

The impact of renewable on-site energy production on property values

On-site energy
production

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Abstract

Purpose – Contrary to the traditional technology project perspective, real estate investors see building-specific renewable energy (on-site energy) investments as part of the property and as something affecting the property's ability to produce a (net) cash flow. This paper aims to show the value-influencing mechanism of on-site energy production from a professional property investors' perspective.

Design/methodology/approach – The value-influencing mechanism is presented with a case study of a prime logistics property located in the Helsinki metropolitan area, Finland. The case study results are compared with the results of a survey answered by over 70 property valuation professionals in the Finnish real estate market.

Findings – Current valuation practice supports the presented value-creation mechanism based on the capitalisation of the savings generated by a building's own energy production. Valuation professionals see benefits beyond decreased operating expenses such as enhanced image and better saleability. However, valuers acted more conservatively than expected when transferring these additional benefits to the cash flows of the case property.

Practical implications – Because the savings in operating expenses can be capitalised into the property value, property investors should consider on-site energy production when the return of on-site energy exceeds the return of the property. This enhances the profitability of on-site energy, especially in urban areas with low initial yields.

Originality/value – This is the first research paper to open the value-influencing mechanism of on-site energy production from a professional property investors' perspective in commercial properties and to confirm it from a market study.

Keywords Property value, Distributed renewable energy investment, On-site energy production, Responsible property investment, Sustainability in real estate, Sustainability

Paper type Research paper

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1. Introduction

Transitioning to renewable energy systems is one of the most efficient ways to fight climate change. Because buildings account for roughly 40% of energy use and carbon emissions [International Energy Agency (IEA) 2018], the real estate sector plays an essential role in the urgently needed energy revolution. A global energy ecosystem that would be based solely on renewable energy by 2050 would require investments worth \$67tn, of which roughly \$16tn would be needed for renewable building-specific energy production, including rooftop solar photovoltaics (PVs), heat pumps, batteries and bioenergy (Ram *et al.*, 2019), hereafter termed on-site energy. The real estate industry is worth approximately 60% of individual, corporate and national wealth, totalling over \$200tn (Savills, 2016). In this sense, real estate owners could easily finance a significant part of on-site energy investments, which offer several advantages over conventional energy production for property owners. On-site energy production will most likely increase the value of the property through the capitalisation of decreased operating expenses, as the International Valuation Standards (IVS) (2019) suggest. Furthermore, on-site energy production hedges property owners against rising electricity prices and helps avoid both energy transfer fees and taxes. In addition to these direct savings in operating expenses, it can also enhance the green reputation of the building. Increased sustainability may appeal to potential tenants and enhance other cash flow parameters (e.g. rents, rental growth rate, occupancy ratio, depreciation and yield) of the property and, consequently, the value of the building, as discussed in more detail in the next section. This perspective is particularly suitable for professionally managed investment properties, the value of which is based on their ability to generate income for their owners.

The energy industry often approaches on-site energy investments from a technological project perspective by focussing on payback periods and the returns of energy production investments. Professional property investors, on the other hand, are more interested in the overall impact on properties' net cash flow and the capitalised value of the savings generated from the properties' own energy production and from other possible improvements in the cash flow parameters. Besides acting responsibly, property investors are primarily interested in the financial benefits of sustainable buildings and related investment options. Poor environmental performance is increasingly seen as an investment risk (Lorenz and Lützkendorf, 2008). However, sustainability (or poor environmental performance) may not currently be fully transferred to the value of properties, which does not encourage mainstream investors to conduct investments that enhance the sustainability of properties. Property valuers, who assess and advise on properties' market values (Warren-Myers, 2012), play an important role in either enabling or hindering sustainability investments.

The purpose of this research is to evaluate and analyse the economic value created for property owners through renewable on-site energy production. Adopting the real estate owners' perspective, the value-creation logic of on-site energy investment in the discounted cash flow analysis context is demonstrated with the help of a case study. This paper compares the presented value-influencing mechanism with the current valuation practice in the Finnish real estate market. This research underscores the importance of understanding the property valuation logics in the profitability analysis of on-site energy production: it is not only a decrease in the property's operating expenses that matters but also it is the value created through capitalising the savings, not to mention other potential financial and nonfinancial benefits of enhancing sustainability that is crucial. To the best of our knowledge, this is the first public research that empirically examines the value-influencing

mechanism of on-site energy production from the perspective of professional property investors in commercial properties.

