation, which is one of the earliest phases in the cost-planning. (ÖNORM, 2009; DIN 2008).

Project data		
GFA (Gross Floor Area)	32.75	m²
Construcion costs	52 532.30	€
Life duration	5.00	a
Operation months	Mar.-Oct.	
Total energy consumption	19912.03	kWh/a
Photovoltaics	14.40	m²
Photovoltaics output	1710.00	kWh/a
Cleaning costs	1800.00	€/a
Water use	20,67	m³
Costs for yearly storage and dismantling	3 800.00	€

Table 1: Project Data

Calculation of Life-Cycle Costs was based on following cost-groups (DIN 276-1,2008):

- Selected construction costs
- Waste disposal
- Energy / electricity and water
- Sewage water
- Cleaning costs
- Operation, inspection and service
- Maintenance of HVAC
- Repair/Replacement of building construction and HVAC

Costs according to DIN 276-1:2008-12		
Cost-Group	**Description**	**€**
300	Building structure	18825.88
400	Technical facilities	8880.20
Total	NET	**27706.08**

Table 2: Cost estimation for smoothie-bar

For the calculation the discounted cash flow (BNB, 2011) method was used, with the rate of interest of 5,5%. For the time horizon of 5 years, present discounted values (PDV) were calculated.

Life-Cycle Costs	
Costs of building structure	18 938.84 €
Costs of HVAC	8 921.82 €
PDV of irregular payment for replacement of building structure	415.57 €
PDV of irregular payment for replacement of HVAC	199.60 €
PDV of regular payment for maintenance of building structure	596.16 €
PDV of regular payment for maintenance of HVAC	803.45 €
PDV of following costs for cleaning	14 657.25 €
PDV of following costs for energy	14 824.17 €
PDV of following costs for water / sewage	286.99 €
PDV of dismantling, construction, transport and storage	16 227.08 €
PDV total	**75 870.92 €**

Table 3: Life-Cycle Cost Calculation

The scenario-based evaluation considered the time horizons of 5 and 50 years of life time. The allocation of the Life-Cycle Costs shows, that energy consumption, cleaning and demolition, construction, transport and storage are the major cost-drivers and therefore the main areas for optimization. Especially in the field of cleaning, there are unreliable and very general benchmarks listed, which do not allow customized, demand-oriented planning solutions. The importance of these topics should be taken into account, when developing of LCC-optimization.

