Performance Metrics for Sustainability Value

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Licentiate Thesis

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Abstract

The trend that started with Green Building has moved on into Sustainable Building. But how do we know that something is really sustainable? This project started out with the intention to find a small set of performance indicators for commercial buildings, which could be continuously measured and monitored over time, which would give a good indication of the level of sustainability of the building and as such, and be presented as an additional part in a valuation. Since it has been shown several times over by now that properties that can prove they are sustainable generate a higher market price, these performance indicators would be interesting from the perspective of a valuation professional. In order to find these parameters, the project began with three of the international environmental certification systems and one Swedish system, to study which parameters are considered important in these systems. Following that study, surveys and interviews within the real estate business in Sweden provided an insight into how performance is measured today. Lastly, by combining those studies with a review of the sustainability information considered important by the Royal Institute of Chartered Surveyors (RICS) from a valuation professional's point of view and an updated literature review, a simple set of indicators could indeed be identified. There is however, still a problem with defining their actual impact on market price. Other authors have come to the conclusion that although sustainability can be measured to some extent, incorporating that information into valuation of the property in a statistical secure way is not yet possible. We need to increase our knowledge about the performance of our built environment and the presented key performance indicators in this thesis would help us do just that. We can also see that real estate owners in many cases already gather much information about their buildings, but they lack the incentives to share that data with others.

Sammanfattning

Trenden som startade med grönt byggande har gått över till hållbart byggande. Men hur kan vi veta och avgöra huruvida något faktiskt är hållbart? Det här projektet startade med en intention att hitta en kort lista med prestandaorienterade indikatorer för kommersiella fastigheter, som skulle vara möjliga att mäta kontinuerligt över tid, som skulle ge en tillräckligt bra bild av hur hållbart byggnaden presterade och som därigenom skulle kunna bli ett användbart tillskott till en fastighetsvärdering. Då det vid det här laget har visats vid ett flertal tillfällen att en byggnad som kan bevisa att den är hållbar, antingen genom certifikat eller annat, kan generera ett högre marknadspris, så skulle dessa parametrar vara intressanta för en fastighetsvärderare. För att finna och identifiera dessa parametrar så inleddes projektet med en studie av tre internationella och ett inhemskt certifieringssystem för kommersiella byggnader som alla var vanligt förekommande i Sverige. Syftet var att studera vilka parametrar som dessa certifieringssystem valt att fokusera på, och som de därmed ansågs vara viktiga indikatorer för en hållbar fastighet. Nästa logiska steg var att genom enkäter och intervjuer inom branschen ta reda på hur byggnaders prestanda mäts i dagsläget. Avslutningsvis, genom att kombinera dessa studier med en granskning av den hållbarhetsinformation som the Royal Institute of Chartered Surveyors (RICS) ansåg viktigast för deras medlemmar att förhålla sig till i en fastighetsvärdering och en uppdaterad litteraturstudie, så var det möjligt att identifiera en kort lista med indikatorer för en byggnads prestanda. Det kvarstår däremot en problematik med att avgöra dessa indikatorers påverkan, och magnituden av sagda påverkan, på ett marknadspris. Andra forskare har dragit slutsatsen att även om hållbarhet kan mätas i viss mån, så är det i dagsläget omöjligt att införliva den informationen i en fastighetsvärdering på ett statistiskt säkerställt sätt. Vi behöver öka vår kunskap om prestandan på vår byggda miljö och den lista med indikatorer som presenteras i den här uppsatsen skulle kunna hjälpa oss att göra just det. Vi har också sett att fastighetsägare och operatörer i flera fall redan samlar in en stor mängd data om sina byggnader, men de saknar incitament för att dela med sig av den informationen till andra.

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Contents

1. Introduction

Seeing the effects of human activity on the environment started the movement for protecting and preserving the environment several decades ago, but it took a long time to realize just how dire the situation actually was. In 2013, UN presented a report that gave clear messages on how our attitude towards the environment need to change, produced by the International Panel for Climate Change (IPCC) (Stocker, et al., 2013). The growing awareness of how human actions are reflected in the environment and the consequences of those actions made it impossible to continue to build our houses, stores, offices and restaurants without paying attention to the environment.

Around the same time as the IPCC report, the real estate and construction industry started to realize that building green was also beneficial, producing lower energy costs and more efficient use of materials (Wheeler et al., 2013). After the awareness was raised, people and businesses were also prepared to pay more for a property that could show it had a small ecological footprint. But people soon saw the need for a more holistic approach, since if the building was "green" but not beneficial for society, it did not live up to its potential. The concept of sustainability grew, based on three individual "legs": environmental, social and economic sustainability. The term sustainability in this context is older than that discussion and is usually still defined by "meeting the needs of the present without compromising the ability of future generations to meet their own needs" made famous by the Brundtland Commission in 1987.

Even if the definition of environmental and social sustainability can be put in writing, it is still unclear what it actually means. Many institutions and researchers worked on different schemes in order to assess the sustainability of our built environment. The results are a multitude of sustainability assessment schemes, such as LEED, BREEAM and DGNB and several academic articles on their effectiveness. In order to keep with the times, all these schemes also needed to periodically upgrade their certificates, effectively multiplying the total amount of certificates to keep track of. This is something that Lützkendorf et. al. (2012) has raised warnings for, meaning that the sheer number of available certificates might confuse the market and lessen the impact they have. As mentioned later in this thesis, there are indications that this is not the case in Sweden, a key representative from one of the larger companies in Sweden also expressed a belief in upcoming legislation concerning sustainable buildings, something that was addressed by Lützkendorf et. al. as well in the same article.

Early efforts by institutions were to a large extent focused on new construction and major refurbishments, trying to answer the question of how we go about constructing an environmentally friendly building. It did not take long before an increased interest concerning the possible effects these schemes and environmental performance might have on property value were raised. But valuation is considered a reactive activity and there were no data around to help the valuer to include sustainable performance in their valuation. At this point, the academic world and business professionals called out for more information. How do we tell if a building is performing in a sustainable way and how does that information actually impact the value of the building? In order to be able to answer these questions, we need access to much more information. We need access to information on the performance of the buildings together with the transaction price to be able to see a possible connection. If we are to assess the performance of a building we need measurable and trustworthy parameters that are accessible and understandable.

The main goal of this research project is to identify a short set of parameters that are easy to use and understand, technologically available, that give us information on the environmental performance of both new and old buildings on a more continuous basis and that can be of interest for valuation professionals in that they can be expected to have an impact on market price. The parameters will focus solely on the performance of the building once it has been commissioned, meaning that the construction phase is not to be addressed by them, there are other assessment schemes already in place that adequately describe that. They will also not reflect the geographical position of the building. The work that has been done to achieve this goal can be broken down into three efforts:

- The study and description of some of the more popular assessment schemes used in Sweden in 2014 in the context of performance in existing buildings, reviewing how the institutions behind these schemes view sustainable performance over time. How are performance measured initially and how is it followed up over time?
- Investigation of how the environmental performance of commercial buildings in Sweden today is measured and monitored. Which technologies are available for measuring performance in buildings? What is the industry's attitude towards certification systems and environmental work?
- Exploration of the extent that these measurements and metrics of sustainability could contribute to the valuation of a property and see if a clear set of sustainability metrics could be distinguished that provide enough information about the performance of the building and are likely to have an effect on price.

The development of the thesis went from studying different environmental certificates and moved forward by looking at the present state in Sweden by studying some of the more advanced buildings in Sweden, and the behavior of some of the larger real estate owners; how they measured, monitored and operated their buildings. The work revealed a big interest in sustainability and those that had not seen the benefit on operations from close monitoring was hoping for it, a benefit that has been showed before by the likes of Wagner et. al. (2013). They showed, by referring to a German study that constructing a very energy efficient building does not have to be more expensive, it does not have to cost more to commission, but also that the impact on occupant satisfaction is not necessarily positive, if it is perceivable at all. An appropriate monitoring, measuring and ongoing commissioning have the potential to have a huge impact on operation and energy performance (Wagner et. al., 2013).

Finally going into the area of how to accurately determine the value of sustainability, the third article looked to RICS and their sustainability checklist and other previous literature. Value and sustainability have been an intensively studied topic over the last few years, with several researchers trying to create mathematical models and valuation methods in order to incorporate sustainability in the value of a property. It has shown to be very difficult and has also provided unexpected effects, such as in Australia (Warren-Myers, 2012) where valuers claim they put emphasis on sustainability, but it seems they know very little about the subject and because of that are slowing down the rate of sustainable development. The issue of sustainable development is critical for our society on both a regional and a global scale so these questions of how to work with the value of sustainability is very important, so that it does not become something that is considered unreliable or a risk.

2. Theoretical framework and earlier studies

The theory around green and sustainable buildings has grown very quickly in recent years. Although effective use of natural resources and a higher concern for the environment has had a place in the spotlight since the seventies, the environmental and social aspects of our built environment, apart from energy savings, was not explored very much until the late nineties. After that, the literature has exploded, and it is interesting to take a look at the literature that precedes the articles presented in this thesis. Two academics that have been very important for the development of the literature in the area of green and sustainable buildings are David Lorenz and Thomas Lützkendorf, which is why also interesting to follow their publication over the last decade, together with some additional views.

Kohler and Lützkendorf early saw the need for a Life Cycle Analysis (LCA) approach if one was to talk about sustainability, but in the process of trying to create a tool for LCA assessment for buildings, they also began to see the major difficulties in creating such a tool. The main issue usually being lack of information and lack of access to information (Kohler & Lützkendorf, 2002).

At the Pacific Rim Real Estate Society conference in 2004, Kimmet and Boyd addressed the fact that in order to capture the aspects for environmental and social sustainability as well as economic sustainability, there was a need for environmental and social metrics. They also address several of the issuers surrounding social and environmental assessments. The lack of commonly accepted definition of social sustainability only being one of the major ones. The goal is still to try and calculate the added value of these dimensions when assessing a property, and they give warning to the method of a single standard multiplier, and advocate developing several different metrics in order to create a more stable system of calculating the sustainability value, or triple bottom line value as they speak of (Kimmet & Boyd, 2004).

In 2005, Lützkendorf and Lorenz identifies a number of possible key performance indicators as a way to value sustainable buildings through measuring property performance. The result are 34 different indicators spread over 16 different criteria for the existing buildings, with almost as many for the planned buildings. In their conclusions, they address the fact that the environment and building research community need to agree upon a common terminology and that existing databases need to be extended, and new databases need to be created. In other words; there is still a lack of available information in order to properly draw any conclusions of the impact of sustainability on property value (Lützkendorf & Lorenz, 2005). In the same year, Assefa produced a doctoral thesis where he argued that using the existing expertise and assessment technology, it was not even possible to determine the path or the position of sustainable development, but it is possible to determine how unsustainable a certain performance is (Assefa, 2005), seemingly addressing the same point from another direction.

A year later (2006), Lützkendorf and Lorenz present a paper that well summarizes the state of the research done within the field of sustainability assessment of commercial buildings. They address the most critical challenges for future research and the most difficult problems of that day. They also, again, presents a new system for the description and assessment of building performance. The main problems are still concentrated around lack of sufficient data, which is nothing strange, without access to data about the buildings, it is impossible to say much about what kind of performance adds value to a specific property. They also acknowledge that the popular LCA approach has mainly focused on newly constructed buildings, and is quite difficult to apply to existing buildings. Few of the LCA approaches also has the possibility to assess environmental *and* economic performance. But it is also not only a case of needing more data, it needs to be good data, data that is transparent, conclusive, comparable and standardized. In order to gain access to this data, they discuss the different benefits and risks of mandatory versus voluntary systems. Although they reach no specific conclusions in that area, they argue that the increasing trend around Corporate Social Responsibility (CSR) and Socially Responsible Investment (SRI) could heavily impact the possibility of access.

At this point in time, there is a simultaneous demand for more complex and robust models that calculate with several criteria and for simple assessment processes and presentations. This has started the discussion about an “obligatory minimal list of assessment indicators”, preferably one that can be extended if needed (Lützkendorf & Lorenz, 2006). They conclude with observing that assessment tools that are limited to environmental consideration alone will not meet the requirements for sustainable development in the future, and that the focus in the future will shift from 'what is possible' to 'what is required'. When those articles were written, different assessment schemes were in abundance, several national versions are competing with a few international ones, and there is a tendency that the market does not really know what to do will all these systems. Cole (2006) looks at how different assessment schemes functions in shared markets and concludes that “coexisting assessment systems can benefit from each other and push the development further, but also confuse the market to the point where it gets lost in different versions of different assessment systems (Cole, 2006).” Ellison & Sayce proposes in 2007 a set of eight criteria by using focus groups and input from environmental specialists working within property. The criteria are: Accessibility, Building adaptability, Pollutants, Contextual fit, Energy efficiency (including climate control), Occupier, Waste management and Water consumption. They also let the focus groups weigh these criteria, and probably as a result of the focus groups consisting of professionals within investment appraisal and valuation, a very high grade was given to Accessibility, which can easily be translated to location, something that is established as perhaps the most important aspect in valuation. The criteria are rather straight forward, but in some regards difficult to assess and in many cases impossible to measure. How do you measure things like "contextual fit" and "occupier"?

In 2009, one of the first steps away from sustainability only as a possibly added value to a single property can be found in a paper by prof. Newell (Newell, 2009). He uses the information gained from a number of UK property companies that rank high in the SRI criteria (Sustainable and Responsible Investment) to create a number of performance indicators that can be used to create a 'socially responsible property investment index' for UK property companies. The paper is an interesting analysis of empirical data that shows that companies that rate high in SRPI (Socially Responsible Property Investment) can show a better performance than other similar companies over time. This is of course not a prediction of the future as Newell himself says, but in many ways it is similar to the 'Business Case for Green Building', that came out a couple of years ago, that clearly showed the financial benefits of building green, even if it is just the 'first stage in rigorously assessing the integrity and potential added value of SRPI in UK property companies' (Newell, 2009). In this case, it showed the benefits of placing high in SRPI categories. So, while specific indicators might not show it, there is a possibility of seeing added value in aggregated form for a portfolio.

There was also another approach presented, perhaps as a response to that so much of the previous literature called out for more information, Pivo (2009) presented a number of metrics that where accessible simply by using google without any sort of membership involved. He first used what is called the Delphi process, thoroughly explained in the article, to produce the set of criteria, which was then presented to a panel of professionals that weighed the different criteria. Rather unsurprisingly, the biggest weight was given to criteria that affected location, and this particular information is also quite available online. Getting access to it however, does require effort for each property and Pivo does address this as a problem with this method. In his conclusions, Pivo advocates for combined efforts to collect data into databases that can be publicly accessed for further research and give property investors and managers better possibilities for rational decisions concerning environmental and social issues (Pivo, 2009).

As Lützkendorf and Lorenz mentioned in 2006, at that time, most efforts were going into the standardization of the methodology in choosing KPIs, rather than the actual KPIs themselves. This was still the case in 2010, as can be seen by Shah, et al. (2010), even though the title "Selecting Key Performance Indicators for Sustainable Intelligent buildings" might have you believe otherwise. They do not provide any concrete KPIs, but they do come to the same conclusions as many before them, that appropriate capture of KPIs are essential to ensure sustainability. Aside from that conclusion, they also advocate strongly for a semiotic approach in the methodology, referring to Stamper (1996).

In 2011, Lützkendorf and Lorenz published two articles together in two separate journals. The first one (Lützkendorf & Lorenz, 2011) is rather straight forward and deals with the now common problem of not enough available information about our buildings. They also provide evidence that sustainability does indeed affect transaction price, but the magnitude of the effect is very hard to predict in a case-by-case scenario. This fact makes some of the popular methods of dealing with sustainability in valuation vulnerable to critique. One such critique is that the effect on transaction price is not valid over different geographical regions due to differences in quality and construction standards. They again ask for coordinated efforts to collect, store and make available the information about our buildings if we are to increase the collective knowledge about them and be able to more precisely relate sustainable performance criteria to value. Later that year (Lorenz & Lützkendorf, 2011) they published another article. This one took a good look on the history of publications in the subject of sustainability and properties, citing 31 articles and 10 different projects and initiatives and also dividing them into different categories, one being 'Performance measurement and reporting', of which there were nine cited articles between the years 2002 and 2009. This was part of the main purpose of the article, to systematically evaluate the existing approaches to sustainability and property valuation. This literature review provides them with agreement on eight different issues and four main reasons to include sustainability in valuation. They also provide suggestions for future work. They still make the relevant argument for more information in order to better find quantitative proof for cause and effect, but they also for the first time acknowledges the prospect that the perfect formula might not be possible. They say that there is little experience in coping with the environmental, social and cultural aspects of property assets when using financial analysis, and that there is a danger that financial variables are computed in isolation when there are impact from other variables on our every-day life and well-being. They even suggest a different and more comprehensive approach towards value, not as a replacement, but as an addition, because; "Consequently, aspects that are not directly measurable or not yet monetizable may also play a role in the property price formation process, i.e. the assessment of single buildings' contribution to sustainable development or their "value" for society, culture and the environment slowly enhances and complements the other, more traditional drivers and components of property value. (Lorenz & Lützkendorf, 2011)"

The research in later years to a large extent acknowledge difficulties in putting a monetary value to sustainability, but also see that the need for sustainable development is imminent, so they have instead provided more philosophical discussions about value and work ethics. For example Hill & Lorenz, (2011) talk about the ethical responsibility one could possibly put on a valuation professional and how to perceive and account for natural resources. They say that "the challenge is to enable valuation professionals to make their judgement about the value of an asset in a wider context of value judgements on social, environmental and economic need" (Hill & Lorenz, 2011). Later as a follow up, Hill et. al. (2013) also give a philosophical view that provides an ethical framework for valuation professionals to work from. They acknowledge the fact that the economic incentives are not there to consider sustainability to the extent that is necessary and that politicians have limited possibilities due to connections to public opinion and the market. Instead, they plead the professional body in the real estate market to re-evaluate their mission for economic growth and put a larger emphasis on providing use. They see the need for sustainable development, but have found it difficult to provide the necessary incentives for it in a market context (Hill et. al., 2013).

