Decision support for facilities management of the future : sustainability acellerator

DECISION SUPPORT FOR FACILITIES MANAGEMENT OF THE FUTURE: SUSTAINABILITY ACCELERATOR

WIM ZEILER[i1], RIK MAAIJEN[1] AND WIM MAASSEN[2]

[1] TU EINDHOVEN, EINDHOVEN, THE NETHERLANDS
[2] ROYAL HASKONING, THE NETHERLANDS

Future buildings must be much more sustainable than the existing buildings. Therefore sustainability will become a major issue for facilities management. Currently most important decisions about the building sustainability are made by applying sustainability assessment tools, the so called green rating systems, like BREEAM and LEED. However these tools have their flaws and are not really suited for the early conceptual design phase, were the most important decisions have to be made. New design tools, to support design decisions are necessary to stimulate and accelerate application of sustainable solutions, products and systems. The 'Sustainability Accelerator' is a decision support tool, which uses an approach to Life Cycle Performance Costs calculations, based on discounted cash flows and user scenario's. A first version was used to compare performances of different building services alternatives for office room conditioning over Life Cycle Costs and Life Cycle Performance Costs. With the Life Cycle Performance Costing tool, facilities managers involved in the design process, can determine the most cost effective sustainable solution over the whole life cycle of the building.

Key words: sustainable assessment tools, life cycle performance costs

INTRODUCTION

Buildings are a necessity of human activity, but unfortunately represent a significant contribution to energy use and consequent green house emissions (Morrissey and Horne 2011). Buildings are durable and thus decisions about building design aspects related to their performance have long-term consequences (Ryghaug and SØrensen 2009, Morrissey and Horne 2011). Following the Kyoto summit, and all the other summits on sustainable development, it is clear that one of the driving forces in the design and refurbishment of the building stock is determined by sustainability factors (John et al. 2010). Sustainability is a crucial issue for our future and architecture has an important role to direct sustainable development (Taleghani et al. 2010). However it is not only the architects and the engineers of the design team that have a huge influence, also facilities managers have a great role in contributing to the reduction of the built environment impact on the environment. Facilities management, as a profession, became latched onto the sustainability agenda, as a result of the increasing environmental awareness and legislative pressures (Elmualim et al. 2010). The European Union and its Member States have a large number of on-going policy initiatives directly aimed at supporting of sustainability of the built environment. As the built environment is responsible for nearly 40% of CO_2 emissions, new approaches are necessary stimulated by legislation. The climate and energy strategies are aimed, that by 2020 renewable energy to represent 20% of energy production; a reduction of greenhouse gas emissions by 20% (base 2005) and achieving energy savings of 20%. The targets go even further: to reduce CO_2 emissions by 80-90% (Nearly Zero) by 2050. In addition, Directive 2006/32 EC requires Facility Managers to reduce energy consumption and operational costs. In a recent report of the Pacific Northwest National Laboratory (PNNL), they gave results of a post-occupancy evaluation of 22 'green' federal buildings from across the United States. PNNL found that, on average, green buildings, compared to commercial buildings in general use 25% less energy, emit 34% less carbon dioxide, cost 19% less to maintain and have 27% more satisfied occupants (Fowler et al. 2010). So sustainability is a way to reduce energy consumption and reduce operational cost as well. Therefore conducting (sustainability) performance based assessments of buildings operation is of great importance and should be considered right from the early design phases (Keller et al. 2008).

An important additional development is the shift by clients, from focus on (energy) efficient to effective building solutions. Buildings, when properly designed and constructed, can lead to significant improvement in the productivity of the workers using the buildings. Buildings facilitate the core business function of organizations and can as such contribute to higher business gains for the organization by enabling higher productivity of the employees (John et al. 2010). The added value of the building, to the client's business process, is now the main concern when designing. This new business strategy is combined with the quest for more sustainable solutions (see

i. w.zeiler@bwk.tue.nl

Figure 1). The goal is a 'greener' ecological foot as well as a more effective building.