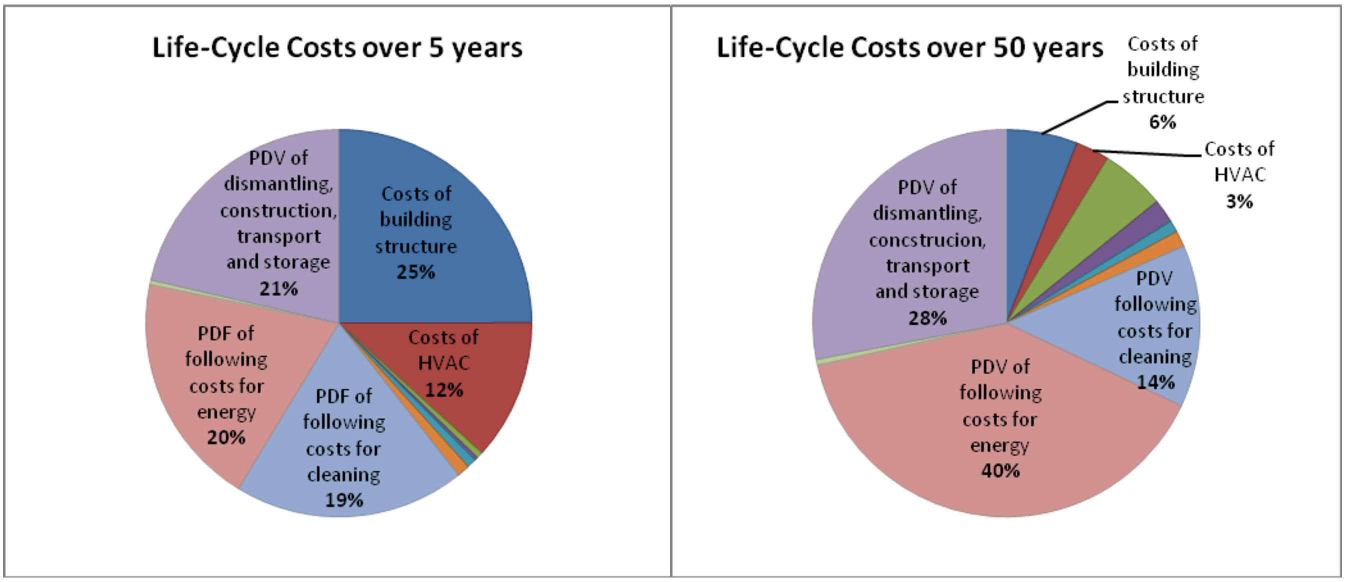

Figure 5: Option-based Life-Cycle Cost Calculation

Two scenarios (A and B) were also simulated for the energy consumption (see Table 1) of the bar. The initial investment for the photovoltaic-system of an area of 14,40 m², which was conceptualised in the project, at a price of 450 €/m² would sum up to **6.480,00 €.**
The difference of the present value after one year is:
(price increase of energy: 4%, rate for present value: 5,5%)

Scenario A: With PV

C_1 = (19.912,03 kWh -1710 kWh) * 1,04 * 0,17 €/kWh = 3.218,12 €

$C_0 = C_1 / (1+0,055)^1$ = **3.050,35 €**

Scenario B: Without PV

C_1 = 19.912,03 kWh 1,04 * 0,17 €/kWh = 3.520,45 €

$C_0 = C_1 / (1+0,055)^1$ = **3.336,92 €**

The scenario B would result with Savings in energy consumption after one year:
3336,92 € - 3050,35 € = **286,57 €**

The cost-benefit calculation over 30 years and sum the savings per year, results with an ROI after approximately 27 years. With governmental subsidies of renewable energy (in Austria it amounts 0,38 €/kWh) the Break Even point can be reached after 11 years.