Bonde writes in his doctoral thesis (Bonde, 2016) about how an added value can be noticed for green buildings, but that the specific impact is hard to determine. We have a need for more sustainable buildings as presented by IPCC report on climate change, but it seems that the economic incentives for landlords to fulfill the criteria for sustainable buildings are just not there to the extent that is needed for actual change to happen. There are to many uncertainties around the possible added value. Several other authors talk about the need of more information concerning our buildings, but the same thing goes here, the incentives for the owners are not large enough to take the extra cost associated with gathering that data. In order to help development move forward, a path could be to implement a small set of measurable metrics, that helps provide a more conclusive image of the buildings' sustainable performance metrics that are easy and cheap to measure and monitor and do not rely on complicated and work intensive assessment schemes such as LEED or BREEAM. If the metrics are cheap and easy enough, the mere benefit of reducing risk could possibly be incentive enough while we wait for legislation to address the sustainability issue.

This selection of articles have brought us up until today as far as assessing sustainability value of a specific property in concerned. But the questions and conclusions presented in these previous works invites the more philosophical question of value. In this, (Klamer, 2003) makes some very interesting points when it comes to the concept. A large part of the theory around sustainability is the potential added value to sustainability. But in those cases, value generally means 'increased market price'. It can be interesting to look at if it is really realistic and reasonable to try and calculate the environmental and social sustainability of a certain property in some currency or other, when economics is actually just one leg of the triple bottom line that is sustainability. As Klamer mentions, it is not the first time that one has tried to put monetary on something that has a much wider scope of value than just money; just look at the debate concerning the arts. Why this is usually the first step to attempt is not very strange according to Klamer, if everything can be expressed in monetary terms, then rational decisions become a matter of adding and subtracting. In the final notes of his article, Klamer mentions the difficulties of putting a monetary value to different kinds of human interactions and attitudes, which does not translate well into the subject of this thesis, but surely things like our planet, natural resources, wildlife, public health and safety are equally difficult to put an exact price on?

3. Method

From the start it was decided to focus exclusively on commercial buildings in Sweden in order to have a scope that was manageable. As an employee of Skanska it was also important to try to keep as much of an objective eye as possible.

The work done for this thesis started with desktop work concerning professional literature dealing with the more prominent certification systems used in Sweden in 2014 and what their approach looked like concerning systematic monitoring of certified buildings. As a source of information, the Swedish chapter of the global organization Green Building Council provided good access to the different certification systems, as guides and official documents are readily available on their web page. Previous academic published literature had in this specific area mostly addressed the comparability of these certification systems, all coming to the conclusion that it was very difficult due to lack of transparency and probably also because most certification systems have a bottom-up construction, meaning they all have slightly different starting points, although following the same philosophy. Since the point of this review was focused on the specific question of monitored performance over time, the comparison became easier, and valuable information could be extracted from the literature and presented in a systematic way.

In order to gain a deeper understanding about the certification systems, interviews with professionals that worked actively with the different systems was carried out. In order to help prepare for the interviews, meetings with a reference group with representatives from both academia and industry were held. The interviews where then completed in a semi-structured format with a small set of questions in order to be able to have a conversation around the subject and be free to follow up on new information and insights. At the time, the researcher was also working at Skanska as a project engineer with a building that was going to be certified LEED Platinum, which gave the opportunity of participant observation. Participant observation originated in anthropology as a way to provide researchers with opportunities to observe behavior and practice of individuals and groups within different cultures (Dhalke, et al., 2015). In this context, it gave the researcher access to documents, meetings and working groups involved with certifying the building, giving further information on the contents of the certificate as well as an understanding of the work involved with the certification process.

For the next step, it was interesting to look at what kind of approach existed towards monitoring and measuring building performance in certified buildings. To get an idea of this, a selected case study as explained by Flyvbjerg (2006), with carefully chosen buildings that could well represent the more ambitious buildings in Sweden, was carried out. The material provided insight into what was possible to measure in an advanced commercial building today. Another reason to choose the selected approach was that it studied the early adopters within the industry and this provides insight into where the industry is heading.

Using the information gained from the cases, an online survey was conducted directed to 58 of the larger commercial real estate owners in Sweden. The survey was designed to get information on the extent that real estate companies in Sweden work with environmental certificates and how much they measure and monitor their buildings. (The questions in the survey can be found in the appendix to this Introduction.) There were a total of 14 respondents to the entire survey, a figure that cannot be considered large enough to provide statistical significance, but still it can provide information on the philosophy and business profile of early adopters, the reasoning behind this being that primarily early adopters are likely to complete such a survey. Additionally it also gave information on how common it is to certify buildings among these companies, which parameters these real estate owners would like to be able to measure and what information they would like access to. Three of the respondents were chosen, because of complete answers in the survey with additional free text comments, for in-depth, follow-up interviews on how their companies viewed sustainability and how they worked with it. They are, to an extent, subject to bias since both the author and the interviewee have interest in sustainability, but they provide an important perspective into how different types of real estate owners approach the subject of sustainability (Boyce & Neale, 2006).

After gathering all the information in the previous steps, the next step was to put this information in a different context, that of potential price impact. At this point it became necessary to gain the perspective of a valuer or surveyor to get an idea of what kind of information they believe could add value to a building. A previous study of material from the Royal Institute of Chartered Surveyors (RICS) provided the opportunity to use the information gathered in the earlier stages and make a comparison between both practice, RICS sustainability checklist, due diligence and some of the available certificates for existing buildings. As part of the search to understand how real estate actors value sustainability, an online study was done by mapping the home pages of 32 different real estate owners and looking up what information they present concerning sustainability and the environment. It was interesting to see how many companies that choose to specifically present and push their corporate social responsibility. In the end, it was possible to create a short list of measurable and accessible parameters that together with information on transaction prices have potential to be beneficial when trying to find the causal link between a buildings performance and its market price. The process of the work on the three articles is illustrated in figure 1.

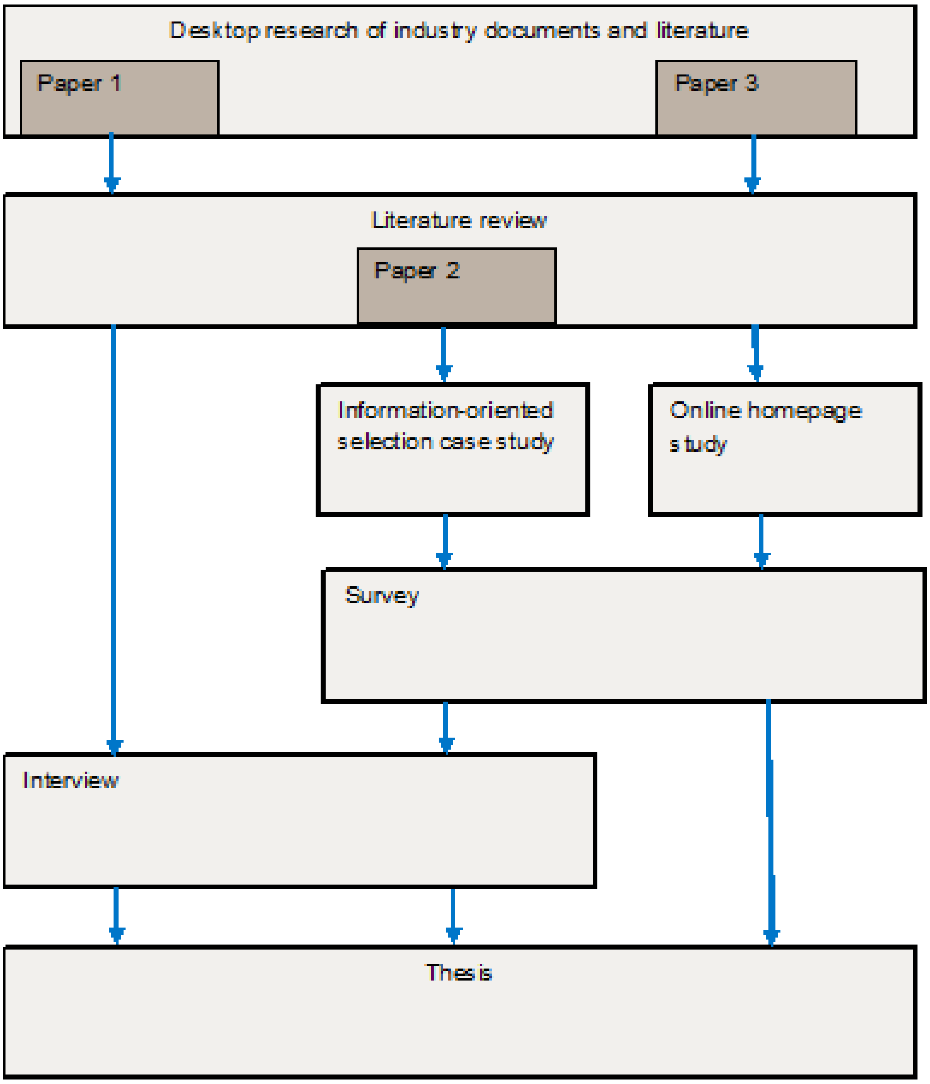

Figure 1 Research model

Since the parameters were chosen from existing and well researched certificates as well as from studies of current buildings, they can be considered relevant and reliable. The connection to the guidance notes from RICS and the standard Due Diligence also gives credit to their potential impact on market price. The information gathered from survey and interviews are susceptible to certain bias, since a company representative is likely to promote the certification system that the company has chosen to work with, but since this is not a paper on which certificate that is the "best" so to speak, that is not relevant. All conclusions made in the thesis are in line with existing literature, but the connections between environmental impact, measurability and potential impact on value are new.

4. Summary of the articles and discussion

All these articles have been written as collaborations. In the first article, my supervisors Professor Hans Lind and Associate Professor Abukar Warsame helped with the disposition and some of the connections to previous literature. The second one was written with colleague Magnus Bonde, Phd, who assisted with the literature review and contributed with insights and formulations for the conclusions. The third article was written with Professor Hans Lind that assisted with the connections to the literature on the theory of valuation.

4.1 First article – Sustainable Performance in Buildings

The first article attempted to compare popular environmental certificates for newly constructed buildings from the perspective of the demand of follow-up. As certificates have been shown to affect the market value for a building, but not to guarantee planned performance, it was necessary to investigate how the certificates approached continuous monitoring. The question was if there were any demands at all on a newly constructed and certified building to provide any form of proof that they perform according to the promises of the certificate. The research done for this paper relied mainly on desktop research of the different certificates and a literature review of academic articles. Two interviews with industry professionals as well as three meetings with a reference group to provide additional insight into the experiences of working with the certificates. The study found that although some certificates do have versions that are directed towards existing buildings, and how they are commissioned, the emphasis is on how to build or refurbish a building so that it has a low ecological footprint and provide a snapshot version of the building. Aside from this information, the study also gave insight into the categories and parameters that are considered important for each respective certification organization.

4.2 Second article – Sustainability Metrics for Commercial Buildings in Sweden

In the second article, the focus was on newly constructed commercial buildings in Sweden and how their owners choose to work with measuring performance. By performing a selected case study, conducting a survey and follow-up interviews among Swedish real estate companies and finally study available industry information, the second article provided information on what key performance indicators real estate developers choose to monitor as well as how they go about to collect and use the data in their operations. This gave an idea of what is already monitored and to which extent. The case study also gave insight into what is technologically possible to measure and monitor. The cases where chosen in order to represent the front runners in environmental profiling and performance monitoring of commercial buildings. After a comparison of this gathered data with the requested information from the academic world about buildings it turned out that the information we need in order to increase our knowledge about a buildings performance, and the possible impact of it on market price, is already being gathered to a large extent, but it is not made available. The rather large diversities in attitude towards assessment schemes and certifications was also highlighted, showing three distinctively different approaches from three different companies.

4.3 Third article – Performance Metrics for Sustainability Value

The third article looked at the notable and reappearing metrics from the previous articles and their possible connection to value. The aim was to try and identify a minimalized shortlist of performance metrics that have the potential to affect market price in commercial real estate. Previous literature had proven that certified buildings can fetch a higher price on the market, but that that is related to the certificate rather than the performance. By addressing the parameters from sustainability assessment schemes in comparison with the RICS sustainability checklist, Due Diligence and previous studies on what is technologically available, it was possible to draw conclusions as to what kind of parameters could answer the call for performance indicators that says something about the environmental performance of the building, as well being likely to have an impact on market price. In the end, a minimalized short-list was presented that has the potential to help us understand more about the connections between sustainable performance of commercial buildings and market price. The idea is to use the information provided from the shortlist in valuation reports, this way, it will be possible to identify connections between specific performance metrics and market price in the future.

Table 1 Proposed list of key performance indicators as part of a valuation report

CO_2 emissions	An equivalence calculated based on fuel and electricity consumption
Particle levels indoor	Ratio of hazardous particles in the indoor air
Total Energy Consumption	Total energy consumption for the building
Net Green Energy Consumption	The ratio of the total energy consumption that comes from renewable energy sources
Green Energy Production	Amount of green energy produced on-site
Total Amount of Fresh Water Bought	Total amount of fresh water bought, not including fresh water produced on site
Amount of Fresh Water Produced	Total amount of fresh water produced on-site
Total Amount of Waste Produced	Total amount of waste
Total Amount of Waste Recycled	Total amount of waste recycled

The KPIs in the list hold up to the required characteristics that were asked for in the beginning of the project. They are easy to understand, they are continuously measurable, the technology is already present, they can easily be applied to both new and old buildings, provided an upgrade in the installation systems in some cases and they finally also provide important information on the environmental performance of the building in categories that dominant certifying systems of today consider important.

A closing remark is also given in line with a paper of Lorenz & Lützkendorf (2011) and their discussion about value, and how others have addressed this issue, others like (Klamer, 2003) and (Canonne & Macdonald, 2003) who addresses this problem in various ways by trying to use mathematical models to safely incorporate sustainability into different valuation methods. Lorenz and Lützkendorf (2011) see this as a problem and argue that the future in valuation is not in models, but rather in the relationship between humans and its environment. Also, present methods have led to an unnatural separation of economic, environmental and social measures that are intrinsically linked and non-divisible.

5. Final Comments

The goal of this thesis was to find a set of key performance indicators as described in the introduction and the work went through three stages; to review how significant the performance of a commissioned building is among the more popular assessment schemes, to investigate how the commercial built environment in Sweden today is measured, monitored and operationalized in buildings and to explore the extent that these measurements and metrics of sustainability could contribute to the valuation of property and see if a clear set of sustainability metrics could be distinguished that provided enough information about the performance of the building and had statistical significance on price.

The first question was to some degree answered during the time of putting this thesis together, since several of the certifying institutions in action started to present assessment schemes for existing buildings that relies heavily on performance metrics. The field work done in relation to this thesis revealed good information as to how at least companies with a prolific approach to sustainability in Sweden act concerning monitoring, measuring and operations of their buildings. The academic literature provided good insight into the last question concerning sustainability and added value to market price.

The academic world have asked for more data on the performance of our built environment for several years now. In Sweden at least, it seems to be the case that this data to a large extent is already being collected and stored by the real estate owners themselves, but apart from information that they have to share due to legislation, they are reluctant to part with this information. This is not very strange, sharing the data in a structured format would require extra work and as of today, there is no structured framework for them to use and there are also no incentives for them to share this knowledge with the public. The data they do measure and store does give a good picture of the performance of the building, but in order to better capture at least the environmental aspects and ecological footprint, this thesis has suggested seven key performance indicators that, if they were to be put to use, would increase our knowledge about the ecological footprint of our built environment (see table 1).

It has been noted that additional value can be ascribed to sustainable buildings, but the magnitude of that value is too unprecise to create incentives for extensive measuring, monitoring and above all, sharing of information from the owners perspective. More knowledge about the effects from the built environment on climate change and social development is still the main goal, but it seems like the economic incentives for increasing that knowledge might not be sufficient, at least until we have access to more transactions with more performance data on the buildings. The technology is there, but the incentives are not.

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Appendix

Survey questions (for inclusion of available responses to the multiple choice questions, see full survey in appendix of article 2)

1. Name of company/organization that you work for
2. Name and position of the respondent
3. How long have you worked in the real estate business?
4. Do you work with any form of certification system for your estates (for example LEED, BREEAM, Miljöbyggnad, Green Building)?
5. What proportion of you building stock have some form of certification?
6. Do you continuously measure the consumption of property electricity?
7. How often do you measure the consumption of property electricity?
8. How is the data from the measurements of the property electricity stored?
9. How is the data from the measurements of the property electricity consumption used?
10. Do you continuously measure the consumption of tenant electricity?
11. How often do you measure the consumption of tenant electricity?
12. How is the data from the measurements of tenant electricity stored?
13. How is the data from the measurements of the tenant electricity used?
14. Do you continuously measure the consumption of fresh water?
15. How often do you measure the consumption of fresh water?
16. How is the data from the measurements of fresh water stored?
17. How is the data from the measurements of fresh water used?
18. Do you have real estate where the ventilation is regulated through presence?
19. What proportion of you building stock have presence controlled ventilation?
20. Do you measure indoor air quality in your buildings?
21. What proportion of you building stock do you measure the indoor air quality in?
22. How often do you measure indoor air quality?
23. How is the data from the measurements of indoor air quality stored?
24. How is the data from the measurements of indoor air quality used?
25. Do you have data on how much waste that leaves a single property?
26. What proportion of you your building stock saves that kind of data?
27. Is there a separation of tenant waste and waste from operation of the building?