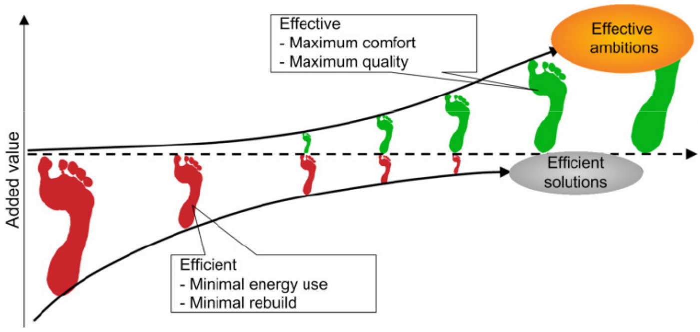


Figure 1. Strategy to come from efficient to effective buildings

There are many sustainable assessment tools available to support design teams in their quest for green effective buildings (Sanuik 2011), which makes it difficult to choose, which tool should be used to implement the new business strategy most effective.

CASE STUDY SUSTAINABLE ASSESSMENT TOOLS

The four most popular sustainable assessment tools used in the Netherlands were determined: BREEAM, LEED, Greencalc+ and Ecological Footprint. To investigate their usefulness and to compare their results, the four most popular sustainable assessment tools in the Netherlands (BREEAM, LEED, Greencalc+ and Ecological Footprint) were applied to a set of 8 state-of-the-art buildings. To test and evaluate the sustainable assessment tools it is necessary to select a representative set of buildings and to use the similar objects and aspects as a basis for comparison. From earlier studies analyzing buildings in Germany and the Netherlands in total 8 buildings were selected (Zeiler and van Deursen 2010). Not all aspects of the buildings can be used for comparing the sustainable assessment tools because Ecological footprint and Greencalc+ can only be compared at the aspects "materials, land use & ecology", "energy", "water" and "transport". To compare the selected assessment methods, their results need to be calculated as the maximum percentage for an specific aspect of a building performance. This is because the results of all assessment methods are expressed in different values, namely: Global hectares (ecological footprint), Earth's environment costs in € (Greencalc+) and credits for the checklists (LEED and BREAAM). The comparison of results of the 4 common aspects (energy, transport, water and materials, land use and ecology) of the assessments tools, shows that there is a fluctuation (up to 20%) in total score between buildings depending on which sustainable assessment tool is used, see Figure 2. This makes it in fact rather uncertain to base the design decision on them.

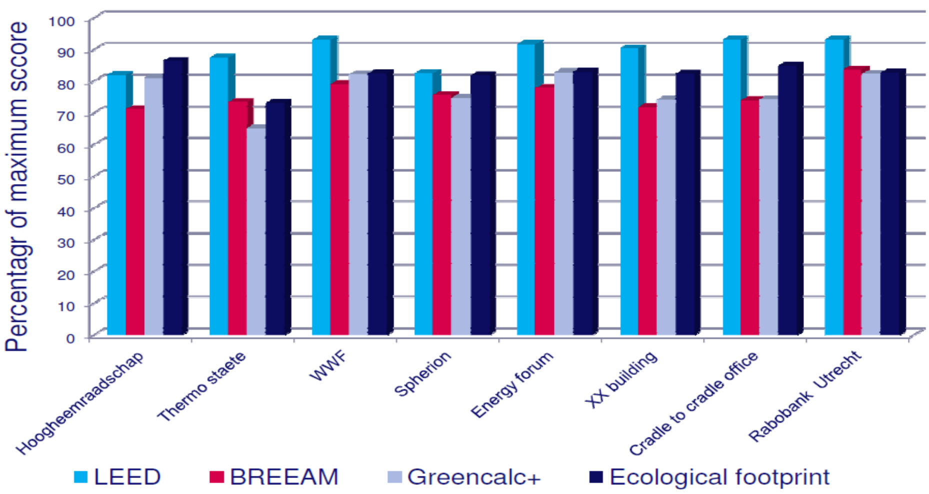


Figure 2. Results of total score of four common aspects by the different assessment tools