According to the results, on-site energy investments can be evaluated based on their ability to increase properties' net cash flow. The case study shows that the value of the property increases by €2,048m after the conducted on-site energy investment. The value increase exceeds the investment costs of €1,560m by €0.49m. More than 70 valuation professionals working in the Finnish real estate market confirmed the presented value-influencing mechanism. Furthermore, they also recognised other benefits than just the capitalised savings in operating expenses such as improved leasability and saleability, enhanced attractiveness and a better image of the property. However, they acted more conservatively than expected when transferring these additional benefits to the cash flows of the case property. Compared to the traditional technology project perspective with its payback time of over 14 years, the investment is very appealing when evaluated through the property's cash flow. Understanding property investors' appraisal logic enhances the attractiveness of on-site energy production investments and may help speed up the needed energy revolution.

2. Environmental sustainability and property value

Responsible property investing means maximising the positive and minimising the negative effects of properties on society and the environment while also ensuring investors' goals and fiduciary responsibilities (Pivo and McNamara, 2005). Several actions to execute environmentally sustainable investments (the focus of this article) exist such as energy conservation, renewable energy and greenhouse gas emission reduction. These actions most often benefit property investors financially, which has been widely acknowledged in previous academic research papers, especially concerning green certificates and energy efficiency labels. However, previous research on the economic implications of on-site energy is almost non-existent, with the exception of US houses with PVs (Section 2.3).

2.1 Drivers for property investors to invest responsibly

The drivers influencing green building adoption can be grouped into the following categories: external drivers, corporate and individual level drivers and project- and property-level drivers (Darko *et al.*, 2017). External drivers, such as governmental and international regulations, policies and incentives, demand and pressure from clients, rising awareness and the number of tools to implement sustainability, have proven to be important drivers for companies to act sustainably (Sayce *et al.*, 2007; Braun *et al.*, 2017; Nousiainen and Junnila, 2008). Sustainability is also a way to enhance corporate image and increase differentiation from competitors (Andelin *et al.*, 2015). Marketing benefits strongly encourage sustainability: green signalling is an important means to position properties better in the eyes of tenants and potential buyers. Because people are the ones making decisions within organisations, it is also important to understand how evolving social consciousness drives individuals to implement green building practices in their projects and organisations (Darko *et al.*, 2017; Braun *et al.*, 2017).

In addition to external drivers, corporate- and individual-level drivers, benefits both at the project (e.g. construction costs and time, safety, reduced amount of waste, etc.) and property level are crucial, the latter of which is the focus of this article. Falkenbach *et al.* (2010) present property-level drivers as components that influence cash flows and, thus, the value of properties. Directly adjusting single valuation input parameters is one way of considering sustainability in valuations, with the other methods being a lump-sum adjustment or calculation of a sustainability correction factor (Lorenz and Lützkendorf,

2011). Enhanced sustainability may have the following effects on the valuation parameters (RICS, 2013; Lorenz and Lützkendorf, 2011; Lorenz and Lützkendorf, 2008; Lützkendorf and Lorenz, 2005): increased rent levels, rental growth and occupancy rates decreased operating expenses and reduced risk level (yield), which is usually based on reduced risk of obsolescence and regulatory risk.

2.2 Empirical evidence: green certificates

Green certificates and energy efficiency labels (hereafter certificates) have drawn much attention in empirical sustainable property investment research; these studies have indicated a clear relationship between sustainability investments and better financial performance. With reference to the above property-level drivers, properties with green certificates have been reported as having higher rents (Fuerst and McAllister, 2009b; Fuerst and McAllister, 2011; Reichardt *et al.*, 2012; Reichardt, 2014; Holtermans and Kok, 2019), as well as a lower vacancy (Miller *et al.*, 2008; Fuerst and McAllister, 2009a; Wiley *et al.*, 2010; Reichardt *et al.*, 2012) and operating costs (Newsham *et al.*, 2009; Pivo and Fisher, 2008; Reichardt, 2014). These enhancements, together with the green signalling effects of certificates (Fuerst *et al.*, 2016; Reichardt, 2014), lead to better sales prices of certified properties. Sales price premiums (Pivo and Fisher, 2008; Fuerst and McAllister, 2009b; Eichholtz *et al.*, 2010; Fuerst and McAllister, 2011; Eichholtz *et al.*, 2013; Chegut *et al.*, 2014; Kahn and Kok, 2014; Fuerst and McAllister, 2009b; Eichholtz *et al.*, 2010; Fuerst and McAllister, 2011; Eichholtz *et al.*, 2013; Chegut *et al.*, 2014) are typically found to be much larger than the enhancements in cash flow parameters. This might be because of the combined effects on the capital value of better rental income, lower vacancy and operating expenses, as well as lower risks (yield).