28. Is there anything you would like to measure concerning the performance of the buildings that you feel you lack options for today?
29. Are there parameters out of the ones you do measure that are difficult to get reliable data on? Which are they?

Examples for interview questions – article 1

The interviews started with asking the professionals name and occupation. The open-ended interviews where based around the professionals experience from working with a specific certificate.

1. How does your organization work with certifications?
2. Which certificates do you work with?
3. How many of the credits are based around planned and measured data respectively?
4. Are there any demands for continuous monitoring?

Examples interview questions – article 2

The interviews started with asking the professionals name and occupation. The open-ended interviews where based around the spoken strategy of the companies attitude towards certifications and measuring building performance.

1. Which certificates have you chosen to work with and why?
2. How much emphasis is put on measuring the performance you your buildings?
3. How are you seeing the development and future in measuring building performance?

Sustainable performance in buildings
Time-frames and follow-ups in environmental rating systems

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Abstract

An environmental certificate gives information about the characteristics of the building today, but does not, as the current study shows, guarantee future performance. The question investigated in this study is if there are any demands at all on a newly constructed and certified building to provide any form of information that shows that the building actually perform according to the promises of the certificate. If there is, then which certificate does have these criteria and how common is it? This report is an attempt to compare popular environmental certificates for newly constructed buildings, but from the perspective of their demand of follow-ups. From the point of view of a property investor and a valuation professional, it should be of interest to identify measurable parameters that could provide historical performance data on a building. Also from an environmental perspective actual long term performance should be most important. In the paper we formulate three conditions that a long term credible environmental rating system should fulfill: any certificate should only be preliminary until it has been verified by actual performance metrics, continuous monitoring should be done and it should be mandatory to re-evaluate the building every fifth year according to updated versions of the rating system in question.

Keywords

Green Building, Measure performance, Certification systems, Follow-up

1. Introduction

Construction projects, including buildings, have a huge impact on the environment. According to EU Energy Efficiency Plan 2011, buildings are responsible for nearly 40% of energy consumption in the EU countries. A similar pattern is also reported in the US where buildings account for 39.4% of energy consumption in 2002, with 56% and 44% accounted for by residential and commercial buildings respectively (Choi, 2009).

As the awareness about climate change and environmental impact increased, the real estate industry recognized the need for a shift in focus. Development of concepts such as green buildings or environmentally friendly buildings allowed the construction industry to move toward achieving the objectives of sustainability (Pearce, et al., 2012). Different actors in the construction and real estate sector might have different interest and requirements; investors are interested in economic performance while tenants are interested in health and comfort (Haapio & Viitaniemi, 2008), but the increased use of Corporate Social Responsibilities (CSR) and Socially Responsible Investment (SRI) indicated the importance of the growing link between sustainability and investment opportunities that do not only focus on the economic performance of investment, but also takes into account the environment and social aspects (Lützkendorf & Lorenz, 2008). In order to reduce the environmental impact of new and older buildings, it has been noted that proper tools for evaluating and assessing these potential impacts, performance, and necessary improvements are, if not required, then at least a huge help (Malmqvist, et al., 2011). Thus a number of different environmental classification systems that are intended to assess the impact of buildings on the environment have been developed since early 1990s (Furr, et al., 2009). Some of the most common rating tools are LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method) and GreenBuilding.

Cooper (1999) raised several challenges associated with existing environmental assessment methods and one of them is their lack of measuring progress for sustainability in relation to targets or time frames. He argues that "the ability of buildings to meet and maintain their given targets should be measured over a standardized time frame". The concerns were not unfounded, as reports started to appear that showed a disappointing level of performance from these certified buildings. A report from a study in New York that covered more than 900 commercial buildings, 21 of which were LEED certified, showed no difference between conventional buildings and certified buildings concerning energy efficiency and greenhouse gas emissions, unless the certified building had achieved at least gold level (Scofield, 2013). A cross-country study made in 2007 reached opposite conclusions, stating that LEED certified buildings reached an energy use intensity (EUI) that was 25-30% lower than the benchmark building, represented by averages from a national initiatives with information from thousands of buildings, but also reported large varieties in the data (Turner & Frankel, 2008). A report from the World Green Building Council (WGBC) clearly stated the business case for green buildings (Wheeler & al, 2013), but the reports about underperforming certified buildings still argue for a closer look at the certificates.

The basic underlying query in this study is to investigate to what extent an environmental label, given to a building at a certain point in time, gives information about the current environmental quality of the building. Are there e.g. any demands for follow-ups in order to keep a certain environmental label? This will also become a more and more important question because environmental systems change over time (see DeLisle, Grissom & Högberg 2012). This means that from a property market perspective, a certain environmental label will be more and more difficult to interpret over time as the conditions for getting a certain label may have changed. The study also looks at the initial verifications demanded in the system and e.g. whether theoretical calculations or actual measurements are made, as this is also something that affects the credibility of the system for investors.

This article studies five environmental certification systems with a focus on their approach towards a continuous monitoring and reporting of a buildings performance concerning environmental issues. Four of the five mentioned systems are internationally well-known systems: BREEAM, LEED, EU Green Building and DGNB from Germany. The fifth is the local Swedish system Miljöbyggnad, which in Sweden is more common than BREEAM and LEED. In the first part of the article, the focus is on cases where the classification is assumed to be applied to the new construction of a commercial building, typically for office use. Then we also investigate two systems used for classifying buildings in use.

The structure of the paper is as follows; section 2 describes the method used in the study and section 3 gives a short description of the assessment systems chosen for this paper.

During the work the following aspects were identified as being important and these are covered in sections 4-7.

- System for initial verification in relation to the theoretically based evaluation used during the design stage.

- Demands for short term follow-up after 1-2 years when e.g. the technical systems have been adjusted.

- Demands for more long-term follow-ups after say 5-10 years, or whether there is some kind of time-limit for the classification, which means that if a new evaluation is not carried out then the official grading expires.

- Special demands concerning the management stage that is not of the type that concerns a follow up at a certain time.

Section 8 highlights the most important results and also includes some suggestions for future developments of the certification systems.

2. Method

The article is mainly based on academic literature and official guides concerning the different certification systems. One provider for these documents has been the Swedish Green Building Council (SGBC) web site, where most of this information is publicly available. One of the main purposes of SGBC as well as for all national Green Building Councils is to provide information and education on different certification systems, their web page and office can be described as a library for information on these systems. The documents and guides are rarely produced by them, but gathered from the responsible organizations and stored at the same place to be more accessible. One exception is that they commonly translate international documents into the native language and for some assessment systems, such as for example BREEAM, they are involved with creating nationally adapted versions of the original system.

In order to gain a deeper understandings of how these systems are to work with, and how professionals and academics view them, two interviews with additional correspondence and conversations as well as three meetings with a reference group consisting of professionals from the real estate industry and academia have been conducted. As these interviews and correspondences had as main purpose to check that the systems were correctly understood, the information from these sources are not presented explicitly below.

3. The certification systems: A short description of aspects covered

3.1 BREEAM

The first system was created in 1990 in UK by Building Research Establishment, a former establishment of the UK government, but a private organization today (BREEAM - About, u.d.; BREEAM - FAQ, u.d.). Since its initial release, the system has gone under four major updates as well as added versions to include homes, neighborhoods and assorted types of specialized buildings. In Europe, BREEAM is commonly customized for specific countries, at present there are eight different adaptations for different countries (BREEAM - About, u.d.). BREEAM also has a specific certificate for existing buildings called BREEAM In-Use (2014). The design of the system is that the object receives credits for a number of different indicators, divided into nine different categories; Energy, Management, Health and Wellbeing, Transport, Water Consumption, Materials, Waste, Pollution, Land Use and Ecology (SGBC BREEAM, 2014).

3.2 LEED

Developed by Green Building Council in USA, the first edition was officially unveiled in March 2000 (USBGC History, u.d.). Since then, three more editions have been released, the latest in November 2013 (LEEDv4). There are also several versions of the certificate, depending on if the construction in question is a new construction, a major refurbishment, a school or involving healthcare (USBGC LEED v4, u.d.). There is also a version for operations and management LEED EB:O&M (USGBC LEED rating systems, u.d.). In each version, the object achieves credits for a number of different indicators, divided in eight different categories covering Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation and Regional Priority (USGBC Rating systems recources, u.d.).

3.3 DGNB System

The DGNB System was developed in Germany by the German Sustainability Building Council that was established in 2007. Started by 16 different initiators, the council today has more than 1100 members all over the world (DGNB, u.d.). As with the other major international certificates, there are several versions depending on the purpose of the building and also a separate one for existing office buildings. The DGNB system is, aside from being as encompassing as LEED or BREEAM, promoted with having a greater focus on life-cycle analysis (LCA) (DGNB The certification system, u.d.).

3.4 Miljöbyggnad

Developed by the Swedish Green Building Council (SGBC), this system is designed for Swedish conditions and to work smoothly with Swedish laws and regulations (SGBC Miljöbyggnad, u.d.). Designed to look only at the specific building and its performance, rather than activities in the building and factors concerning its location, Miljöbyggnad has a more narrow focus that covers energy, materials and indoor environment quality.

3.5 Green Building

Developed on an initiative from EU in 2005, this system is significantly narrower in scope compared to the other systems. Green Building is only focused on energy and is largely based around different calculations of energy consumption. When an application is made, the evaluation is based on a comparison to similar buildings and/or standing regulations. (Joint Research Centre - Institute for Energy and Transport, u.d.)

	Green Building	Miljöbyggnad	BREEAM	LEED	DGNB
Energy	x	x	x	x	x
Construction material		x	x	x	x
Indoor environment		x	x	x	x
Water			x	x	x
Operation and management			x	x	x
Construction waste			x	x	x
Infrastructure and communications			x	x	x
Ecology and location			x	x	x
Pollutions			x	x	x
Construction process and innovation			x	x	x
Systematic comissioning			x	x	x
Life cycle assessment					x

Table 1 Summary of aspects covered in the different systems (SGBC, 2014)

4. Initial verification and early follow-ups

For a new building, all the international systems studied require that the performance of the building can be measured, but actual data of the performance is not reported to the certifying authority (SGBC BREEAM, 2014; DGNB, 2013; SGBC Om Miljöbyggnad, u.d.). This means that the environmental classification primarily is based on theoretical calculations based on the design, using established evaluations programs for the different aspects. This is of course necessary if it should be possible to market a new building with a certain environmental label.

The Swedish Miljöbyggnad does demand actual operations data as well, and it also differs from the other systems in that the initial data only allows a preliminary certification. The permanent certificate is handed out only after a verification that is made up to two years after the commissioning (SGBC Om Miljöbyggnad, u.d.). When a project is about to verify their certificate and make it permanent, the documentation required concerns the operational data. An interesting question is how probable it is that a preliminary certified building actually will gain a permanent certificate. The system is however still rather new and the SGBC, that are doing the evaluation, are still establishing their routines, so it is still too early to make any statements about the relation between the preliminary classification and the final classification based on available data.

As it takes time before the building ”stabilizes” and also because the actual working of a building can differ from the theoretical calculations, especially after a few years, it is interesting to see what the systems demand in terms of follow-ups. The systems differ somewhat in this area. As mentioned, Miljöbyggnad only gives out a preliminary certificate when the building is new and awards the actual certificate when a follow-up has been made after one to two years of commissioning. LEED, BREEAM and DGNB, for their respective new building certificates, have no demand for any kind of follow up after the certificate has been awarded. The certificate in these cases therefore represents the buildings (theoretical) performance at a single point in time.

A LEED certificate can however be revoked. This can happen if, for any reason, the building is the target for a Certification Challenge, handled and usually initiated by the GBCI (Green Building Certification Institute). The Challenge must take place within 18 months from the date of the certification, and all projects that are awarded the LEED certificate is therefore obliged to retain all project information concerning the certification on-site for a minimum of two years (USGBC Guide to LEED, u.d.). No information is however presented about how common such challenges are and what the results of the challenges have been.

LEED, BREEAM and DGNB also have a separate certificate for buildings in-use, and these have more demands for follow-up. An EU Green Building certificate has to be renewed and revised every year or the building will lose its certificate (SGBC EU GreenBuilding, u.d.). These are discussed below.

5. Demands for more long-term follow-ups after 5-10 years

Considering newly constructed building for commercial use, the only international system that demands yearly data on the performance of the building is the EU Green Building system, which, as mentioned, requires new information every year since the certificate is only valid for one year at a time. This yearly renewal is done by sending reports on the energy consumption of the building to the national Green Building Council or similar organization (SGBC GreenBuilding Certifiera, u.d.). The required data is, however, not very extensive since the only demand to achieve the certificate is to show a 25% decrease in overall energy consumptions since before a major renovation, or a 25% lower consumption than what is regulated by the Swedish Building Regulations (SGBC EU GreenBuilding, u.d.).

In the other systems, there are longer periods until the certificate has to be renewed. The certificate from Miljöbyggnad is valid for at the most 10 years, or until a major refurbishment. The same is the case for LEED, where any certificate is valid for 10 years from that versions launch date of the system (USGBC Guide to LEED, u.d.; SGBC Om Miljöbyggnad, u.d.). The certificates from BREEAM and DGNB do not come with an expiration date. There are new upgrades of these every second to third year, but there is no demand that the certificate should be updated.

6. Special demands concerning the management stage

In order to be awarded a certificate from the international and more extensive systems like LEED, BREEAM and DGNB, there is a demand to verify a systematic commission and to provide manuals and documents that will guide the management to operate the building to its optimal performance (USBGC LEED v4, u.d.; SGBC BREEAM, 2014; DGNB GmbH, 2014). This goes for all three systems. No specific required documents are listed, instead, examples of documents are listed that can provide sufficient evidence for an auditor to award a suitable amount of credits. This is a way to try to secure the performance of the certified building without burdening the owner with a returning evaluation process. Miljöbyggnad and EU Green Building do not have any demands concerning management or commissioning. Even if there is a demand for a "management manual" there is no system to follow up that such a manual actually is followed and this might be extra problematic if the building is sold and new actors take over the management of the building.

7. Certification systems with continuous reporting

There are some systems available today that are constructed to report the continuous performance of the building. Most of these systems are extensions of a pre-existing certification system. Two of those that can be considered most well-known are presented below.

7.1 BREEAM In-Use

Developed in 2009, this system is based on the same nine categories as the original BREEAM, but the whole assessment is done online by a licensed assessor and the assessment itself differs somewhat from the system for new buildings in that it is more flexible in order to be compatible with other major regulatory and corporate reporting systems, such as ISO 14001, Energy Performance of Buildings Directive (EPBD) and the Global Reporting Initiative (GRI).

The assessment is done in three parts: the asset (an entire building or part of a building), the building management and the occupier management. The rating is then done according to the usual BREEAM star rating. As part of the system, BRE Global provided ten Key Performance Indicators (KPIs) to make the assessment easier and to create a base for comparability between assets in a property portfolio (figure 2). These KPIs are not however, directly relatable to the In-Use ratings, but are meant to assist in reporting specific performance levels.

KPI	Description	Measurement
KPI 1	Building CO_2 (kgCO_2 eq pa[3] per m^2 GIA[4])	The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from direct fuel use at the asset (for electricity, heating and cooling) consumed during the reporting year.
KPI 2	Building CO_2 (kgCO_2 eq pa[3] per FTE[5])	The mass of CO_2 eq[1] per Full Time Equivalent[5] personnel employed at the asset arising from the fuel and electricity consumed by the asset during the reporting year.
KPI 3	Business CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4]) Staff CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4]) Goods Transport CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4])	The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from business travel by personnel (based at the asset) and from goods (dispatched from the asset) during the reporting year. The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from business travel by personnel (based at the asset) during the reporting year. The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from business travel associated with goods (dispatched from the asset) during the reporting year.
KPI 4	Staff Commute CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4])	The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from personnel travel to and from the asset during the reporting year.
KPI 5	Total CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4])	Total mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from the fuel and electricity consumed by the asset, business travel of personnel based at the asset and transport of goods dispatched from the asset, during the reporting year.
KPI 6	Building Primary Energy (kWh pa[2] per m^2 GIA[4])	The kilowatt hours per square meter of the asset (GIA[4]) of fuel and electricity consumed by the asset, measured in terms of primary energy[6] equivalent, for the reporting year.
KPI 7	Water Consumption (m^3 pa[2] per m^2 GIA[4])	The cubic meters of water consumed by the asset in the reporting year per square meter of the asset (GIA[4]).
KPI 8	Total Waste (tons pa[2] per m^2)	The tons of waste removed from the asset during the reporting year per square meter of the asset (GIA[4]).
KPI 9	Proportion of Waste Recycled (%)	Percentage of total waste produced by the asset which is recycled.
KPI 10	Proportion of Waste to Landfill (%)	Percentage of total waste produced by the asset which is sent to landfill.

Figure 2 Table that presents the ten KPIs developed for the BREEAM In-Use assessment scheme.

[1] CO_2eq Carbon Dioxide (CO_2) equivalent: a measure of the global warming potential of different greenhouse gases in relation to that of carbon dioxide; it is defined as the amount of carbon dioxide that would give the same warming effect as that of the greenhouse gases being emitted.

[2] $kgCO_2eq$ Mass (in kilograms) of CO_2 equivalent.

[3] pa Per annum

[4] GIA Gross Internal Area: the whole enclosed area of a building within the external walls, taking each floor into account and excluding the thickness of the external wall.

[5] FTE Full Time Equivalent: a unit which is used to measure the people employed, or studying in a comparable way, even if they work or study a different number of hours per week. A full time employee or student is counted as 1 FTE, a part-time worker/student will be measured proportionally to the number of hours they work in comparison to a full time person.

[6] Primary Energy which has not been subjected to any transformation or conversion process.