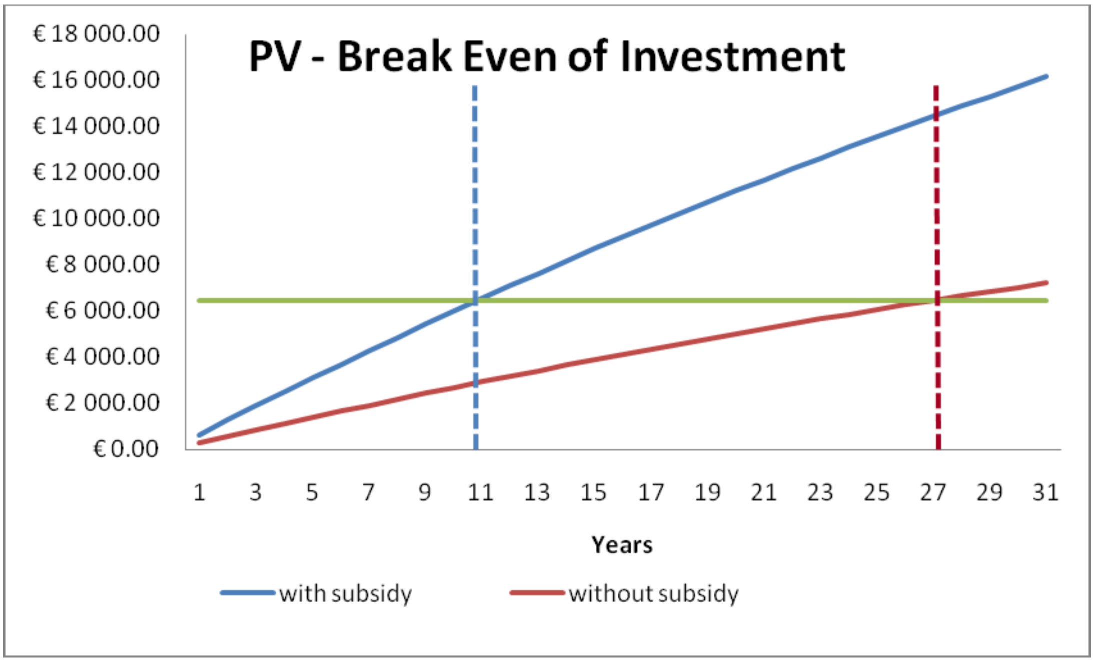

Figure 6: Cost-Benefit calculation of PV-use

Therefore, the conceptualised use of PV for a buidling with life duration of only 5 years can be regarded as cost-inefficient solution.

6.2 Life-Cycle Assessment

To calculate and describe all the BNB-certificate indicators related to LCC and LCA assessment would exceed the scope of this paper, so we focused on for the certificate weighting system the most important ones:

- Global Warming Potential (GWP)
- Ozone Depletion Potential (ODP)
- Photochemical Ozone Creation Potential (POCP)
- Acid Potential (AP)
- Eutrophication Potential (EP)
- Primary energy consumption, not renewable (PE_{nr})

- Total primary energy consumption (PE_{total})
- Demand on drinking water and sewage water
- Building-related Life-Cycle costs (LCC)

Due the fact that the smoothie-Bar is equipped with a large number of electrical appliances (e.g. refrigerator, ice cube maker, etc.) on the extremely small space, the composition of purchased electricity has significant importance for the Life-Cycle Assessment.
Two possibilities of electricity-mix-supply were considered:

- general mix (EGM) consisting of lignite, coal, natural gas, petroleum, uranium, hydropower, windpower and others
- hydroelectricity (HE) consisting of 99,5% waterpower.

For the data on materials the ÖKOBAU.DAT database was used. (ÖKOBAUDAT, 2011).
In the Table 5 the environmental data of the used materials is gathered.

EPD		Unit	GWP_100	AP	EP	ODP	POCP	PE_nr		PE_r	
			[kgCO2-Equ]	[kgSO2-Equ.]	[kgPhosphat-Equ.]	[kgR11-Equ.]	[kgC2H4-Equ.]	[MJ]	[kWh]	[MJ]	[kWh]
Construction	Composite lumber	m³	-751.00	0.538000	8.2700E-02	3.1300E-05	6.5800E-02	5958.00	1655.00	10591.00	2941.94
	Solid wood	m³	-818.00	0.456000	6.7900E-02	2.7900E-05	5.5500E-02	5144.00	1428.89	10800.00	3000.00
	Glass	kg	8.43	0.050700	7.5400E-03	3.9500E-07	3.2800E-03	143.00	39.72	1.92	0.53
	PVC roof awning	kg	5.89	0.019800	1.9700E-03	1.7400E-07	2.8000E-03	98.50	27.36	2.21	0.61
	Steel shapes	kg	1.710	0.004820	4.5700E-04	3.7800E-08	7.3800E-04	23.20	6.44	0.96	0.27
	Photovoltaics	m²	120.00	0.803000	2.7500E-02	1.0200E-05	6.0000E-02	1557.00	432.50	310.00	86.11
Operation	EGM	MJ	0.182	0.000270	2.4500E-05	2.8500E-08	1.9300E-05	3.07	0.85	0.39	0.11
	HE	MJ	7.45E-03	2.430E-06	4.4900E-07	2.3800E-11	2.1900E-07	0.007	1.94E-03	1.41	0.39
	Photovoltaics	MJ/kg	11.080	0.018900	1.5600E-03	1.8300E-06	1.2600E-03	172.00	47.78	8.67	2.41
End of life	Photovoltaics	kg	-3.087	-0.017955	-5.6930E-04	-1.8612E-07	-3.0500E-02	-650.00	-180.56	-212.00	-58.89
	Lumber & wood	kg	1.180	0.000830	2.1800E-04	-2.2500E-08	3.3500E-06	-10.30	-2.86	-0.11	-0.03
	Glass	kg	8.27E-03	0.006760	1.0100E-03	5.2700E-08	4.3700E-04	19.20	5.33	0.26	0.07
	Steel profile	kg	-0.833	-0.002950	-2.7400E-04	3.5600E-08	-4.7100E-04	-11.70	-3.25	-0.0125	0.00
	PVC roof awning	kg	1.580	0.000290	2.2800E-05	-2.0770E-08	5.8900E-05	-2.23	-0.62	-0.78	-0.22