Beside property-level indicators, corporate-level benefits, especially higher returns and lower risks, have gained some attention in the earlier research. Listed green real estate funds and companies – measured, for instance, by the number of certified assets or other green scoring systems – offer possibilities for these inspections. For instance, Sah *et al.* (2013) report that green real estate investment trusts had 5.68% higher annualised returns compared with their less-green peers. Fuerst (2015) observe that green real estate investment trusts in North America, Europe and Asia had higher asset and equity returns, as well as higher returns per unit of risk. Cajias *et al.* (2012) state that among the listed European real estate companies, sustainability increased companies' ability to generate revenues and decreased the level of idiosyncratic stock volatility. Further, Eichholtz *et al.* (2012) note that green real estate investment trusts have lower systematic risk, suggesting that green portfolios are better protected against certain risks, such as rising energy prices and changing environmental legislation. An and Pivo (2017) concentrate on default risks and report that green buildings in commercial mortgage-backed security loans had a 34% lower default risk than regular buildings. Lower risks have also been reported on the asset level in the form of decreased yields (McGrath, 2012; Miller *et al.*, 2008).

Green buildings may also enjoy better loan conditions (Eichholtz *et al.*, 2015; An and Pivo, 2017), improving the net cash flow of properties from investors' perspective. Besides these financial indicators, Devine and Kok (2015) document the intangible benefits as follows: higher tenant satisfaction, a higher probability of renewing leases and decreased tenant rent concessions in certified buildings compared with non-certified ones. However, the tangible and intangible benefits must outweigh the additional cost for the investment to be profitable. Evidence of this is very sparse. Further, the research is usually based on a few case studies, making generalisation of the results difficult. Some of the existing studies found green building cost premiums of up to 20% (Dwaikat and Ali, 2016; Kats, 2010), and

some studies have found no statistical difference between conventional and green buildings (Matthiessen and Morris, 2007; Rehm and Ade, 2013). A study by Chegut *et al.* (2019) is the first to compare both the green building cost premium and benefits on a large UK data set; they report higher marginal construction costs for green buildings but even larger benefits. However, higher design costs and longer construction time of green buildings compared with conventional ones increases developers' risks, hindering developers from adopting green features in buildings.

2.3 Empirical evidence: renewable on-site energy production

Another track of sustainable property investment research has delved into the effect of PVs on house sale prices, the vast majority of those using statistical analysis in different states in the USA, especially California. These studies have been able to find a positive relation between house values and installed PVs. Hoen *et al.* (2017, 2013) find strong evidence that houses with PV have sold at a premium over comparable houses without PVs. Based on their data set of 72,000 houses in California sold between 2000 and 2009, the writers find a premium of \$3.9-6.4 per installed watt in those 2,000 houses with PVs, with most models coalescing at \$5.5 per watt. The installation cost of PV systems amounted to \$5 per watt within the same time period in California, implying that PVs would be profitable investments. When the data set was split among new and existing houses, the writers show that existing houses had higher premiums and that when PV systems age, the premium decreases. Using a data set of approximately 490,000 transactions in their statistical analysis and approximately 80,000 transactions in their repeat sales analysis, Dastrup *et al.* (2012) find a premium of 3-4% for houses with PVs over comparable houses without PVs in San Diego and Sacramento, CA. Combining demographic data into their house sales data, they also show that the sales price premium varies with neighbourhood characteristics such as environmental ideology, income and education level. One of the earliest studies included Farhar and Coburn's (2008) repeat sales analysis concerning 15 energy-efficient houses in San Diego, where they provide evidence of higher sales prices in PV houses over 12 comparable houses.