Once the initial certificate is achieved, it is valid for one year. In this regard, BREEAM In-Use is like the EU Green Building in that it demands a recertification every year. Since the system is completely online, after the initial setup, the work involved in recertification is not that intense, as long as you have access to the necessary data (Summerson, et al., 2016).

7.2 LEED EB:O&M

The following description is from the 4th edition of LEED from 2009. Built around the same categories as all LEED certificates, and with the same base number of available points, EB:O&M is quite extensive. There are 26 available points in category Sustainable Sites (SS), 14 in Water Efficiency (WE), 35 in Energy and Atmosphere (EA), 10 in Materials and Resources (MR), 15 in Indoor Environmental Quality (IEQ), 6 bonus points in Innovation in Operations (IO) and 4 more bonus points in Regional Priority (RP), giving a total of 110 possible points over 7 categories. The bonus points are, as can be expected, not necessary, and for a large part of the existing buildings out there, not possible. The concept is that you make an initial certification for your building, and later follow this up with recertification. At the initial verification, which is necessary to do no matter if the building has been previously certified or not, the building is given its rating. In order to keep this certificate, the building has to be recertified at least once every five years with figures that contain yearly performance for the building. If these figures or data cannot be presented, then the building loses the certificate and need to do an initial certification once more in order to get the certificate back.

The initial certification process is really the same as for the usual certification that is associated with LEED for new constructions and large renovations. The recertification on the other hand is made much simpler and is based only on performance documentation unless major renovations or changes have been made to the building. As mentioned, there is a requirement for recertification at least once every five years, but it is possible to recertify every year if there is a wish for it.

How much the property owner need to measure, monitor and report is completely dependent on the level of the certificate from the initial certification. What can be said specifically of LEED is that it takes into the consideration the activities and purpose of the building in a much wider context, just as BREEAM. Several points can be earned if you can show that the tenants changed their commuting to public transport or if transports of goods have been lessened by way of better coordination and such. It also places weight on energy and electricity usage by the tenants, so the landlord and the tenant need a working agreement concerning how to operate and use the building in order for the owner to earn extra credit points.

7.3 Comparison

The focus areas or categories are similar for these two systems, but on a point by point or parameter by parameter basis, these two systems are about as difficult to compare as their original ones. They both have a bottom-up approach, meaning that they originate from specific problems, such as CO_2 emissions, and then provide solutions for assessing those levels, and it can be said is that they both offer the user the option of choosing their own ambition concerning the sustainability of their buildings and provide documents and literature on how higher ambitions can be achieved. One difference between these systems lies in the recertification process. Where LEED EB&OM gives the user the option of voluntarily doing the recertification every year, the requirement for keeping the certificate is only once every five years. The process in itself, while being easier after the initial certification, still requires physical documents to be gathered, compiled, sent to an accredited part for assessment and possibly complete with additional information. BREEAM offers a solution for both certification and recertification that is completely online, making at least the recertification easier to do as long as the necessary data are available. As such, LEED EB&OP can reasonably be assumed to be more work intense thanBREEAM In-Use. BREEAM can also be said to be tougher from the perspective of consistent monitoring since the certificate is only valid for one year, making it mandatory to do the recertification every year in order to keep the certificate.

8. Conclusions and recommendations

The main conclusions so far can be summarized as follows:

- Most environmental rating systems have a rather limited system for following up on the performance of the building.
- Some of the established environmental rating systems base their rating to a large extent on theoretical calculations and not on actual performance.

This implies that there might be problems with the long term credibility of the rating system, both from an investor perspective and from an environmental perspective. An investor would want information on actual current performance and on probable future performance, and in that scenario, several of the current rating systems would seem to be rather irrelevant. The same holds if society want to know how good the buildings really are from an environmental perspective.

We would therefore argue that a credible environmental system has the following characteristics:

- The initial classification of the building should be based on actual data and not on theoretical calculations only. Before the actual measurements are carried out, there should only be a preliminary rating, as in the Miljöbyggnad system.

- The environmental qualities should be monitored yearly and the rating evaluated at least every fifth year. We believe that it should be mandatory for a LEED or BREEAM classified new building to use the system for evaluating buildings in use as described above.

- The evaluation every fifth year should be done according to changes and updates in the rating system. The aim should be that the rating should not depend on the initial vintage of the rating system, but on how the building would be classified according to the most recent rating criteria.

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Sustainability metrics for commercial buildings in Sweden

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Abstract

Environmental rating systems typically focus on building characteristics at a specific point in time. From an investment and valuation perspective, actual performance over time should be the most important. This paper investigates how frontrunners on the Swedish green building market actually monitors their new buildings. Newly constructed commercial buildings today usually come with a high degree of technically advanced installations and a wide range of monitoring possibilities. This provides us with the possibility to monitor a buildings in-use performance. By performing a selected case study, conducting a survey and follow-up interviews among Swedish real estate companies and finally study available industry information, this paper studies what key performance indicators real estate developers choose to monitor as well as how they go about to collect and use the data. By doing this, we can get an idea of what is already monitored and to which extent. The case study also provides insight into what is technologically possible. A comparison of this gathered data is then made with information that investors and property valuers can be expected to be interested in and it is found that this to a large extent is information that the frontrunners already gather, but it is not made publicly available. One area where important information is lacking is however data about indoor climate.

Keywords

Green Building, Monitoring, Building Performance

1. Introduction

Many developers of new commercial buildings aspire to be Green/Sustainable. Even though no uniform definition exists of what makes a building green, most of these developments focus on energy efficiency, to avoid hazardous materials and create good indoor comfort. In order to evaluate these parameters, different environmental assessment tools have been developed and are now used worldwide. In Sweden, the most common schemes for assessing commercial buildings are BREEAM, LEED (Cole & Valdebenito, 2013) and Miljöbyggnad[1] (Denell & Bonde, 2015; Malmqvist, et al., 2011). These schemes mainly focus on the construction phase, and less on the operating/maintenance phase (O'Sullivan, et al., 2004), at least in their basic version.

In recent years, both LEED and BREEAM have developed certificates, or subcategories in their certificates, that are tailored towards different situations, such as existing buildings (Cole & Valdebenito, 2013), but these systems are rather new on the market and not too many have started working with them yet. As argued in Sundfors et al (2016), it is important both from an investor perspective and from an environmental perspective not only to know that the building was green at a certain historical point in time, often according to theoretical calculations, but also to know the actual environmental characteristics today. Therefore, it is important to study the monitored performance of the current green buildings in-use today, in order to know if the qualities still holds up or not. The importance of such measurable metrics for monitoring the buildings (environmental) performance is also emphasized by Crawley and Aho (1999). From a life cycle analysis perspective, this is also interesting as the operation phase of the buildings lifespan has an impact on the whole building life cycle energy usage; even though the size of it depends on building usage, type of construction etc. (Liljenström, et al., 2015; Ramesh, et al., 2010).

Systems for monitoring the current environmental characteristics of a building are especially important as the building in use often do not perform as well as projected in the design phase (Hitchcock, 2002). Both Piette (2001) and O'Sullivan (2004) argue that a better monitoring with suitable performance metrics could reduce this difference, as it could provide the operating staff with the necessary feedback. Using this information as decision basis for both short terms decision about adjustments of technical systems and for more long-term decisions to modify the building installations/retrofit the building, as illustrated in Fig. 1 would be beneficial (BLC in the figure refers to Building Lifecycle). Such a systematic working procedure should bring about a better indoor environment, as well as energy savings (Costa, et al., 2013) (Piette, et al., 2001). Wang et al. (2012) also accentuate advantages with monitoring building energy usage, as it gives a more accurate overview of the building's energy usage. Being able to show the buildings performance over a specific period of time also has a large potential to add value to the building (Ellison & Sayce, 2007).

With this background in mind, it would be interesting to investigate how actors in the real estate sector in Sweden work with monitoring their commercial buildings, especially buildings where they aim to get an environmental certificate in one of the leading international or national environmental classification systems. What exactly is considered important to monitor and how do they plan to develop it further in the near future? To sum up, the aim of this paper is to study the front runners in

[1] Miljöbyggnad is a Swedish environmental assessment scheme, which assesses the following parameters: *Energy, Indoor Environment* and *construction materials*.

sustainable real estate in Sweden today, and look at how they work with systems for continuous monitoring of their buildings..

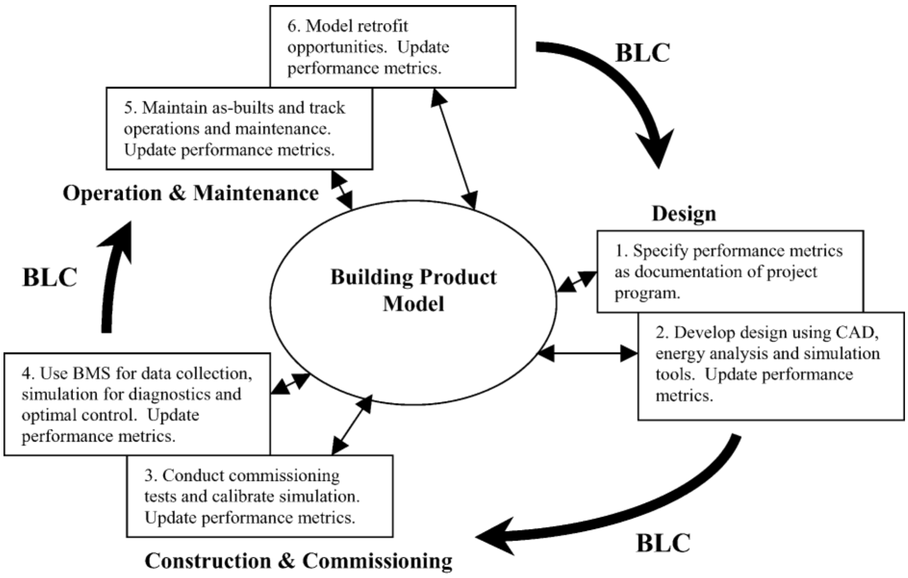

Fig. 1. Lifecycle performance metric tracking scenario (O'Sullivan, et al., 2004).

2. Method

Using several approaches were necessary in order to collect information about the possibilities of monitoring sustainability in existing buildings and how Swedish real estate companies do this.

First, two newly constructed buildings and one projected development were chosen for case studies, two of them in collaboration with Skanska. The three cases are Uppsala Entré, Väla Gård and Utbildningshuset at KTH. The cases where to some extent chosen for convenience, but also, and more importantly, as representatives of modern commercial buildings in Sweden, with a strong focus on sustainability and technological development. As such, the cases can be described as being *critical cases* of an *information-oriented selection* as described by Flyvbjerg (2006). That is also an argument for choosing a building that is now under construction as it provides an additional insight into the ambitions for planned buildings with a strong sustainability focus. Following Stake (1994) the case studies have an *intrinsic* approach, as the main purpose is to describe and understand the cases studied. Using the classification scheme in Yin (2009), the study is categorized as a *single-case (embedded)* study, as different embedded units (“cases”) are studied in order to reveal information about the main research question (case).

The necessary data about the three cases were collected through interviews and reviews of reports and other documents, but also elements of participant observation in Skanska. The data gathering method is therefore a combination of analyzing documents, interviews and direct participation and observation, in which the researcher plays a more active role. This also gives the researcher the opportunity to observe the case “from the inside” (Flick, 2009; Yin, 2009). The interviews were in-depth and conducted in a semi-unstructured format, scheduled for a specific date and time and conducted around a short set of open-ended questions. This provides the opportunity to ask new questions that emerge during the interview and are well suited for gaining a deeper understanding of the subject at hand (DiCicco-Bloom & Crabtree, 2006). The people selected for the interviews where professionals directly involved in the project, e.g. working with creating reports showing the performance of the building, or planning the installation systems that will provide the necessary performance indicators.

In order to provide a broader perspective on the monitoring of commercial developments an online survey containing 28 questions was sent out to 58 different professionals from a total of 30 different real estate companies within the commercial real estate industry. The persons had leading positions within sustainable development in their respective companies and there were people responsible for property management within a certain region. Out of the invited 58, 13 respondents completed the survey, giving a responding quota of 22 %. The list of companies included several of the largest privately owned real estate companies in Sweden. The survey, apart from multiple-choice answers, also contained the possibility of additional comments from the respondents.

From the respondents that gave additional comments and expressed a more ambitious attitude towards monitoring their buildings, three where approached for follow-up interviews concerning their respective companies' philosophy in sustainable development. Those interviews followed the same format as the ones carried out in the first three case studies.

3. Results from Case studies

3.1. Uppsala Entré

Uppsala Entré, situated in central Uppsala, is a six-floor building that was commissioned in the beginning of 2012. The rentable commercial area is approximately 12 500 square meters, consisting of office space, retail and cafés/restaurants. The building has a LEED (Core & Shell) Gold certificate, which is the second highest certificate in the LEED scheme.

In order to uphold the building performance over time, an extensive building monitoring system, consisting of 426 measuring points, was implemented. All data records are stored in a database, which is managed by the developer Skanska. The system is not designed to alert if any measurement breach a threshold limit value, but instead to alert if the technical installations are malfunctioning. The data from the scheme is the groundwork for the quarterly reports of the building performance, following the standard Energy Agreement 12 (Energiavtal 12), as outlined by Sveby[2].

The energy metering is logged in different categories; electricity and heating/cooling. In order to separate the property energy[3] and operational energy[4] (in accordance with Swedish building code), several metering devices (EN-certified) have been placed throughout the building. As heating and cooling are provided via the district heating/cooling grid, the energy provider supplies the metering

[2] A cross sectional organization with the purpose to standardize energy metering standards in the built environment

[3] Property energy – Energy for heating, cooling, hot water and electricity for building services necessary for the use of the building

[4] Operational energy – electricity used to operate computers, copiers, refrigerators/freezers, lighting etc.

devises. In order to provide accurate data, both water temperature as well as the water flow has to be measured. These logs are then integrated into a software application, which computes the transfer of heating/cooling for any given time period.

The ventilation scheme recovers heat from the exhaust air to heat the supply air, using a heat exchanger. The metering devices are placed in the ducts to be able to monitor the air pressure. In addition; air humidity, airflow, CO_2-levels as well as air damper activity is recorded. The magnitude of the ventilation in the separate rooms is depending on the CO_2-levels, as this provides an appropriate estimator of the number of people present.

Water is registered through conventional water metering. However, as to separate the tenant usage from the remaining, multiple metering devices have been dispersed throughout the building. The meters, provided by the local water supplier, are EEG type approved. These are based on the EN1434 standard and revised by a third party accredited by SWEDAC (Swedish Board for Accreditation and Conformity Assessment) (Engström, 2014).

3.2. Väla Gård

This real estate consists of two separated two-story buildings, which have been connected via an annex. In all, the building consists of about 1 650 square meters (70 workstations). As for the technical installations, the building uses geothermal heating/cooling, solar cells to generate electricity and has a demand controlled ventilation scheme.

The building was commissioned in 2012, and had the ambition to be a net zero energy building, following the definition by Sveriges Centrum för Nollenergihus (Erlandsson, et al., 2012). The criteria's is based on the work by Sartori et al. (2012), which are summarized in Table 1. In addition, the building is certified LEED (New Construction) Platinum.

Criteria	Swedish definition
Physical boundary	In accordance to the Swedish building regulations. Hence, in general, the physical boundary is the building itself
Balance boundary	Energy used for heating, cooling and dehumidification, ventilation and humidification, hot water and permanently installed lighting of common spaces and utility rooms are included in the balance. Other services are not included in the balance (e.g. computers, copiers, TVs etc.)
Boundary conditions	Set point for heating (+21ºC) and internal heat gains is defined
Weighting system	Weighted energy is used, with static and symmetric weighting factors
Balancing period	1 year
Type of balance	Balance is calculated based on import/export
Energy efficiency	Fulfilment of Swedish Passive house criterion
Measurement and verification	To enable verification of the energy performance, energy metering must be separated into heat and electricity

Table 1: Summary of Swedish Net ZEB definition (Sartori, et al., 2012)

The monitoring system consists of 300 measuring points, which was in operation by May 2013. The ventilation scheme is a Demand Controlled Ventilation system (DCV), which adjusts to motion (via presence sensors), air temperature and CO_2-levels. The DCV is interconnected with the ventilation decks, in which monitor instruments that measures air flows, duct pressure and air temperature are installed. In addition, the relative humidity (RH) is logged for the separate rooms.

To monitor the energy usage, 18 energy meters have been installed in the building. In accordance with Swedish building code, the property and operational energy is logged separately. The building uses geothermal energy to supply the building with heating and cooling, as well as to heat the tap water. The tap water consumption is only logged for billing purposes, with a meter provided by the local water supplier.

All data is stored in the building's mainframe computer on an OPC[5] server, connected to a database where it can be accessed and analyzed. Data from the DCV system (including ventilation engines) can also be accessed via a web-based application. In order to minimize working hours, the real estate developer sought to implement a system, which process and analyze the data into a weekly standardized report. These automated reports could then be complemented with a more thorough revision, produced manually with lesser intervals (Kempe, 2014).

3.3. Utbildningshuset KTH

This building was, when the study was carried out, yet to be constructed, but is currently (september 2016) under construction. The ambition levels are high and the concept for the building is interesting enough to be part of the case study. As part of the campus for KTH (Royal Institute of Technology) in Stockholm, there is an idea to make the building as a sort of live in lab where the students will be able to access the information about the building as part of their education. The building will consist of 3500 m^2 over 7 floors that are designed for teaching and learning. It is planned to be in commission at the end of 2016. Apart from extensive possibilities to measure and monitor the building, a strong focus is set on low energy consumption, aiming for a level at least half of the guide value from the Swedish building regulations (BBR). Among the available certificates on the market, the decision landed on the Swedish certificate Miljöbyggnad, with the highest grade, gold, as target. Miljöbyggnad has a more narrow focus than for example LEED or BREEAM in that it is only the building itself that is of interest. Location of the building and activities within it are of no consequence. Since it deals with fewer parameters, the only way to achieve higher grade is to perform better for these parameters. The system was created with this specific purpose in mind to be tailored for Swedish conditions and easy to use.