In addition the different current sustainability assessment tools all have still some flaws and the green building standards are 'still' under construction (Block 2009). Construction industries and clients need to be provided with tangible proof from the schemes' operators that increasingly demanding green rating systems will actually add value to all and not become a souvenir trinket from hell (Sanuik 2011). At the moment the current sustainable assessment tools do not facilitate the proactive investigation of the creative solution space or the architectural aesthetics involved in building design (Hansen and Knudstrup 2009). There is a pressing need for practical tools for sustainable facilities management (Elmualim et al. 2010). The priority for the near future is to provide insight into the consequence of building design decisions on building sustainability performance.

Facilities managers need decision support tools to make their (future) building more resilient to risk, cost-effective to maintain and run, use less energy and other resources and are more comfortable and better places to work. Only then, progress can be made towards more effective, productive as well as more sustainable buildings. Based on the results of the comparison of the 4 existing sustainability assessment tools, research was started to develop a new tool, which would support designers, as well as facilities managers, more effective in their decision making during the building design process.

FURTHER RESEARCH: THE SUSTAINABILITY ACCELERATOR

Architects, especially those heavily involved to sustainable design, stated that the change towards more sustainable building solutions is slow and that it remains a constant battle to implement sustainable design solutions (Emmitt 2008). The report 'Aanvullende beleidsopties Schoon en Zuinig' (Daniels and Elzenga 2010) examined effects and costs of policy options, aimed at attaining the sustainability targets of the "Schoon en Zuinig" (Clean and Efficient) policy program for energy and climate, introduced in 2007. The Netherlands will have to gear up its (renewable) energy policy to meeting the binding EU targets of renewable energy use in 2020. So it is not easy to reach the sustainability goals. Cook et al. (2007) listed the most significant drivers and barriers for the use of sustainable technologies, the research suggest that financial viability is considered to be the most important deciding factor in the selection of sustainability options in building projects (Alnaser et al. 2008). Lifecycle Cost Performance Calculations (LCPC) approach enable to compare several sustainability concepts with each other. To be able to make good and simple comparisons, could accelerate application of sustainable options. Therefore in 2010 Royal Haskoning started, in collaboration with TU Eindhoven, the development of a 'Sustainability accelerator'. To be able to reach the necessary targets it is necessary to accelerate the achieved sustainability performances, see Figure 3.

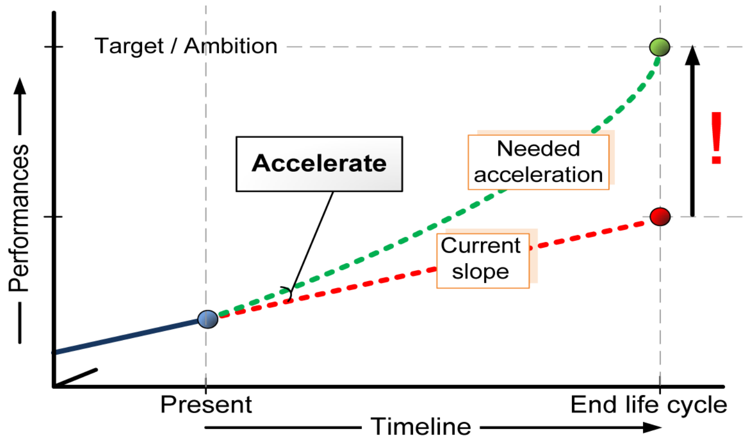


Figure 3. The necessary acceleration to reach the target and ambition goals

To perform the required LCPC analysis a generic tool has been developed to be able to compare several design concepts that help to meet the demands for a specific level of sustainability. It is necessary to accelerate sustainable applications in the built environment, to achieve the strict demands of society on sustainability in time. The 'Sustainability Accelerator' is meant to accelerate the decision process around sustainable applications over the lifetime of the building. This is because normally, there is no clear method prescribed and there is no adequate tool available to link the pros and cons over the lifetime of the building to all stakeholders involved. However it is very important to clarify for the client the benefits of the sustainable alternatives in terms of savings in labor costs, reducing absenteeism and/or higher productivity due to a better indoor climate. The LCC approach is thus extended to a LCPC (Life Cycle Performance Costing) approach.