Table 4: Results of Life-Cycle Assessment related to [m²NFA*a] for a life-duration of 5 years

The option-based LC-evaluation for EGM and HE electricity supply is presented in the following table:

Life Cycle Assessment Results	**Target**	**Reference**	**Limit**	**Smoothie-Bar (Project)**	
				EGM	**HE**
GWP [kgCO2-Equ]	39.90	57.00	79.80	422.96	41.19
ODP [kgR11-Equ]	3.50E-06	5.00E-06	2.50E-05	6.46E-05	2.33E-06
POCP [kgC2H4-Equ]	0.0105	0.0150	0.0210	-0.0143	-0.0560
AP [kgSO2-Equ]	0.217	0.310	0.434	0.782	0.197
EP [kgPO4-Equ]	0.0147	0.0210	0.0294	0.0786	0.0260
PE_nr [kWh]	203.00	290.00	406.00	1596.62	-264.29
PE_total [kWh]	125.20	219.10	406.90	1755.29	512.25
Drinking water [m³]	9.28	18.56	28.13	20.67	20.67

Table 6: Results of LCA related to [m²NFA*a] for a life-duration of 5 years

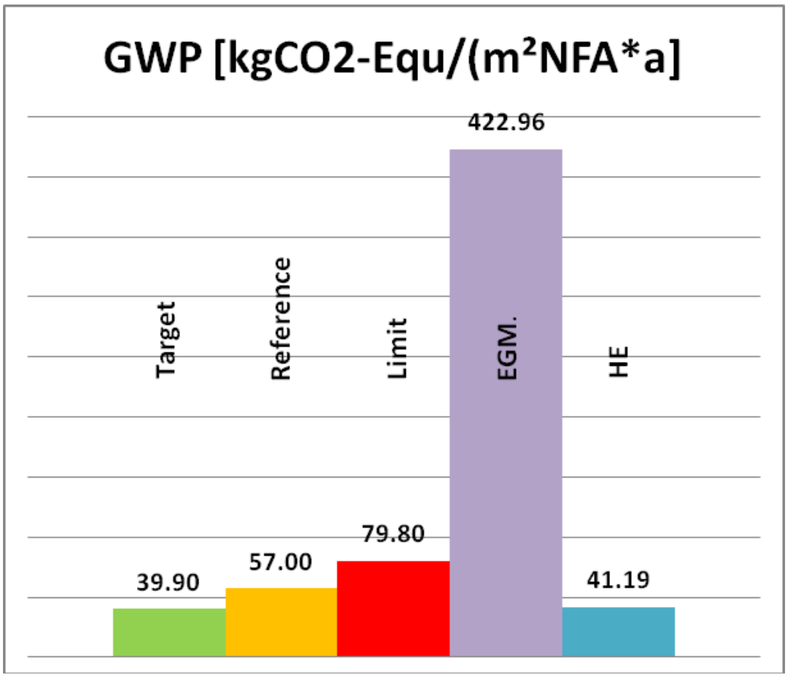

Figure 7: GWP assessment for EGM and HE electricity

The majority of emissions occurs through operation. This can be led back to the unfavourable proportion of electrical appliances to the net floor area (NFA) and the resulting energy consumption.