The system that is going to monitor the building is specified in the technical descriptions in the specifications. There is no demand for the actual number of sensors required, but six different types of sensors are described that are needed to acquire the desired data from the building. These sensors will gather data concerning energy consumption, heating, cooling, air pressure, air flow, temperature and some sensors are also built into the walls and the foundation in order to provide information of how the relative moisture levels change over season and over time. These sensors specifically comes with a higher level of uncertainty, since one cannot be sure if changes are because of the material or the sensor itself.

Energy will be measured and presented in accordance with Swedish energy regulations and it will show the amount of energy bought from renewable energy sources versus conventional energy bought. The ventilation system will be a FTX system with heat recovery and ventilation will be controlled by CO_2 levels. Water will be logged for the entire building rather than by each floor since the tenant is the same for the entire building.

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[5] OPC = OLE for Process Control

The ambition for the building is also that the focus on low energy consumption and extensive logging and monitoring will be beneficial for the costs of maintenance and operation. However, as there is not much data available to prove this, KTH has had a hard time to get this into the contract with the owner of the building, a government company that owns and runs just about all the university buildings in Sweden. They see the higher construction costs and want to raise the rent accordingly, making the negotiations tougher than necessary when the user wants improved performance. One way to lower the costs for KTH has been to apply for government funds from the Swedish Energy Agency which has been granted. This means that apart from logging and storing the data concerning the performance of the building, KTH is also obliged to send data to the Swedish Energy Agency to display that the building performs as promised (Eriksson, 2014; Incoord; Edberg, Olle;, 2015).

4. Results from survey

4.1. Survey

The survey (see Appendix A) was sent out to 58 different employees at several of the largest private companies in commercial real estate in Sweden. Out of those, there were 13 that completed the survey, giving an answer frequency of just above 22%. The survey consisted of 26 different questions concerning which certification system they use, if any, how the companies measured the performance of their commercial buildings, what do they measure, how often and how is the data treated.

The first questions concerned if they worked with any certification system and if so, how much of their real estate portfolio was certified. Out of the respondents, three (21 %) answered <5%, two (14%) answered 10-20%, seven (50%) >20% and one was not sure. They all measure property electricity consumption on a regular basis, eleven of them (85%) does it every month, the final two have access to the figures on an hourly basis. The information is then stored in a central database for the entire corporation. The odd exception being one company that is buying a subscripted online service from the municipality that they are active in, this service gathers, stores and presents most of the metrics that the company is interested in. How this data is later used does differ a bit, but not very much, aside from one company, they all use it for statistics, follow-ups and operation optimization. Most also report the figures to tenants and in some cases a third party such as Swedish Energy Agency as part of an agreement. One company also uses the information for yearly climate impact calculations.

When it comes to tenant electricity consumption, there are four (31%) that do not measure it and nine (69%) that does. Seven of those that do measure it do it once a month (54%). The company that has bought that service uses the online service, called e-report, for this. The other companies store the data in their central database. The data is used mainly for information to tenants, statistics and follow-ups. Three of the companies use it for operation optimization and one also provides an app, where the tenant can see their consumption and follow changes, trends and savings in real time.

They all but one measure water monthly and the data is collected in the central database and used for mainly statistics and follow-ups. Five of the companies work with the data in their operating optimization. The e-report is used for this data as well. Another common feature is presence-controlled ventilation. Eleven (85%) of the responding companies answer that they have it in at least some buildings, six of these (46%) have it in more than 10% of their buildings.

The next part of the survey dealt with air quality, and unfortunately, the question was apparently formulated in an ambiguous way since the replies implicated misunderstandings from some of the respondents. What can be said from the responses is that measuring air quality in the sense of measuring particle levels aside from CO2 seems very unusual, and just about never done in a systematic way.

The following part of the survey dealt with waste, and it turned out that nine (69%) do measure waste, five of those (38%) separate tenant waste from waste from maintenance and operations. The last part dealt with thoughts on the future and metrics that are desirable but difficult to get reliable data on, and the main issue turned out to be tenant electricity. It should be noted that the survey had no questions regarding energy; this is mainly because in Sweden you are obligated to measure energy.

To sum it up, most companies that responded to the survey do work quite extensively with monitoring their buildings in various ways, as well as working with several different certificates. Worthy to note is that half of the respondents, albeit being representatives of a group of early adopters, said that more than 20% of their portfolio had one certificate or more.

5. Results from the interviews

5.1. First interview

Company 1 has chosen to work primarily with LEED. They feel that it is more encompassing than the Swedish system that is more directed towards just the building, and that their requirements for certification are a bit too low for their standards. LEED had a different advantage in that it had a system for volume certification, meaning that certificating the existing property portfolio could be done much easier. Because of this, 71% of Company 1 properties are certified, a figure that is comparatively very high. Company 1 has a philosophy with a very high focus on climate footprint and has ambitions to certify all their properties to as high a level as can be done. They have seen the role that real estate plays in the climate debate and are determined to act accordingly, and see it as their responsibility to do what they can to create sustainable real estate for the future. LEED EB&OM is in that regard the type of system that they work the most with and they feel that it works. EB&OM has several parameters that you have to present, not just show that you measure them, but the actual figures. Because of this, most of Company 1 properties have rather extensive installations for measuring performance, specifically in energy, water and waste. What they do feel that they lack is access to the tenant electricity, since focus is more and more going towards a supply-chain philosophy when it comes to sustainable work and improvement, much as other industries have already gone into. Company 1 feels that the existance of different certification systems on the market is not really a problem. In Sweden there are three, perhaps four, major ones and that does not feel like too many. Of course, there are new versions of all these systems coming out on a regular basis, but that is as it should be, since development and technology are constantly pushing the boundaries. In fact, if anything, the existence of several systems on the market is probably pushing the development more aggressively, which is a good thing. In the longer perspective, Company 1 (the interviewee) is hoping and believing that sustainable properties and construction will not only be the norm, but legislation will actually be put in place to prevent real estate that are bad for the environment and climate. One thing they feel that is needed to look into is the follow up on green bonds and options that are created in order to finance green buildings, but as of today there is no specific tool or system to evaluate if the end result actually came out as green as intended (Denell, 2016).

5.2. Second interview

Company 2 is a commercial real estate company based in Gothenburg with their entire portfolio in Gothenburg. Because of this, they make use of some regional benefits and systems in order to be updated on their buildings. The local energy company has an e-report available for an additional extra fee that is not too high, and thanks to this, Company 2 can have access to the performance of all their buildings just a few clicks away. The report can register such things as energy, water and waste. The information available about the energy also includes such things as usage, amount of energy bought, type of energy (however, as of today, not able to differ between green and ordinary energy) and when Company 2 does build it, they can also measure the amount of energy produced on site from solar power. The report system is logged in on the meters in the buildings, so Company 2 can have information by the hour. As it stands, they only produce monthly reports in order to check status and look for trends and malfunctions that have to be addressed. Company 2 works predominantly with three different certification systems, Green Building (EU certificate that only focuses on energy), BREEAM (Company 2 was involved in the first BREEAM certified property in Sweden, it was a demand from the client) and the Swedish system Miljöbyggnad. The main focus is on Miljöbyggnad, and that is the system they have chosen in order to try to certify a large part of their existing portfolio in. The main idea is to get at least the basic certificate for as many buildings as possible, but some buildings are simply not suited for certification, depending on age and so on. It is also of course a question of cost and revenue. They feel that Miljöbyggnad is easy to work with, and that a benefit for the system is that you are simply told which parameters to work with, where as in BREEAM and LEED, you need to choose your parameters, that is something that creates more work and extra costs (De Hollanda, 2016).

5.3. Third Interview

Company 3 owns and operates around 55 commercial buildings in Stockholm. Whereas they do not have a very strong focus on certificates, they are working towards certifying their portfolio in BREEAM In-use. What they do have is a very strong focus on energy and monitoring functionality in their buildings. The installation systems in just about all their buildings have a very extensive system of sensors, giving maintenance and operation a very powerful tool to optimize the performance of the building. They do measure water and waste as well, but that is not where the primary focus is. Ventilation is controlled by temperature, as opposed to CO_2 levels. They have done the occasional measurement of CO_2 emissions, but since the values were so low, that is also not a focus area. Their ambition is to be able to monitor the functionality and energy of the buildings with the aid of constant logs. The focus on consistent logging of the functionality of different areas in a building is something that they are, if not alone, then at least among the few to focus on. This means an enormous amount of data and of course, not everything can be kept forever, but Company 3 still has access to a large part of the history for their buildings. A problem with extensive monitoring is that when you are looking at functionality (for example a ventilation damper or elevator), in order to have any idea about whether that function is working properly, you need reference values, and these need to be calculated separately for each sensor. If you have hundreds or thousands of sensors, that makes for a lot of reference values that need to be calculated in order to have something to calibrate against. Company

3 has this for the most part, but there is still a long way to go before all buildings are up to the desired standard (Rosén, 2016).

6. Example of Key performance indicators (KPI) used by the industry

As in most industries, private initiatives to gain more complete knowledge about the industry are abundant in the real estate sector in Sweden. One such initiative is from the firm Incit. Among their products are a book series that collect statistics for comparison for different types of buildings. Their latest book for offices is the 36th edition, and provides statistics for 20 different KPIs for operational costs. These are: administration, property tax, property fee, insurance, Energy use – heating, energy use – cooling, electricity use – property, electricity use - tenant, water consumption, supervision and maintenance – ground, supervision and maintenance – building, supervision and maintenance - installations, waste disposal, cleaning, troubleshooting maintenance, planned maintenance – ground, planned maintenance – building outdoor, planned maintenance – building indoor, planned maintenance – installations and rent level. The data is collected from a large number of companies, but also from their own services as a consulting firm within the real estate industry. Overall, the material covers a total building area of 900 000 m^2 with an average area per building of 7 400 m^2, and roughly 120 commercial buildings. The office buildings included have a varied disposition concerning age that looks like follows:

Year of construction	Percential disposition
-1957	38
1958-1967	12
1968-1974	3
1975-1989	31
1990-1999	11
2000-	5

Table 2_Age of buildings in the Incit data-base

Directly relatable to this article are the parameters dealing with energy, electricity, water and waste. This show, together with the performed survey, that at least to some extent, monitoring of several of these parameters are already in place (Incit AB, 2016).

7. Analysis

The three buildings present interesting cases for how monitoring of building performance can be carried out. Today, the technology is available to monitor (and assess) a large number of building performance indicators, as to evaluate the building's sustainable features. The monitoring also makes it possible to more effectively fine-tune the building's installations in order to improve the building's energy performance and indoor environment. However, the interviews revealed that the information from the monitoring is used a bit differently. While the maintenance staff at Väla Gård used it to fine-tune the building's installations, the operating staff at Uppsala Entré used it to control that the building performed at an acceptable level (that is, in line with the agreement with the tenant). In the third case, as mentioned earlier, the information is also supposed to be a part of the education at the university and accessible for students for school projects.

The survey did not provide answers from a large number of actors on the commercial real estate market, but out of the ones that did complete the survey, several are among the top 20 largest actors in the commercial real estate industry, including the largest private real estate company in Sweden. This means that the answers from the survey still provide a useful insight into the behavior and trends in the market. It is also necessary to take into consideration that the companies that did complete the survey also belonged to the group commonly referred to as early adopters in sustainability, so the answers cannot be said to represent the industry as a whole. This was not the intention anyway, as the purpose was to see just how these early adopters worked with monitoring in order to identify the state of the art in the industry.

From the answers, there are some interesting points to mention. First, almost all of the companies that responded have certified at least one building, most of them more than 20 % of their stock. So certification is certainly something very relevant, and this is in line with the responses of the focus group that claimed almost all larger commercial buildings being constructed in Sweden today are certified by one or several of four certificates; LEED, BREEAM, Miljöbyggnad and Green Building. In fact, none mentioned any other certificate. This interest in certification gives an indication that sustainability characteristics are important for marketability.

As far as the performance indicators go, the survey did not bring about any large surprises; electricity, water, waste and CO_2 is commonly measured. They measure it, collect it and use it in much the same way. There are of course differences, but considering the number of respondents, it could be dangerous to draw any more general conclusions based on them. In the section with an open question with room for further comments, three of the respondents wished for access to more information concerning tenant activity, such as tenant electricity use and tenant waste.

The indicators gathered by Incit are interesting, even though the data still does not represent more than 120 buildings, and it seems like the companies in the real estate industry are not that interested in sharing their knowledge about their individual buildings.

The indicators that have been identified in the Incit initiative which has an environmental focus, the three cases in this paper and the ones represented in the survey is summarized in the table below.

KPI from Incit	Monitored KPI Case 1	Monitored KPI Case 2	Monitored KPI Case 3	Inquired KPIs from Survey
energy use - heating	energy use - heating	energy use - heating	energy use - heating	(redundant)
energy use - cooling	energy use - cooling	energy use - cooling	energy use - cooling	(redundant)
electricity use - property	electricity use - property	electricity use - property	electricity use - property	electricity use - property
electricity use - tenant	electricity use - tenant	electricity use - tenant	electricity use - tenant	electricity use - tenant
water consumption	water consumption	water consumption	water consumption	water consumption
waste disposal	(no info)	(no info)	(no info)	waste disposal
cleaning	x	x	x	x
x	Temperature	Temperature	Temperature	x
x	CO_2 emissions	CO_2 emissions	CO_2 emissions	Indoor air quality (CO_2)
x	Air pressure	Air pressure	Air pressure	x

Table 3 Overview of KPI´s used

Concerning the cases, the matter of waste disposal was never covered, hence the lack of information on that specific parameter.

It looks like there is some degree of consensus about which performance indicators to assess, but the interviewed real estate developers seemed to await an even more standardized method to monitor building performance. The lack of consensus could be because the majority of environmental assessment schemes do not request any monitoring in their assessment criteria's. This is unfortunate, as it has been shown that a building's performance often underperform the intended performance levels. In addition, agreements where the developer has to provide reports on the completed building's ongoing performance is very seldom used, a least in Sweden. What was also revealed in the interviews with the real estate developers is the confidence that the environmental certification process more or less ensure good building performance.

Earlier studies, for instance Eichholtz et al. (2010) and Fuerst and McAllister (2011) indicate that sustainable building brings about an economic additional value, such as rent and sales price premiums. However, for these premiums to survive the test of time, the buildings have to show that the benefits of sustainability (lower energy usage, better indoor environment etc.) are constant and lasting over time. If these benefits where to be uncertain, the tenants and real estate buyers will not be willing to pay any premiums.

Noteworthy in this study is that none of the developers had decided to monitor the actual quality of the indoor air quality (with exception of CO_2-levels). This is probably due to that most ventilation systems do not have the capacity to monitor and log for instance particle levels, and therefore additional equipment would have to be used. However, from the authors' point of view this would be beneficial in order to be able to verify a good indoor air quality. What also has been emphasized by Jarnehammar et al. (2015), is the monitoring of the building materials. As they deteriorate over time, they may cause unhealthy emissions in the future. However, in order to evaluate this, monitoring devises would have to be built into the building components, a very complex procedure that would require a broad cooperation between real estate developers, construction entrepreneurs and suppliers.

This paper has focused on commercial buildings alone, for offices, restaurants, cafés and a school building for university. Yet three different approaches was discovered from three different interviews; the larger owner with a big portfolio over a large geographical area that focuses strongly on certifying as many buildings as possible and a high ambition in CSR, the somewhat smaller owner with a strong regional focus and limited possibilities in their focus on sustainability that chooses a more simple assessment scheme and knows their limits as to which buildings they can afford to certify, and finally the rather wealthy owner that does not think too much about market value but have a business in owning and operating prime real estate with a long term perspective. They choose to basically ignore the certificates unless their tenants demands it, but at the same time, they arguably knows the most about their buildings since they put such a large emphasis on monitoring and optimizing the operation of their buildings. It would be very interesting in a further study to conduct a larger number of interviews among the real estate actors and see if there are other approaches and if some sort of categorization depending on size, structure and strategy could be discerned.

8. Conclusions and recommendations

The aim of this study was to review how leading real estate developers and property owners monitor in-use building performance today. Investors and valuation professionals should be expected to demand more complete knowledge about a buildings actual performance over time , and what this paper show is that at least some of the information required to answer those demands is already being gathered. However, it is not necessarily made public, the owners mostly keep the information for themselves in order to monitor and, at least to some degree, tune the operations of their buildings.

It is also important to note that some of the selected companies had no short run interest in the market value of their buildings, and that the company that put the most effort into monitoring their buildings is a long-term owner that focus on operating their buildings in an efficient way. This provides an insight into which kind of approach different real estate owners can take towards a sustainability assessment scheme.

It would seem that in many cases, we know more about our buildings than we think we do, but the information is privy to the owners and not necessarily made official and public. Perhaps the first step towards gaining more knowledge about how a building's sustainable performance might affect the market value is simply legislating that more information about the building should be made available. The technology is there, the possibilities are there and in many cases, it looks like the information is actually already there, we just need access to it, or rather, the owners need more incentives to gather and share that information.

A category that quite thoroughly is measured and monitored in the buildings from the case study, but is largely unaccounted for in the industry KPIs from Incit and is largely not addressed by the companies in the survey, is indoor air quality and indoor environment. Here there seems to be a gap, while even the new buildings do not measure levels of hazardous particles in the indoor air, all three have systems for measuring CO_2 levels to operate and calibrate their ventilation. In Sweden, there does not seem to exist any real interest in measuring levels of particles on a regular basis, but the answer to that is that the few measurements that have been done show such low levels of particles even in high traffic crossings at city centers, that it has yet to become an issue.