EXAMPLE OF LIFE CYCLE PERFORMANCE COSTING

To illustrate how the 'Sustainability Accelerator' works it was used to calculate the Life Cycle Performance Costs and so includes the benefits of workplace air conditioning concepts. Four concepts were considered, see Figure 4: induction units in the ceiling (reference/base concept (A) thermally active building structures (B) climate ceiling (C) and personal conditioning concept (D).

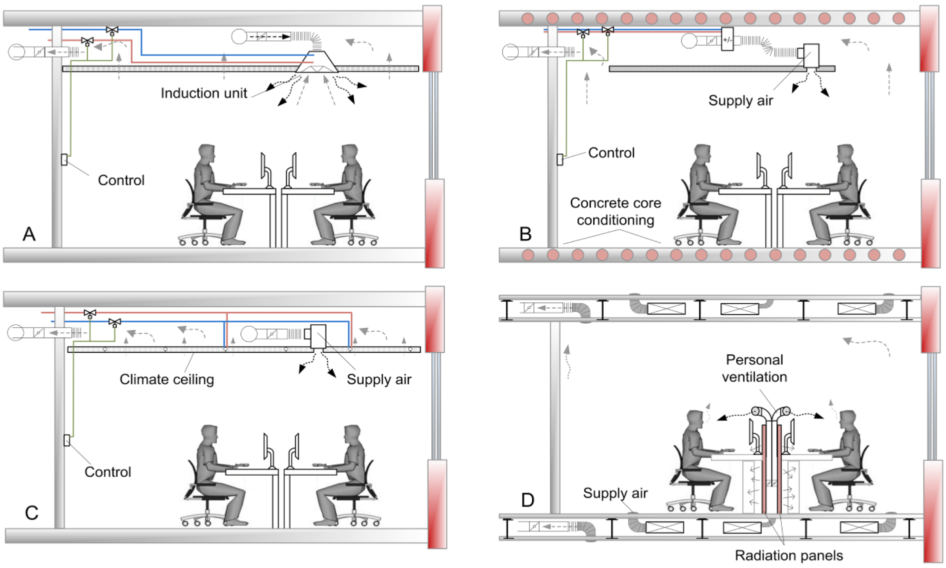


Figure 4. Schematic presentation of workplace air conditioning concepts

For all concepts the same level of thermal comfort and air quality is realized. The investment costs (CAPEX) are determined considering an office building of 10,000 m2. For the different concepts the investments cost above 850 €/m2 are determined. The building services other than the workplace concepts are considered equal. Also Energy, OPEX(Operational Expenditure), replacement costs are considered (see Table 1 and 2).