In addition to the Californian studies, other US markets have been analysed. Using house resale and PV building permit data from 2000 to 2013 in Hawaii, Wee (2016) found that the presence of PVs adds an average of 5.4% to the value of a house. Based on transaction and valuation data in Arizona, Qiu *et al.* (2017) conclude that houses with PVs enjoy a premium of 15% compared with the median house value and a premium of 17% over median house sales price in the control groups; their result suggests that PV investment costs are offset by the value increase, at least on average. In the same study, they also examine whether solar water heaters have a similar premium as PVs but could not statistically confirm this. Desmarais (2013) find that PVs increased the value of houses and decreased the marketing time in her 30 case studies in Denver. Using a sales comparison analysis on 23 properties in Oregon, Watkins (2011) also finds that there is a positive premium. In their study covering almost 23,000 houses in eight states in the USA during 2002-2013, Hoen *et al.* (2017) also confirm that houses with PVs are consistently traded with an average premium of \$4 per installed watt.

Income and replacement cost methods have been suggested as alternative approaches when using the comparable sales method is not possible. However, studies using these methods are very limited. Klise *et al.* (2013) developed a PV value tool to address the value of the electricity-generating capabilities of a PV system and to overcome the lack of comparable market information. In addition to the PV value tool, Adomatis and Hoen (2016) compare the results of income (DCF) and replacement cost approaches with the paired sales

method in 43 PV houses in six different states in the USA and the results from previous hedonic regression analyses. Based on a paired sales analysis, they find that PV systems garnered an average premium of \$3.78 per installed watt and the premium was close to the PV cost estimate. The income approach resulted in more conservative values for PVs compared with paired sales and hedonic regression analysis; the authors conclude that cost and income approaches can be used if other approaches are not possible.

2.4 Defects of the reviewed literature

Most of the certificate studies have relied on statistical analyses based on large data sets of certified and noncertified commercial properties in the US markets relying mostly on EcoStar. Relying on the same data, these studies may suffer from systematically biased data. PV house studies also focus on the US market and may potentially have similar limitations as certificate studies. Studies on value increase through on-site energy production in commercial properties are virtually non-existent. Because professional property investors' way of thinking and conducting value calculations differ greatly from that of house owners, studies focussing on commercial properties are needed. Furthermore, there are few studies that investigate on-site energy production other than PVs. Nor does certificate research separate the impact of on-site energy production from other green factors. The results of the existing studies are difficult to apply to individual properties because of the heterogeneity of markets and assets. Furthermore, in small markets, an insufficient amount of comparable transactions limits the usefulness of statistical analyses. Therefore, it is important to understand how sustainability affects cash flow parameters in the discounted cash flow framework and, consequently, the value of an individual property. The guidance note of the RICS (2013) also mentions that DCF calculation may reflect sustainability issues faster than other appraisal methods. DCF enables surveyors to reflect more closely on the attributes that do not impact the market value yet but that may have an influence in the future.

Vimpari and Junnila (2014) and Christersson *et al.* (2015) seem to be the only practitioners who have considered value-influencing mechanisms of green certificates and energy efficiency, respectively, in the discounted cash flow framework. All the respondents in Vimpari and Junnila's (2014) study valued the case property with a certification more highly than without a certification. The main reasons for the observed average value increase of 9% in the certified property were improved net operating income and lower discount rate, which is in line with earlier research. Christersson *et al.* (2015) studied energy efficiency investments in almost 30 case properties, finding an average property value increase of 2.5%. Popescu *et al.* (2012) claim that in addition to energy savings, property value increases are essential in the assessment of the payback period in energy efficiency investments. However, the current study is the first one to elaborate on the value-influencing mechanism of on-site energy production from that of professional property investors' perspective in the discounted cash flow framework. We also claim that the location of the property significantly affects the value of on-site energy production, which has mostly been ignored in previous (on-site) energy feasibility studies. On-site energy systems in more appealing locations have more value to investors than systems in more remote locations. The value generated through location can be incorporated into the analysis by using the property's yield as a discount rate when capitalising energy savings into the value of the property (Leskinen *et al.*, 2020; Vimpari and Junnila, 2019; Vimpari and Junnila, 2017; Vimpari and Junnila, 2017).

3. Methods and data

The empirical part of the research is based on a commercial property case study and a survey targeted at property valuation professionals in the Finnish real estate market. The case study shows the value-influencing mechanism of on-site energy production from the professional real estate investors' perspective, and the aim of the survey is to validate the presented approach with current market practice and valuers' insights.