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Appendix

		1	2	3	4	5	6	7
Do you work with any form of certification system for your portfolio? Which ones?	Q1	LEED, Minljöbyggnad, Green Building	Miljöbyggnad, Breeam in use, Green Building	Breeam, Miljöbyggnad, Green Building	Breeam	Miljöbyggnad, LEED	Green Building, Miljöbyggnad	LEED
How large is the share of certified buildings in your portfolio?	Q2	<5%	>20%	10-20%	10-20%	>20%	Vet ej	>20%
Do you measure consumption of property electricity in a continuous way?	Q3	YES	YES	YES	YES	YES	YES	YES
How often do you measure consumption of property electricity?	Q4	Once a month	Once a month	The technology makes it possible to see consumption every hour	Once a month	Varje dygn, timvärden	Once a month	Every hour for new buildings, less when performance is optimized
How is data stored from these measurements?	Q5	Corporate database	Corporate database	Online service sold by municipality	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of the property electricity put to use?	Q6	Follow-up, Commissioning, Statistics	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party
Do you measure the consumption of tenant electricity in a continuous way?	Q7	YES	YES	NO	YES	NO	YES	YES
How often do you measure the consumption of tenant electricity?	Q8	Once a month	We measure our own every 10 sec and the same wherever we provide the tenant electricity	Some of the properties have we measure manually every month, others are remotely read every hour. In most properties we don't measure tenant electricity at all since tenants have their own contracts	Once a month	We measure some properties	Once a month	Once a month
How is data from these measurements stored?	Q9	Corporate database	Corporate database	Online service sold by municipality		Corporate database	Corporate database	Corporate database
How is the data from the measurements of tenant electricity put to use?	Q10	Information to tenants	Follow-up, Commissioning, Statistics, Information to tenants, Information to third party, Is presented in an app that the tenants can use to monitor, change and see the effects of their consumption in real time	Information to tenants, To invoice tenants	Follow-up, Information to tenants	Information to tenants	Follow-up, Statistics	Follow-up, Commissioning, Statistics, Information to tenant

Do you measure consumption of water in a continuous way?	Q11	NO	YES	YES	YES	YES	YES	YES
How often do you measure the consumption of water?	Q12		Once a month	Once a month	Once a month	Once a month	Once every three months	Once a month
How is the data from these measurements stored?	Q13		Corporate database	Online service sold by municipality	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of water consumption put to use?	Q14		Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Statistics	Statistics	Follow-up, Statistics
Do you own properties where ventilation is controlled and adjusted by presence?	Q15	YES	YES	YES	YES	YES	YES	NO
How large a share of your portfolio have presence controlled ventilation?	Q16	<5%	>10%	Don't know	>10%	>10%	5-10%	Don't know
Do you measure air quality in your buildings?	Q17	YES	NO		NO	NO	YES	YES
In how large a share of your portfolio do you measure air quality?	Q18	5-10%	Don't know	Don't know		Don't know	>10%	<5%
How often do you measure air quality?	Q19	Rarely	Rarely	Don't know			Every year	Rarely
How is data from these measurements stored?	Q20	Corporate database		Don't know			Corporate database	Specific database for that building
How is the data from measurements of the air quality put to use?	Q21	Follow-up, Commissioning, Statistics, Information to tenant					Follow-up, Statistics	Follow -up, Information to tenant
Do you have data on how much waste that is leaving a single property?	Q22	NO	YES	YES	YES	YES	YES	YES
From how large a share of you portfolio is that kind of data gathered and stored from?	Q23		>10%	>10%	>10%	>10%	5-10%	>10%
Do you separate the data of waste beloning to maintenance and operation of the property from the tenants?	Q24		NO	NO	YES	NO	YES	YES
Is there something you would like to monitor/measure regarding the performance of the properties that you feel you lack the possibilitie to do today?	Q25		We would like to measure property electricity every 10 sec, but the energy companies don't want to releas that information from their sensors	As the trend is leaning towards looking at the entire consumption in the building, we would like access to tenant electricity and energy	Would like to measure allot more, like temperature, air quality, sound, lighting etc			
Are there parameters from the ones you do measure that is difficult to get reliable data on? Which ones?	Q26		The electricity from the electric suppliers, they want their data for themselves	Sometimes it is mixed property electricity and tenant electricity on the same sensor, that makes life difficult	waste			

		8	9	10	11	12	13
Do you work with any form of certification system for your portfolio? Which ones?	Q1	Mostly LEED	Breeam, Miljöbyggnad, Green Building	Miljöbyggnad for existing portfolio and Breeam for new construction	Green Building och Miljöbyggnad	Miljöbyggnad	It is under revision
How large is the share of certified buildings in your portfolio?	Q2	>20%	10-20%	>20%	<5%	<5%	>20%
Do you measure consumption of property electricity in a continuous way?	Q3	YES	YES	YES	YES	YES	YES
How often do you measure consumption of property electricity?	Q4	Once a month	Once a month	Once a month	Once a month	Once a month	Once a month
How is data stored from these measurements?	Q5	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of the property electricity put to use?	Q6	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party, climate impact calculations	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Statistics
Do you measure the consumption of tenant electricity in a continuous way?	Q7	YES	NO	NO	YES	YES	YES
How often do you measure the consumption of tenant electricity?	Q8	Once a month	We measure where we forward the bill	We don't have access to consumption of tenant electricity	Once every six months	Once a month	Once a month
How is data from these measurements stored?	Q9	Corporate database	Corporate database	See Q11	Corporate database	Corporate database	Corporate database
How is the data from the measurements of tenant electricity put to use?	Q10	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Statistics, Information to tenant	See Q11	Follow-up, Commissioning, Statistics, Information to tenant		Follow-up, Statistics
Do you have data on how much waste that is leaving a single property?	Q22	YES	YES	NO	YES	NO	NO
From how large a share of you portfolio is that kind of data gathered and stored from?	Q23	>10%	>10%	Don't know	Don't know		
Do you separate the data of waste beloning to maintenance and operation of the property from the tenants?	Q24	NO	YES	NO	YES	YES	
Is there something you would like to monitor/measure regarding the performance of the properties that you feel you lack the possibilitie to do today?	Q25	Air quality is sometimes difficult to measure. It would be good with an easy way to monitor and follow up the tenants commuting	Consumption from tenants	Possibly the collected instantaneous effect and the energy status	We would like to improve the measuring of for example, geothermal energy. We measure, but we can improve		Energy and watern on the real estate where we lack the ability
Are there parameters from the ones you do measure that is difficult to get reliable data on? Which ones?	Q26	Sometimes it is hard to gain access to tenant electricityt	Waste recycling where tenants have their own responsibility		We can develop the carbondioxide equivalents more and spread the knowledge about them		

Do you measure consumption of water in a continuous way?	Q11	YES	YES	YES	YES	YES	YES
How often do you measure the consumption of water?	Q12	Once a month	Once a month	Once a month	Once a month	Once a month	Once a month
How is the data from these measurements stored?	Q13	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of water consumption put to use?	Q14	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Statistics, Information to tenant	Follow-up, Statistics	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics	Follow-up, Statistics
Do you own properties where ventilation is controlled and adjusted by presence?	Q15	YES	YES	YES	YES	YES	NO
How large a share of your portfolio have presence controlled ventilation?	Q16	Don't know	>10%	Don't know	>10%	>10%	<5%
Do you measure air quality in your buildings?	Q17	YES	YES	YES	YES	NO	YES
In how large a share of your portfolio do you measure air quality?	Q18	Don't know	<5%	Don't know	>10%		<5%
How often do you measure air quality?	Q19	Different in different buildings	Daily	Difficult to answer since the definition of air quality is not provided. CO² emissions is an indicator that we use in some cases, but then mostly to adjust ventilation etc.	Continuously, for instance CO² in certain facilities		Rarely
How is data from these measurements stored?	Q20	Specific database for that building	Specific database for that building		Specific database for that building		
How is the data from measurements of the air quality put to use?	Q21	Follow -up, Information to tenant	Follow -up, Commissioning, Information to tenant	See Q22	Commissioning		
Do you have data on how much waste that is leaving a single property?	Q22	YES	YES	NO	YES	NO	NO
From how large a share of you portfolio is that kind of data gathered and stored from?	Q23	>10%	>10%	Don't know	Don't know		
Do you separate the data of waste beloning to maintenance and operation of the property from the tenants?	Q24	NO	YES	NO	YES	YES	
Is there something you would like to monitor/measure regarding the performance of the properties that you feel you lack the possibilitie to do today?	Q25	Air quality is sometimes difficult to measure. It would be good with an easy way to monitor and follow up the tenants commuting	Consumption from tenants	Possibly the collected instantaneous effect and the energy status	We would like to improve the measuring of for example, geothermal energy. We measure, but we can improve		Energy and watern on the real estate where we lack the ability
Are there parameters from the ones you do measure that is difficult to get reliable data on? Which ones?	Q26	Sometimes it is hard to gain access to tenant electricityt	Waste recycling where tenants have their own responsibility		We can develop the carbondioxide equivalents more and spread the knowledge about them		

Sustainability Metrics and Property Value: The need for a standardized sustainability description

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Abstract

It is known that certified buildings can fetch a higher price on the market, but that it is related to the certificate rather than the performance. If those price premiums are to continue existing, there is a need to be able to prove that certified sustainable buildings also perform according to expectations. The aim of this paper is to try and identify a minimalized shortlist of performance metrics that have the potential to affect market price in commercial real estate. By addressing sustainability assessment schemes in comparison with the RICS sustainability checklist, Due Diligence studies and previous studies on what is technologically available, a shortlist comprised of nine key performance indicators is proposed that can help understand more about the connections between sustainable performance of commercial buildings and market price. The list covers the basic categories of emissions, energy, water and materials and can provide an idea of the environmental performance of the building while in operation. The idea is to use the information provided from this shortlist in valuation reports, and in this way it will be possible to identify connections between specific performance metrics and market price in the future.

1. Introduction

There is a considerable amount of literature about valuation of sustainable (commercial) buildings in general, and also more specific literature, with a focus on the value of buildings with high grades in an environmental classification system, and about how valuation of sustainable building relates to ordinary valuations.

One important starting point for this study is that the environmental classification systems that have been the predominant way of showing that a building is sustainable, typically only considers the characteristics of the building when it was built. Many of the certificates, or ratings that those systems lead to, are also based on projected models of performance and not on data on actual performance (see Sundfors et al 2016). From an investor perspective and a property valuation perspective, the most interesting information concerns a buildings actual current and future characteristics and not theoretical estimations at a specific point in time. The question is then what are necessary information relating to sustainable performance that can be continuously updated and preferably monitored in real time. RICS has presented a Sustainability Checklist that can be used for all property valuations, and the first part of this paper discusses the relation between the characteristics that is included in that list and the characteristics that is included in some dominating environmental classification systems and the measurability in them.

The second step is to link this information to available technical systems for measuring building characteristics and current practices in the Swedish real estate market. Interviews, surveys and technical literature from the industry have been used to give insight into accessible and desired data.

The last step is to try to identify the sustainability dimensions that are especially interesting to monitor from a valuation perspective. Both the Sustainability Checklist and the environmental classification systems include very long lists of variables, and the question is if it is possible to make a shorter list that is easier to use in day-to-day valuations. The more specific and final aim of this study is to try to develop such a short list, with parameters that are easy to understand, technologically available and likely to be important for property value. This kind of information could be included as mandatory "Sustainability description" in an appendix to a valuation report, such a description would be a simple and valuable tool to increase our knowledge about the environmental performance of a building that can be expected to be important for the value of a building.

2. Method

The methods used in this paper were chosen to identify measurable parameters for environmental performance that are likely to have an effect on value. In the different parts the results are also linked to previous literature.

2.1 Relating the RICS sustainability checklist to environmental rating systems and Due Diligence

This part of the work is primarily a document analysis where the criteria in different systems are identified and compared in a systematic way. This part of the article is based on Ytterfors (2014) – a Master´s thesis that was written as part of our project.

2.2 Identifying the most relevant dimensions

Through a literature review and a survey conducted among real estate companies in Sweden, the most recurring and relevant parameters are identified. An online study of 29 real estate companies was also done in order to see how they choose to present themselves online, if sustainability and certified buildings is something that they use as part of their public profile. The main idea behind this study was to gain a deeper understanding of how important different companies believe that information is to the public. It also provides some insight into the number of actors on the market that actually work with sustainability assessment schemes. Since the study was made online, there is of course the possibility that a company can have a developed agenda for sustainability work and can have one or several certified buildings without disclosing that information on their web-site and this should be taken into consideration when evaluating the results. Nevertheless, the study still provides information on how common it is in Sweden today to work with sustainability assessment schemes.

2.3 Technical possibilities

This part of the article is primarily based on analysis of technical systems that were implemented in a number of newly developed buildings with a high ambition for environmental performance. The technical systems in these buildings are described more in detail in Sundfors & Bonde (2016). The internet study of the respective home pages for the real estate companies in Sweden also provides information on what kind of technology that is widely available, not the systems in themselves, but what types of information that can be gathered with them. This primarily concerns companies that have chosen to have a sustainability report as part of their yearly financial statement as suggested by the Global Reporting Initiative (GRI) in their G4 Sustainability Reporting Guidelines (GRI, 2016).

3. Literature review

In the area of sustainability metrics, Lorenz and Lützkendorf made an extensive literature review in 2011. As a result of this review, they identified eight common points that give a good overview of the status of sustainability knowledge in the real estate industry (Lorenz & Lützkendorf, 2011). These are:

- Some sustainable issues, predominantly energy-efficiency features, can be seen to have measurable impacts on observed property prices.
- Other issues, such as comfort, are likely to have an effect on price, but available data is not enough to draw any conclusions to what extent.
- Some issues might have more of an indirect effect by, for example, good PR.

- In the short term, green/sustainable buildings will enjoy a price premium, in the long run, the conventional buildings will depreciate faster than their sustainable competition.
- There is no straightforward or automated formula to value sustainability, the impact is also very much dependent on regional conditions.
- In order to include sustainability at all in a valuation, you need to focus on functional qualities of the building in question and describe and evaluate its sustainable performance.
- There is more data needed from transactions and more market research needs to be done (a quote is also that no new valuation methods are needed).
- More information about buildings and their valuation needs to be made accessible and public.

There are also three different approaches available, according to (Lorenz & Lützkendorf, 2011) as to how one can implement sustainability in a valuation. The first (and from many perspectives the most preferable) is to make direct adjustments for single input parameters. This approach is however also the most laborious one for the valuation professional, and good scientific evidence need to be in place concerning the cause and effect of all these parameters, which is not available today.

The second one makes a lump sum adjustment, and is what it sounds, you take all parameters, create a sum that you adjust the price with. This makes it easier to calculate with incomplete information and less labor intense, but also makes it less transparent. The method is used in German speaking countries, but is not commonly used internationally.

The third method uses a sustainability correction factor, typically as a percentage adjustment. The same critique as for the second approach is relevant also here, but these last approaches might on the other hand be necessary until more information is available concerning the cause and effect of different sustainability factors on price, a sort of 'transitional bridges'.

As it is, (Lorenz & Lützkendorf, 2011) argues that consideration of sustainability issues can be addressed with all the commonly used traditional valuation methods, and they provide formulas for comparable sales, replacement cost and two types of investment method (one being German). Lorenz and Lützkendorf also present a valid discussion of how to put a specific figure to a specific sustainable parameter when you are using a distinct formula in order to calculate market value. The main issue is this; if you put a specific figure to a specific parameter, how will you defend it if challenged? Furthermore, they bring up an interesting discussion that more or less started by Muldavin (2009) that the process involved when making a valuation is inherently qualitative in nature, even if it makes use of different quantitative tools and statistics.

The literature on how sustainability features affect value is quite extensive and are, at least on one point, conclusive in their results; a vast majority of available studies show a positive relationship between sustainability/energy efficiency and value. The problem lies in knowing the magnitude of the effects, as the effect can depend on regional differences and the environmental readiness of the market can make property values differ between 10-35 %

(Lützkendorf & Lorenz, 2011). Results from one market cannot therefore be translated to another market.

The (Lützkendorf & Lorenz, 2011) article can be summarized in three distinctive points, possibly four. Sustainability issues affect the value of the building, this we can be sure of. The lump-sum and correction factor methods to take sustainability into account in a valuation process is not very good, mostly because of the risk for double counting (since some sustainability issues are already covered in traditional valuations) and because they are less transparent. The authors propose an integrated approach, based on a determined list of categories that should be involved in the valuation process. They also, as many times before and people before them, conclude that there is a great need for more available information on our buildings. We also need to think about how to get this information, how to use it, how to store it and how to make it available.

Wagner, o.a., (2014) gives a short presentation of the results from a governmental initiative and research project concerning the performances of commercial buildings involved in EnOB (Energy Optimized Building). While the article is short, the material that the conclusions are based on is quite extensive. 53 buildings have been monitored and evaluated over a period of 15 years. The results are both expected and somewhat surprising. Energy-wise, all buildings performed admirably, but an important observation is that while bought energy can be allocated to green energy, the same cannot be said for electricity. 76% of CO_2 emission could be traced back to electricity consumption, meaning that CO_2 neutral generation of electricity is of vital importance for climate neutrality. The economic valuation provides important insights in that lower building specific energy costs could be observed. No figures on how much lower though. On the other hand, it was also observed that energy efficient buildings could be built with little or no additional costs (less than 5%). It was also shown that energy efficient, and as a consequence, more technologically complex buildings, does not mean higher maintenance costs. Somewhat surprisingly, occupant satisfaction was in no way affected in a positive way by energy efficient buildings. During winter time, there was no difference, but during summer time there could be an observed lower satisfaction with indoor climate in the energy efficient buildings. Results are based on 3800 data sets from 38 buildings, of which 15 where conventional and 23 were from the EnOB program. This was however explained by the fact that in the EnOB buildings, the occupants' possibilities to adjust indoor temperature where more limited, and also, they had different indoor space concepts. The EnOB buildings had 17% of the indoor space as open-plan offices and group offices, compared to only 4% of the conventional ones. While it might be productive, it also creates noise. There is definitely room for improvement in indoor temperature and in air quality optimization. So energy performance is not indicative for occupant satisfaction, for this, space design and workplace conditions are still the crucial factors (Wagner, o.a., 2014).