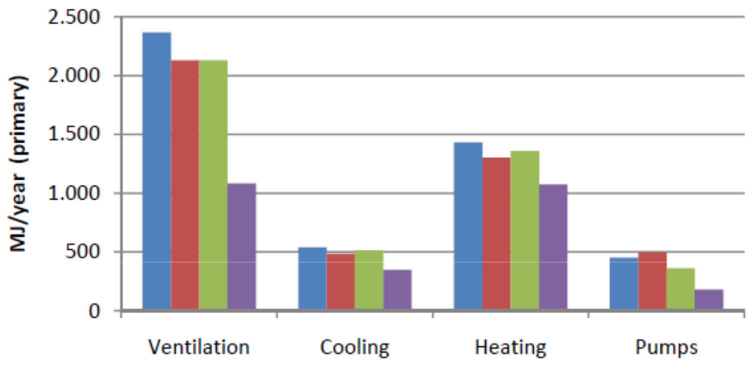
Table 1. Input LCC calculations

Costs		Concept			
		A	B	C	D
CAPEX - investment building services	[€/m^2]	172	201	247	300
CAPEX - construction costs > 850 €/m^2	[€/m^2]	30	140	5	170
Replacement costs after 16 yrs	[€/m^2]	79,6	101,3	160,6	123,7
OPEX - maintenance	[€/m^2 yr]	0,30	0,03	0,25	0,35
Energy costs - gas	[€/m^2 yr]	0,94	0,85	0,89	0,7
Energy costs - electricity	[€/m^2 yr]	5,50	5,08	4,98	2,91
SPOT	[yr]	-	178	81	97

Table 2. Financial input parameters

General parameters			
period	n	30	[yr]
electricity price increase	j_e	7%	[%]
gas price increase	j_g	7%	[%]
increase bio oil	j_o	9%	[%]
inflation	j	2,5%	[%]
equity		20	[€/m^2]
internal discount rate	R_e	7%	[%]
external discount rate	R_d	6%	[%]
repayment period	n'	30	[yr]
financing interest		6%	[%]

The individual workplace air conditioning system (D) uses a significant less ventilation (Zeiler, 2010). This results in large reduction of energy consumption and energy costs. However concept D requires a relatively high investment. The dynamic calculations include also fluctuating energy consumption and their related CO_2 emission costs (see Figure 5). The amount of CO_2 emissions was calculated based on the different energy amounts used for ventilation, cooling, heating and pumps. The initial value for the CO_2 emissions is € 14/ton/yr.



Concept	CO_2 [kg/(m²*yr)]
Induct.	28,4
CCC	26,2
Clim. Ceil.	25,6
Pers. Clim	14,5

Figure 5. Energy consumption of the different concepts and their related CO2 production

Also differences in maintenance costs were considered over time as well as different renovation costs for each concept. It is assumed that the project is financed by a third party using the same discount for each concept. The different LCC values for the system A to D are presented in circular histograms of Figure 6.

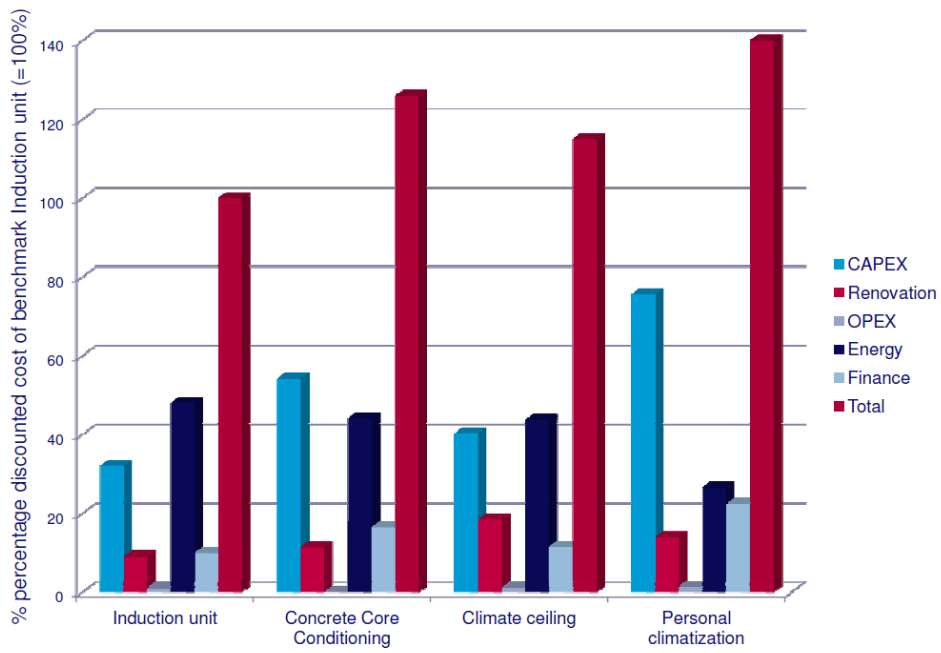


Figure 6. Histograms of concept A to D of the LCC results.