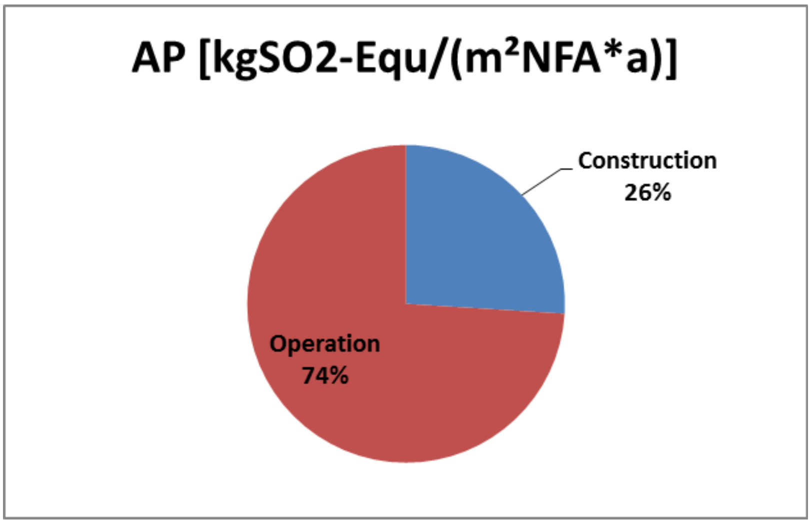

Figure 8: Percentage of SO2-Emissions during phases of construction and operation

Another reason why the results (especially those calculated with EGM) are so far away from the limit-value as defined by BNB, is that the BNB-certificate benchmarks relate to the office- and administrative buildings, and not to gastronomy facilities. The energy consumption of the project amounts 19.912.03 kWh/a related to a NFA of 29,96 m², results with an energy consumption of 664,62 kWh/(m²NFA*a). If we compare this with an ordinary office building, which averagely has an energy consumption of 106,39 kWh/(m²*a) (Aiulfi, 2008), it is obvious that we need adapted standards to compare with.

7. Conclusion

For the specific research question – requirements on planning processes for energy efficient buildings form client's point of view – qualitative and quantitative research has been conducted.
Through qualitative, interviews-based research, was found that all clients require and desire for quantification-tools which would support their decision making process in the early planning phases (pre-design and design). The clients, who are experienced in sustainable building are also aware of necessity of clear aim setting – for this task a support of planning team even before the architectural competition or beginning of planning process is necessary.
All of the interviewed investors see themselves as driving force and are committed to the sustainability-aim, however are also aware of necessity for an integrated planning team, which is based on trust. This is hindered through the competition as currently executed, where investor has almost no influence on the setting or choice of planning team, therefore the instruments of architectural competition as well as the Federal act on planning tenders are seen as major hindering for the realisation of energy efficient buildings for institutional investors.
The application and test of the LCC and LCA tool as decision supporting instrument for clients showed, that data-suitability for a specific building task as well as the considered time horizon of life-duration of a building play crucial role. In order for LCC and LCA to be reliable, the environmental product declarations are necessary as well as improved benchmarks for following costs such as cleaning and maintenance.
In general, the tools should allow support for development of customised strategies according to special building task and suited for short-, mid- and long term time horizons.
The cost-benefit calculation of photovoltaic-implementation on the smoothie-bar project has clearly demonstrated, that for the client in order to reach a proper decision, an option-based evaluation is necessary – which even the current tools with lacking data are capable of.
Therefore, the planning processes for energy efficient buildings should finally leave the traditional, sequential planning paths and build upon the option-based evaluation of possible scenarios, which can be supported through current calculation methods and even more so through strong development of computer-simulations and building information models.

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