Quality-wise, installed technology proved to be surprisingly resilient. Installed vacuum insulation systems where still after 10 years working almost completely without fault with little to no failure to the systems. In their final argument, (Wagner, o.a., 2014) discuss the fact that older buildings only receive monitoring possibilities or certificates in case of major renovations, but the current renovation rate in Germany is only 1%. This needs to be addressed in order to make the whole building stock more sustainable. They argue for multi-disciplinary efforts to accelerate this process. In a last note, they also address an interesting point, considering that the main focus for this project was energy, and that is that the more advanced buildings, that can produce and deliver energy themselves, demand different capacity in the electrical grid. The question of grid infrastructure and capacity can become a rather important factor in the future for the real estate sector, if more and more buildings choose to produce, store and sell its own energy.

In 2012 (Lützkendorf, o.a., 2012) did a summary of the development of sustainability assessment tools over the past decade. Now, in Sweden, after reading this article, it feels like we are a bit behind. Perhaps not in certifying according to already developed systems, but as they show quite clearly, there is a whole lot more to it than this. The authors refer to a selected number of activities, initiatives and tools, developed in Europe, mostly with the assistance of EU (the 'seventh framework program' is mentioned more than once), and just those selected ones are nine to the number, none being LEED or BREEAM. They also mention a rather extensive list of academic articles that have treated the subject of sustainability assessment methods (6), comparisons of systems (8) and general issues of assessing the sustainability of buildings (2), 16 articles in total. ISO has even released a standard for how to develop suitable sustainability indicators, and how to assess the environmental performance of a building. It does look like the real estate industry has invented the wheel over and over again. One other important piece of information from this article is the statement that one cannot really talk about sustainability without a life-cycle approach, since sustainability requires a long term perspective. Consequently, topics such as durability, resistance and adaptability come to the forefront (Lützkendorf, o.a., 2012). This also means that sustainability must be monitored continuously.

4. RICS

Royal Institute of Chartered Surveyors (RICS) saw in 2009 that there was an interest and a need to expand the environmental assessment of buildings in a systematic way. As a result, RICS produced the Guidance Note on Sustainability and Commercial Property Valuation in 2012, and around the same time the Sustainability Checklist that listed a number of factors that a valuation professional should pay attention to in their report, regardless if they had a verified impact on market price or not. Since then, RICS produced an "Application of the RICS Valuation – Professional Standards in Sweden, 1st edition (English language)" with an effective date of 1 May 2016. This document is meant to cover, among other things, sustainability and environmental matters. It is however, only available by RICS professionals.

4.1 RICS Sustainability Checklist

The sustainability checklist contains 38 parameters under four categories; these are presented in the boxes below (RICS, 2016).

Location

How accessible is the property to:
- public modes of transportation?
- private environmentally friendly modes of transportation?
- users with special needs (e.g. physical disability)?
- green and open areas?
- user-relevant basic services?

Site considerations

What is/are the:
- land use and likelihood of achieving a change of type and quality of land use?
- current and planned on-site defenses against environmental risks?
- likely or known on-site contamination?
- building´s exposure to sunlight/shading?
- conditions of the soil (e.g. bearing capability, potential for geothermal energy usage?

Building

In relation to the building´s specification, condition and configuration, what is/are the building´s:
- energy asset rating (if one exists)
- energy performance (consumption of non-renewable resources during use)?
- carbon dioxide emissions?
- source of energy sources available and/or used?
- service in relation to age and efficiency and future life expectancy?
- potential for energy renewal usage?
- likely risks to the local environment through emissions, etc.?
- water consumption during operation?
- water conservation or installation of measures to promote water use efficiency?
- waste reduction facilities (e.g. on-site waste segregation for recycling?
- capacity to be adaptable/flexible to enable it to be used differently in the event of changing demand patterns?
- likely resilience to the consequences of climate change (e.g. storm damage, maintaining usability if temperature change ensues)?
- barrier-free accessibility to and inside the building (e.g. for disabled users)?
- safety under extreme conditions (such as fire and tempest?
- design and construction in relation to its ability to facilitate future re-use and recycling of material in the event of refurbishment and/or demolition?
- health impacts in relation to building material and building specifications (daylight/natural ventilation)?
- ability to support user comfort (thermal conditions, visual conditions, acoustic conditions and indoor air quality)?
- overall likelihood to maintain a long future life based in the developing sustainability agenda including the periods between refurbishments?
- availability of solutions to resist environmental risks (e.g. flood prevention schemes for buildings at risk)?

Documentation

What documentation is available in relation to:
- statutorily required certifications or ratings (e.g. as required in the EU under the Energy Performance in Buildings Directive)?

- voluntary certifications, including the date granted and the grade achieved (e.g. LEED, BREEAM, etc.)?
- any other externally verifiable evidence of sustainability (e.g. winner of any sustainability-oriented design awards)?
- building passports/building files (in the sense of object/building documentations along the building life cycle)?
- ground expert testimonies, building diagnostics, blower-door-tests, etc.?
- planning documentation that supports claims of sustainability?
- life-cycle assessments, ecological footprint analysis, etc.?
- lease terms that encourage or mandate behaviors and standards in relation to environmental and social factors?
- management of the building in line with ethical/social responsibility goals (e.g. Environmental Management Systems, etc.)?

4.2 RICS Sustainability Checklist and international sustainability assessment schemes

Internationally, the most commonly known certifying systems are LEED and BREEAM, while there are other systems such as DGNB, Green Star and different EU initiatives that are becoming increasingly more popular, but LEED and BREEAM can still be said to be the most used. From that perspective, it would be interesting to see how the checklist developed by RICS relates to these two certifying systems. From a brief look, they are all constructed in much the same way, with overhead categories that are broken down into specific parameters. Many parameters are similar but of course not all, but what can be said is that all three can be considered bottom-up systems as defined by Lützkendorf and Hajek (Lützkendorf, o.a., 2012), in that they start off from a perspective of specific, known environmental issues and try to encompass those issues using existing indicators. Since the aim for this article is to look at (practical) measurability, the certificates for LEED EB:O&M and BREEAM In-Use are the most relevant to relate to. Those two are the same type of certificate that demands actual performance data and that are only valid for a shorter period of time before they need to be re-evaluated. In the case of BREEAM In-Use, the period is one year and for LEED EB&OM, the period is *at least* every fifth year with an option for yearly verification.

A complete comparison is difficult to do due to lack of transparency (Roderick, McEwan, Wheatley, & Alonso, 2009) and the fact that they all are based around different concepts. At first glance, LEED and BREEAM looks rather similar, but BREEAM has a large focus on CO_2 emissions and climate impact so most of their credits are related to emissions. BREEAM also provides ten different key performance indicators along with their In-Use scheme and these are not directly relatable to the assessment itself, but are seen as a way to help with assessing specific performance levels. The KPIs are presented in the table below:

Table 1 List of the ten KPIs developed for the BREEAM In-Use assessment scheme

KPI	Description	Measurement
KPI 1	Building CO_2 (kgCO_2 eq pa[3] per m^2 GIA[4])	The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from direct fuel use at the asset (for electricity, heating and cooling) consumed during the reporting year.
KPI 2	Building CO_2 (kgCO_2 eq pa[3] per FTE[5])	The mass of CO_2 eq[1] per Full Time Equivalent[5] personnel employed at the asset arising from the fuel and

		electricity consumed by the asset during the reporting year.
KPI 3	Business CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4]) Staff CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4]) Goods Transport CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4])	The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from business travel by personnel (based at the asset) and from goods (dispatched from the asset) during the reporting year. The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from business travel by personnel (based at the asset) during the reporting year. The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from business travel associated with goods (dispatched from the asset) during the reporting year.
KPI 4	Staff Commute CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4])	The mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from personnel travel to and from the asset during the reporting year.
KPI 5	Total CO_2 (kgCO_2 eq pa[2] per m^2 GIA[4])	Total mass of CO_2 eq[1] per square meter of the asset (GIA[4]) arising from the fuel and electricity consumed by the asset, business travel of personnel based at the asset and transport of goods dispatched from the asset, during the reporting year.
KPI 6	Building Primary Energy (kWh pa[2] per m^2 GIA[4])	The kilowatt hours per square meter of the asset (GIA[4]) of fuel and electricity consumed by the asset, measured in terms of primary energy[6] equivalent, for the reporting year.
KPI 7	Water Consumption (m^3 pa[2] per m^2 GIA[4])	The cubic meters of water consumed by the asset in the reporting year per square meter of the asset (GIA[4]).
KPI 8	Total Waste (tons pa[2] per m^2)	The tons of waste removed from the asset during the reporting year per square meter of the asset (GIA[4]).
KPI 9	Proportion of Waste Recycled (%)	Percentage of total waste produced by the asset which is recycled.
KPI 10	Proportion of Waste to Landfill (%)	Percentage of total waste produced by the asset which is sent to landfill.

[1] CO_2eq — Carbon Dioxide (CO_2) equivalent: a measure of the global warming potential of different greenhouse gasses in relation to that of carbon dioxide; it is defined as the amount of carbon dioxide that would give the same warming effect as that of the greenhouse gasses being emitted.

[2] kgCO_2eq — Mass (in kilograms) of CO_2 equivalent.

[3] pa — Per annum

[4] GIA — Gross Internal Area: the whole enclosed area of a building within the external walls, taking each floor into account and excluding the thickness of the external wall.

[5] FTE — Full Time Equivalent: a unit which is used to measure the people employed, or studying in a comparable way, even if they work or study a different number of hours per week. A full time employee or student is counted as 1 FTE, a part-time worker/student will be measured proportionally to the number of hours they work in comparison to a full time person.

[6] Primary — Energy which has not been subjected to any transformation or conversion process.

(Summerson, Atkins, & Harries, 2016)

It must also be noted that while these KPIs do not cover the entire scheme, they do cover the areas of CO_2 emissions, energy consumption, water consumption and waste. LEED EB:O&M is constructed around the same categories and parameters as all other LEED schemes (Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Operations and Regional Priority), the difference being that actual performance data is required for the ones that can be measured in order to receive or keep the certificate. Those parameters are many to their numbers, the total number of available points in LEED EB&OM is 110, but they also cover, among other things, the same areas as the KPIs provided by BREEAM In-Use: CO_2 emissions (Energy and Atmosphere), energy consumption (Energy and Atmosphere), water consumption (Water Efficiency) and waste (Materials and Resources) (US Green Building Council, 2016).

Out of the 41 factors mentioned in the sustainability checklist from RICS, only three of them can be said to be continuously measurable and provide an indication of the performance of the building: energy performance, carbon dioxide emissions and water consumption. There is a parameter that also concerns waste, but it only takes into consideration whether there are waste reduction facilities present. The rest of the factors mostly deals with information concerning the site, location and if necessary conditions to measure or recycle etc. are available. The list covers the same basic areas as BREEAM and LEED, but asks different questions in relation to them and as a consequence, few can be answered by logged performance data.

Perhaps the most interesting difference is that the RICS´ checklist has a somewhat more dynamic perspective and also include some aspects related to the *potential* of the building and not only the current characteristics of the building. This is a notion that has come to the forefront when talking about sustainable real estate in academia. As mentioned before (Lützkendorf, o.a., 2012), a life-cycle approach is vital when talking about sustainability, so a building that is constructed for one purpose only and is very hard to adapt to a different purpose cannot be considered very sustainable.

4.3 RICS Sustainability Checklist and traditional Due Diligence analysis

4.3.1 Traditional Due Diligence for transaction purposes

The typical process when a commercial property is sold in Sweden is that the seller presents a prospect with basic information about the property. Then there is a preliminary round of bids after which a small number of potential buyers are identified. These buyers then each carry out a detailed and rather costly Due Diligence of the property.

This traditional Due Diligence study typically involves the following elements; see Strand (2014) for further references:

- *Legal*: investigating ownership claims, easements, building rights according to the city plan etc.

- *Financial*: analyzing rental contracts and other economic commitments related to the property, tax aspects.

- *Technical*: analyzing the status of the technical systems in the building.

- *Environmental*: Historically this focused on contaminations in the building or in the ground, but today it can be broader. The content of this part will be discussed further below.

As there is no independent party that does due diligence studies, the costs increase compared to Environmental Assessment schemes as each potential buyer makes their own Due Diligence study - even if the seller can help by creating a "Data room" where the potential buyers can access data about the property. As Strand (2014) discusses, it could be more efficient if the seller could do an evaluation that could be used by all potential buyers, but there are moral hazard problems that can make this difficult.

If a sustainability checklist should be added to the material produced before a transaction, this raises the question; who should carry this out and how can we avoid a situation where each potential buyer has to make their own sustainability checklist in order for them to trust it? Strand (2014) asked actors about the need for standardization, but it turned out that there were very diverse opinions on that issue. It was, however, noted that standardization was more common in other countries (p 58).

Strand argues that at least a common framework, like the standard rental contract could be good. He also mentions a number of other development possibilities:

- Reduce the size of the report, but focus on deviations from what is normal instead of a complete description.

- Increase the amount of information that the seller provides initially in the sales process (increase the information in the prospect). It was however found that some of the information provided through the due diligence process was new also to the seller. It was not believed that this could completely replace the due diligence carried out by the potential buyer.

4.3.2 Environmental information in current valuation reports

Jernberg (2015) made a small investigation into the need to add more environmental information to the current Due Diligence investigations that are carried out on the Swedish property market. A questionnaire with a small number of questions was sent to 57 property companies, of which 14 responded, giving an answering ratio of close to 25%.

The questions concerned to what extent different environmental factors are taken into account in valuation reports. The answers were as follows:

Table 2 To what extent factors are covered in valuation reports (Jernberg 2015)

Categories	Yes	To some extent	Not at all
Public transport	64%	36%	0%
Private transport	43%	50%	7%
Recreational Areas	29%	21%	50%
Service	64%	21%	14%
Known environmental risks (floods, storms etc.)	50%	21%	29%
Exposure to potential dangers created by man	14%	50%	36%
Emissions (exposure to noice, dust etc)	29%	64%	7%
Use of land	79%	14%	7%
Probability to reach a change in type and quality of land use	50%	29%	21%
Ongoing and planned measures concerning environmental risks on site	36%	50%	14%
Probable or known contamination of the site	50%	36%	14%
The buildings' exposure to sunlight/shade	14%	14%	72%
What kind of state the ground is in	29%	64%	7%
Energy access grading (if it is available)	28%	36%	36%
Energy performance (consumption of non-renewable resources)	29%	42%	29%
Carbon dioxide emissions	14%	43%	43%
Energy sources that are available and / or are in use	43%	43%	14%
Potential for renewable energy	7%	57%	36%
Water consumption during operations	29%	50%	21%
Water usage	29%	14%	57%
Facilities to reduce / recycle waste	21%	43%	36%
Ability to facilitate future recycling of material	7%	14%	79%
Effects on health in regard to the building (daylight, natural ventilation etc)	14%	29%	57%
Ability to support user comfort (indoor air quality, thermal-, visual-, and acoustic environment)	14%	57%	29%
Probability to maintain a long life cycle, from an environmentally sustainable agenda	7%	31%	62%
Access to solutions to resist environmental risks (flood protection for buildings in risk zones etc)	29%	14%	57%

Considering the relatively low response rate in the study (25%) it can be suspected that the results represent the companies with a higher interest in environmental issues. Some figures are rather expected, such that most, at least to some extent, consider energy performance. Others are a bit more surprising, such that effects on health are rarely taken into account, but that is most likely due to difficulties in measuring that impact. Another figure that stands out is that exposure to sunlight/shade is not considered very important with 72% of the respondents saying that it is not covered at all in valuation reports, the same is true for the ability to facilitate future recycling of material (79%).

5. Online study

In September 2016, a study was conducted online by observing the homepages of 29 real estate companies in Sweden with at least some number of commercial buildings in their stock. The study was done by accessing the companies' home pages and looking for easily accessible information about their environmental and sustainable profile. A thorough search of every homepage was not done, if the information was not up front and visible, it was not considered to be present. The sizes of the companies varied greatly from small family-owned companies with the odd commercial building in a medium sized Swedish town (estimated population of 30 000 inhabitants) to the largest real estate company in Sweden. The aim of the study was to see what information about the sustainability of their commercial buildings that were presented.

In this study, the results where that 14 of them have at least one certified commercial building and 9 of them construct their yearly Financial Statement according to the Global Reporting Initiative sustainability reporting guidelines G4 (GRI, 2016).

Concerning certificates, the website does not in all cases specify which particular certificate that has been awarded, and since the study was made solely online, there is a risk that the information might not be up to date or that a company might very well have certified buildings that they simply have not presented on their homepage. But most certificates do have the categories of emissions, energy, water and waste as part of their schemes. In the cases that specific certificates where mentioned, the most common ones were Miljöbyggnad, LEED, Green Building and BREEAM.