The breakdown in costs is different for each concept. It can be seen in Figure 4 that the energy costs are the major costs using concept A (Induct) and the investment costs (CAPEX) are highest using concept D (Pers. Clim). From literature (REHVA 2006) it is known that a better indoor climate results in a higher performance of the building users. Within office buildings the productivity can be improved up to 3%. Considering that 94% of the total costs over the life time are labor costs, a productivity increase of 3% represents a large benefit (REHVA, 2006).

Typical labor costs are € 2.000 per m2/year. Based on the differences in air velocity, temperature radiation, individual temperature control and thermal comfort, the increase of productivity for each concept was compared to the reference concept A, B+0,25%, C+ 0,50% en D+ 2,50%. The percentages used for the increased productivity, are derived from the expected hours that temperatures in summer will be above 25 °C. Concepts B, C and D will have less temperatures above 25 °C, which will result in a higher productivity.

The effect of productivity loss due to thermal discomfort is researched in many studies, an overview can be found in (Seppänen et al. 2003, Seppänen and Fisk 2005, Seppänen et al. 2006, Fisk and Seppänen 2007). More recent research (Lan et al. 2011) confirms these findings. The LCC results without and the LCPC results with the effect of productivity are presented in Figures 7 and 8.

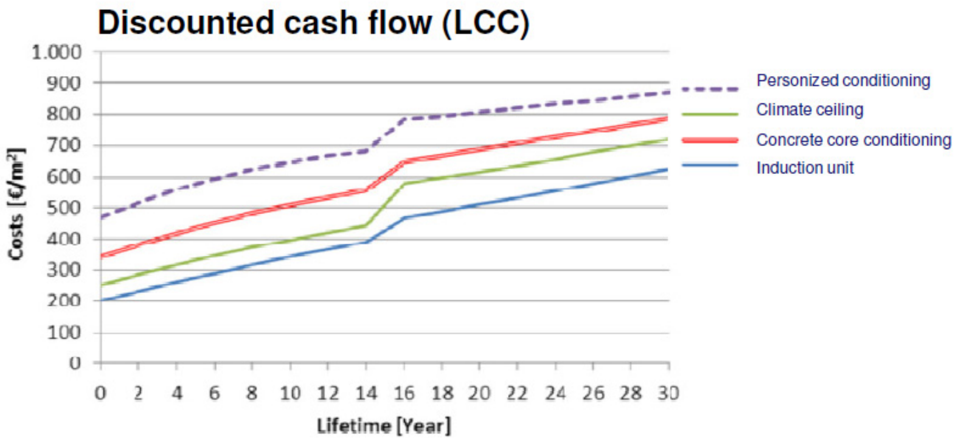


Figure 7. LCC results workplace air- conditioning concepts

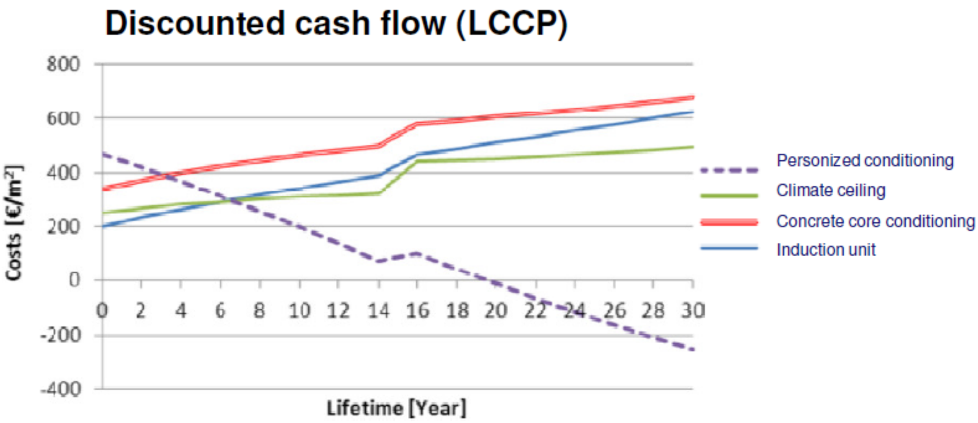


Figure 8. LCPC results workplace air-conditioning concepts with the effect on productivity

The LCC costs in these figures are discounted cumulative costs over the considered period of 30 years. Although the energy costs for concept D are low, the LCC costs are high compared to the other concepts due to the capital cost as a result of the higher initial investment. When the effect of productivity is considered it can be seen in Figure 8 that the effect on LCPC costs is high. The concept C has lower LCPC costs than concept A (Pay Out Time 7 years) and concept D has even a negative LCC meaning that the income due to the increase of productivity is larger than all LCPC costs for workplace air conditioning.

DISCUSSION

A sustainable built environment is a necessity for the future. Although sustainability is a loosely used term to define all things environmentally friendly, the commercial real estate industry is increasingly turning to sustainability assessment standards (Mattson-Teig 2008). However applying the different sustainable assessment tools leads to different choice for the best building, which means that applying such tools for decision support within the conceptual design phase, would lead to different outcomes (Wallhagen and Glaumann 2011). The comparison of the tools and their results is difficult (Haapio and Viitanimi 2008, Roderick et al. 2009) and depends on the tool used as can be seen from the case study.

As financial viability is considered to be the most important deciding factor in the selection of sustainability options our development is focused not on developing a new hybrid approach (Juan et al. 2010) or to extract eco-indicators (Vakili-Ardebili and Boussabaine 2010), but on a method and a tool that supports the design team in the early stages of the design by using a dynamic instead of a traditional static approach. The dynamic approach consists of a LCPC calculation based on discounted cash flows and the use of scenarios.

Some of the current sustainability assessment tools like BREEAM recognize the importance of such a LCPC analysis, by granting points when an LCPC analysis is performed and the results are implemented into the design (Dutch Green Building council 2010) With the tool it must be possible to carry out a LCPC-study fulfilling the requirements of BREEAM-NL (BRE Environmental Assessment Method for the Netherlands) credit MAN 12 (Dutch Green Building Council 2010).

An important motivation for the LCPC analysis is the increasing share of Public Private Partnership (PPP) and Design Built Finance Maintain Operate (DMFMO) building processes in the built environment. The financer of the building is therefore interested in the long term aspects of LCPC. The new hybrid procurement method for new building as well as refurbished buildings, like PPP and DMFMO, are shaping the future horizon of how a built facility is supported throughout its life. Decisions have to be made how to maintain and support the facility for a period of about 30 years (John et al. 2010).

CONCLUSION

From the outset of the design process, a tool is needed for the LCPC analysis to communicate internally within the design team, as well as towards the customers, concerning the LCPC values of different design options. The 'Sustainability Accelerator' is a tool, that supports the design team making design decisions, by using a approach based on the whole life cycle of the building performance. The tool encourages the design team to come forward with innovative sustainable solutions and enables them to give clear insight by evaluating those solutions over the lifetime of the building. The 'Sustainability Accelerator' supports decision making about sustainable alternative design options and therefore accelerates sustainable applications in the built environment. The LCPC tool compares the building performance based on the design alternatives and their different scenarios related to investment, maintenance, operation as well of adjustments to enhance the performance of the building in the future.

The developed LCPC tool gives a clear insight in the results of different alternative solution proposals. The effect of productivity increase on the LCPC results for different workplace air conditioning concepts is large, which can compensate the higher initial investment costs. This also might, in a similar way, affect the decision about more sustainable solutions. Therefore, it is advised for facilities managers, when selecting alternative within the building design process, to consider applying a LCPC tool instead of one of the traditional environmental assessment tools like BREEAM or LEED.

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