GRI originated from two different non-profit organizations in USA and was founded in Boston in 1997. Today it is an international independent organization with the goal of helping businesses, governments and other organizations to understand and communicate the impact of business on critical sustainability issues such as climate change, human rights, and corruption. Their guidelines for sustainable reporting are used by thousands of businesses spread over 90 countries. G4 is their latest standard for sustainable reporting and it requires that you yearly report aggregated numbers in the already mentioned categories of emissions, energy, water and waste as well as a considerable amount of additional information. The development of the standard is described on the organizations' web page (GRI, 2016). The standard is constructed to be used as a part of the yearly financial statement of a company and as such, it does not provide information in detail for a specific building or activity. But, being able to disclose the aggregated numbers means of course you need the ability to gather the individual numbers. Also, the companies that did use the G4 guidelines for their financial statements where without exception larger commercial real estate owners.

6. Ability to measure and monitor

A survey was conducted in 2015 that went out to 58 company representatives in Sweden to get information on how their companies monitored their buildings, which parameters were logged and how often (see Appendix). The survey had a total of 14 respondents, which is not a large number, but it can still be said to be representative of the more ambitious companies in commercial real estate. Together with the online study done for this paper, there is strong evidence for the possibilities to measure performance within emissions, energy, water and waste. To get a more diversified picture on which performance indicators that are commonly used for office buildings, data was also collected from REPAB (Incit AB, 2016), that confirmed that the technological availability is already in place to consistently monitor and gather data on a wide range of performance indicators.

The one parameter that is not commonly built into existing installations as of now, is the level of air particles inside buildings. However, results from most such measurements done in Sweden on a more occasional and random basis, where an outside contractor is doing the measurement, show that it is not of great concern and as such, the interest is not great to incorporate that technology into the standard systems for the time being, at least not in Sweden.

7. Analysis

While it is possible to identify important measurable parameters that can be shown to have an impact on property value, the problem still stands to how great the impact really is. Energy efficiency can present an example. An energy efficient building can reasonably fetch a better price, but we don't know how much better. The reason for this being that the information about the energy efficiency does not come in relation to transaction price in the extent that it needs to, in order for the connection and magnitude to be verifiable. Also, the parameters that are interesting to monitor over time cannot alone deduct the sustainability value of the building, sustainability is more complicated than that.

This view should not, however, stop us from monitoring, measure and log the performance of our built environment, since we still need to know more about the impact of our buildings on the environment and for that, we need the data. In the future, if we have had access to the right tools to monitor our buildings over longer periods of time, and at the same time have had opportunity to register the performance in relation to transactions, then we have a greater possibility to causally relate specific environmental performances to property value.

From previous literature and the work conducted in relation to this article, four distinct categories for measurable environmental categories can be identified: *Emissions, Energy, Water and Waste.* These are the ones that in one way or another re-appear in assessment schemes, domestic or global initiatives, and that also to a great extent are already measured by at least the larger actors on the market. It seems logical to let these categories be continuously measured in order to receive a more complete view of the performance of the building. Other parameters also have a big impact, some even greater, such as *adaptability and location,* but these are factors that does not need continuous monitoring in the same way. The four categories can also be broken down into more specific parameters, such as CO_2 emissions, indoor air quality concerning particles, energy efficiency, amount of energy bought, amount of energy produced, type of energy bought, property energy consumption and tenant energy consumption, amount of waste to deposit, amount of waste recycled etc. Between them, logging data on these four categories could to a great extent increase our knowledge about our buildings and how they perform over time.

Emissions today primarily deal with CO_2 levels rather than particle levels. This is done by calculating CO_2 equivalence based on fuel and electricity consumption for the building as exemplified by several of the KPIs from BREEAM In-Use. At least in Sweden, this is also pretty much the only interesting one, since several measurements made in high traffic areas have shown very small levels of hazardous particles in the air. From a more global point of view though, particle levels in the air is a good idea to keep tabs on for health issues. This gives us two figures of interest in the emissions category: CO_2 emissions and particle levels indoor.

The category of energy will benefit from being explained in further detail. As Wagner, o.a (2014) mentions; bought energy can be allocated to green energy, the same cannot be said for electricity and 76% of CO_2 emission could be traced back to electricity consumption, meaning that CO_2 neutral generation of electricity is of vital importance for climate neutrality. In Sweden, when talking about energy, you generally are referring to costs that are connected to temperature; heating the building in winter and cooling it in summer. This is because a large amount of the buildings in Sweden are heated with district heating, and in those cases, you pay a cost for the amount of energy bought. On the other hand, if you for example have a solution with radiators working directly on electricity, you obviously do not buy energy; in that case you buy electricity. The difference being basically that in the first case you pretty much buy temperature and in the second case you buy a type of energy that can be used for multiple things, temperature included. As seen previously in this article, schemes like RICS and BREEAM refers primarily to energy only. Also, energy for heating is a bit more complex to measure, since you need a calibrated sensor that measures temperature and flow of heated water in an insulated pipe, a technique that as of today still has a noticeable margin for errors. Electricity, and the equipment associated with it, is a lot more precise, and sensors that measure amounts of electricity have been reliable for quite some time. To make things a bit more complicated, the Swedish department of energy has made it mandatory to account for both property electricity (electricity needed to have the building up and running) and tenant electricity (basically everything else that can be associated with the activity happening in the building). Where to draw the line between these two categories is not always easy, many things can complicate it depending on number of tenants and the activities taking place in the building. Who is to pay for the electricity demanded by the elevators? Or the lighting in the entrance?

So what is the most interesting among these aspects from a sustainable valuation point of view? The first things that come to mind when talking about sustainability is energy efficiency and clean, or green, energy. Energy efficiency or total energy consumption is a reasonable figure of interest given the information provided in this article, but we also know today that the capacity to provide large parts of the world with green energy is more than feasible, even if we still have a long way to go (Sovacool & Watts, 2009). Therefore an even more interesting figure could be the ratio of energy consumed to energy from renewable sources. Combining this with the total energy consumption, we get a good indication of energy efficiency and also how green the energy that is used actually is. Since both delivered electricity and delivered energy from district heating is presented in the unit of kWh or MWh, this should not present any problems. There is also one more aspect to consider in this matter. Buying green energy is a decision of the tenants, so it does not necessary provide much information about the performance of the building, even if it does give us information about the environmental impact. To address this matter further, we can consider the possible production of green energy on site. This provides us with three more figures of interest: Total Energy Consumption, Net Green Energy Ratio and Green Energy Production.

Water is the next category, and it should be rather straight forward. We absolutely need to lessen the usage of water, especially fresh water. If the IPCC report was not enough, then in any case most of the developed countries today already measure, and charge for, provided fresh water. It is something that in a large extent already is in place. In order to promote solutions where a property can produce its own water for at least some of the needed use, monitoring the total amount of fresh water bought sounds reasonable, rather than some sort of figure divided by space or area. In order to further promote solutions with on-site production, we can add two more figures of interest: Total amount of fresh water bought and Amount of fresh water produced.

Waste is also a straight forward category, and two major things can be considered important; how much waste is produced and how much of that waste is recycled? Waste is also commonly represented in the different certification systems, and in most developed countries we pay someone to take care of our waste by the tonnage. This gives us two more figures of interest: Total amount of waste produced and total amount of waste recycled.

This review of the categories provides us with nine key performance indicators that, while not telling the entire story of the building, or providing all the information with a potential impact on market value, still provides us with a much better idea of the sustainable performance of the building and can hopefully be a starting point towards a legislated, standardized, minimalized shortlist. They are measurable, easy to understand and the technology is already available to consistently monitor and gather the data. The suggested list looks like this:

Table 3 Suggested list of KPIs

CO_2 emissions	An equivalence calculated based on fuel and electricity consumption
Particle levels indoor	Ratio of hazardous particles in the indoor air
Total Energy Consumption	Total energy consumption for the building
Net Green Energy Consumption	The ratio of the total energy consumption that comes from renewable energy sources
Green Energy Production	Amount of green energy produced on-site
Total Amount of Fresh Water Bought	Total amount of fresh water bought, not including fresh water produced on site
Amount of Fresh Water Produced	Total amount of fresh water produced on-site
Total Amount of Waste Produced	Total amount of waste
Total Amount of Waste Recycled	Total amount of waste recycled

8. Conclusions

Sustainability certainly has value, but all parameters associated with sustainability do not necessarily have an observable impact on market price. How to put a price on sustainability has proven to be very difficult, and the major reason behind this is the lack of accessible data. This paper has presented a set of seven different indicators that together can provide a good starting point to assess buildings environmental performance. They include the major four categories that have been mentioned often in previous literature and that is already addressed in different initiatives and governmental legislation; emissions, energy, water and waste. The suggested parameters are easy to measure and the technology is already in place to get the information, in fact, in many cases, real estate owners already collect most of this data, but it is not made public. The next question then is to study the possibilities to create better incentives for real estate owners to gather this data and make it more accessible. Since the main incentive, money, is difficult to relate to this data, and without more data, there is a lack of incentive, there is a sort of Catch 22. It would be interesting to look into what kind of incentives that could be provided, aside from legislation.

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Appendix

		1	2	3	4	5	6	7
Do you work with any form of certification system for your portfolio? Which ones?	Q1	LEED, Minljöbyggnad, Green Building	Miljöbyggnad, Breeam in use, Green Building	Breeam, Miljöbyggnad, Green Building	Breeam	Miljöbyggnad, LEED	Green Building, Miljöbyggnad	LEED
How large is the share of certified buildings in your portfolio?	Q2	<5%	>20%	10-20%	10-20%	>20%	Vet ej	>20%
Do you measure consumption of property electricity in a continuous way?	Q3	YES	YES	YES	YES	YES	YES	YES
How often do you measure consumption of property electricity?	Q4	Once a month	Once a month	The technology makes it possible to see consumption every hour	Once a month	Varje dygn, timvärden	Once a month	Every hour for new buildings, less when performance is optimized
How is data stored from these measurements?	Q5	Corporate database	Corporate database	Online service sold by municipality	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of the property electricity put to use?	Q6	Follow-up, Commissioning, Statistics	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party
Do you measure the consumption of tenant electricity in a continuous way?	Q7	YES	YES	NO	YES	NO	YES	YES
How often do you measure the consumption of tenant electricity?	Q8	Once a month	We measure our own every 10 sec and the same wherever we provide the tenant electricity	Some of the properties have we measure manually every month, others are remotely read every hour. In most properties we don't measure tenant electricity at all since tenants have their own contracts	Once a month	We measure some properties	Once a month	Once a month
How is data from these measurements stored?	Q9	Corporate database	Corporate database	Online service sold by municipality		Corporate database	Corporate database	Corporate database
How is the data from the measurements of tenant electricity put to use?	Q10	Information to tenants	Follow-up, Commissioning, Statistics, Information to tenants, Information to third party, Is presented in an app that the tenants can use to monitor, change and see the effects of their consumption in real time	Information to tenants, To invoice tenants	Follow-up, Information to tenants	Information to tenants	Follow-up, Statistics	Follow-up, Commissioning, Statistics, Information to tenant

Do you measure consumption of water in a continuous way?	Q11	NO	YES	YES	YES	YES	YES	YES
How often do you measure the consumption of water?	Q12		Once a month	Once a month	Once a month	Once a month	Once every three months	Once a month
How is the data from these measurements stored?	Q13		Corporate database	Online service sold by municipality	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of water consumption put to use?	Q14		Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Statistics	Statistics	Follow-up, Statistics
Do you own properties where ventilation is controlled and adjusted by presence?	Q15	YES	YES	YES	YES	YES	YES	NO
How large a share of your portfolio have presence controlled ventilation?	Q16	<5%	>10%	Don't know	>10%	>10%	5-10%	Don't know
Do you measure air quality in your buildings?	Q17	YES	NO		NO	NO	YES	YES
In how large a share of your portfolio do you measure air quality?	Q18	5-10%	Don't know	Don't know		Don't know	>10%	<5%
How often do you measure air quality?	Q19	Rarely	Rarely	Don't know			Every year	Rarely
How is data from these measurements stored?	Q20	Corporate database		Don't know			Corporate database	Specific database for that building
How is the data from measurements of the air quality put to use?	Q21	Follow-up, Commissioning, Statistics, Information to tenant					Follow-up, Statistics	Follow -up, Information to tenant
Do you have data on how much waste that is leaving a single property?	Q22	NO	YES	YES	YES	YES	YES	YES
From how large a share of you portfolio is that kind of data gathered and stored from?	Q23		>10%	>10%	>10%	>10%	5-10%	>10%
Do you separate the data of waste beloning to maintenance and operation of the property from the tenants?	Q24		NO	NO	YES	NO	YES	YES
Is there something you would like to monitor/measure regarding the performance of the properties that you feel you lack the possibilitie to do today?	Q25		We would like to measure property electricity every 10 sec, but the energy companies don't want to releas that information from their sensors	As the trend is leaning towards looking at the entire consumption in the building, we would like access to tenant electricity and energy	Would like to measure allot more, like temperature, air quality, sound, lighting etc			
Are there parameters from the ones you do measure that is difficult to get reliable data on? Which ones?	Q26		The electricity from the electric suppliers, they want their data for themselves	Sometimes it is mixed property electricity and tenant electricity on the same sensor, that makes life difficult	waste			

		8	9	10	11	12	13
Do you work with any form of certification system for your portfolio? Which ones?	Q1	Mostly LEED	Breeam, Miljöbyggnad, Green Building	Miljöbyggnad for existing portfolio and Breeam for new construction	Green Building och Miljöbyggnad	Miljöbyggnad	It is under revision
How large is the share of certified buildings in your portfolio?	Q2	>20%	10-20%	>20%	<5%	<5%	>20%
Do you measure consumption of property electricity in a continuous way?	Q3	YES	YES	YES	YES	YES	YES
How often do you measure consumption of property electricity?	Q4	Once a month	Once a month	Once a month	Once a month	Once a month	Once a month
How is data stored from these measurements?	Q5	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of the property electricity put to use?	Q6	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party, climate impact calculations	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Statistics
Do you measure the consumption of tenant electricity in a continuous way?	Q7	YES	NO	NO	YES	YES	YES
How often do you measure the consumption of tenant electricity?	Q8	Once a month	We measure where we forward the bill	We don't have access to consumption of tenant electricity	Once every six months	Once a month	Once a month
How is data from these measurements stored?	Q9	Corporate database	Corporate database	See Q11	Corporate database	Corporate database	Corporate database
How is the data from the measurements of tenant electricity put to use?	Q10	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Statistics, Information to tenant	See Q11	Follow-up, Commissioning, Statistics, Information to tenant		Follow-up, Statistics
Do you have data on how much waste that is leaving a single property?	Q22	YES	YES	NO	YES	NO	NO
From how large a share of you portfolio is that kind of data gathered and stored from?	Q23	>10%	>10%	Don't know	Don't know		
Do you separate the data of waste beloning to maintenance and operation of the property from the tenants?	Q24	NO	YES	NO	YES	YES	
Is there something you would like to monitor/measure regarding the performance of the properties that you feel you lack the possibilitie to do today?	Q25	Air quality is sometimes difficult to measure. It would be good with an easy way to monitor and follow up the tenants commuting	Consumption from tenants	Possibly the collected instantaneous effect and the energy status	We would like to improve the measuring of for example, geothermal energy. We measure, but we can improve		Energy and watern on the real estate where we lack the ability
Are there parameters from the ones you do measure that is difficult to get reliable data on? Which ones?	Q26	Sometimes it is hard to gain access to tenant electricityt	Waste recycling where tenants have their own responsibility		We can develop the carbondioxide equivalents more and spread the knowledge about them		

Do you measure consumption of water in a continuous way?	Q11	YES	YES	YES	YES	YES	YES
How often do you measure the consumption of water?	Q12	Once a month	Once a month	Once a month	Once a month	Once a month	Once a month
How is the data from these measurements stored?	Q13	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database	Corporate database
How is the data from the measurements of water consumption put to use?	Q14	Follow-up, Commissioning, Statistics, Information to tenant, Information to third party	Follow-up, Statistics, Information to tenant	Follow-up, Statistics	Follow-up, Commissioning, Statistics, Information to tenant	Follow-up, Commissioning, Statistics	Follow-up, Statistics
Do you own properties where ventilation is controlled and adjusted by presence?	Q15	YES	YES	YES	YES	YES	NO
How large a share of your portfolio have presence controlled ventilation?	Q16	Don't know	>10%	Don't know	>10%	>10%	<5%
Do you measure air quality in your buildings?	Q17	YES	YES	YES	YES	NO	YES
In how large a share of your portfolio do you measure air quality?	Q18	Don't know	<5%	Don't know	>10%		<5%
How often do you measure air quality?	Q19	Different in different buildings	Daily	Difficult to answer since the definition of air quality is not provided. CO^2 emissions is an indicator that we use in some cases, but then mostly to adjust ventilation etc.	Continuously, for instance CO^2 in certain facilities		Rarely
How is data from these measurements stored?	Q20	Specific database for that building	Specific database for that building		Specific database for that building		
How is the data from measurements of the air quality put to use?	Q21	Follow -up, Information to tenant	Follow -up, Commissioning, Information to tenant	See Q22	Commissioning		
Do you have data on how much waste that is leaving a single property?	Q22	YES	YES	NO	YES	NO	NO
From how large a share of you portfolio is that kind of data gathered and stored from?	Q23	>10%	>10%	Don't know	Don't know		
Do you separate the data of waste beloning to maintenance and operation of the property from the tenants?	Q24	NO	YES	NO	YES	YES	
Is there something you would like to monitor/measure regarding the performance of the properties that you feel you lack the possibilitie to do today?	Q25	Air quality is sometimes difficult to measure. It would be good with an easy way to monitor and follow up the tenants commuting	Consumption from tenants	Possibly the collected instantaneous effect and the energy status	We would like to improve the measuring of for example, geothermal energy. We measure, but we can improve		Energy and watern on the real estate where we lack the ability
Are there parameters from the ones you do measure that is difficult to get reliable data on? Which ones?	Q26	Sometimes it is hard to gain access to tenant electricityt	Waste recycling where tenants have their own responsibility		We can develop the carbondioxide equivalents more and spread the knowledge about them		