3.1 Description of the case study and methodology

A Finnish investor provided data for one of their logistic properties located in the Helsinki metropolitan area. The logistics centre was originally built in 2013 and has a leasable area of approximately 20,000 m². The property underwent an extensive energy renovation in 2018: district heating was replaced with a ground source heat pump system, and 480 kWp of rooftop PVs were installed. The ground source system covers 95-99% of the required energy, and the rest is covered with an on-site electric boiler that generates heat directly from electricity. Additionally, the system includes a 5 m³ hot water reservoir for balancing heat peak loads, i.e. the ground source system heats up the reservoir, which can then release energy for heat peak loads to avoid using the higher cost electric boiler. Non-energy generating investments, such as installed light emitting diode lights and other investments that improve the energy efficiency of the case property, were excluded from this examination. Historical performance data ([Actual measurement data, 2019](#)) for the first 10 months (November 2018-August 2019) of operations were provided together with the current pricing of heat ([Local energy company, 2019c](#)) and electricity ([Local energy company, 2019b](#)). To have a full year of performance data, the past two months (September-October 2019) were forecast based on the property's historical consumption data. This data was used to calculate the annual savings for both heat and electricity with the following equations:

$$\text{Annual savings on heat costs} = \sum_{m=1}^{12} (HC^m * DH^m - HP^m * EP^m - EB^m * EP^m) \quad (1)$$

where m is the month, HC is the heat consumption of the property, DH is district heating pricing (incl. share of annual fixed charges), HP is the electricity required by the ground source heat pump to cover the heat consumption, EP is the price of electricity (incl. distribution and taxes) and EB is the electricity required by the electric boiler. Heat consumption and production are weather-normalised.

$$\text{Annual savings from solar electricity} = \sum_{m=1}^{12} (PV^m * EP^m) \quad (2)$$

where PV is the solar electricity produced by the rooftop PV system and the rest as above. The property can self-consume all PV production, meaning that the full electricity price is received (as savings) for all production. For any surplus production fed into the local grid, the local energy company would only pay the electricity price less distribution costs and taxes.

The impact of on-site energy production investments on property value was calculated using a 30-year discounted cash flow analysis. A 30-year cash flow was selected based on

the typical lifecycles of PVs and ground source heat pumps (Branker *et al.*, 2011). The discounted cash flow equation clearly shows that the value of the property increases through the capitalisation of the improved net cash flow because of a decrease in operating expenses, as the IVS (2017) suggests:

$$\text{Present value of property} = \sum_{i=1}^{\infty} \frac{(\text{Gross income} - \text{operating expenses})_i}{(1 + \text{property yield})^i} \quad (3)$$

Accordingly, the increase in property value generated through savings in the operating expenses can be expressed as follows:

$$\text{Property value increase} = \sum_{i=1}^{30} \frac{\text{Net savings}_i}{(1 + \text{Property yield})^i} \quad (4)$$

The present value of net savings over the 30-year lifecycle of the on-site energy investment was estimated based on the first year's gross savings extracted by the maintenance costs and capital expenditure of the investment. Because of confidentiality reasons, we did not have access to the actual maintenance costs. In this paper, the estimated costs are based on the findings of earlier research:

- The maintenance cost of the PV system: 13.5 €/kWp (Vimpari and Junnila, 2019);
- The maintenance cost of the ground source heat pump: 5.4 €/kW (Kontu *et al.*, 2020);
- The capital expenditure of replacing the inverter of the PV system in the year 2015: 0.05 €/kWp (Fraunhofer Institute, 2019); and
- The capital expenditure of the ground source heat pump in the year 2015: 30% of the initial investment cost (Kontu *et al.*, 2020).

In the base scenario, electricity prices are assumed to increase by 4.1% p.a. and district heating prices 4.4% p.a. based on the historical price growth rates during 2000-2018 (Statistics Finland, 2019b). During the same period, the growth of the consumer price index has amounted to 1.5% (Statistics Finland, 2019a), which has been used as the inflation rate. The net savings were discounted with the sum of the prime logistics yield of 5.8% in the area (Datscha, 2018) and the inflation rate (7.3%). Four logistics tenants occupy the case property with gross lease agreements, meaning that the owner will directly and immediately benefit from the savings generated by the on-site energy production system.

3.2 Description of the survey to valuation professionals

According to the reviewed past research and IVS (2017), on-site energy production should be valued so that at least decreased operating expenses will be capitalised into the value of the property, as explained in 3.1. However, because valuing renewable on-site energy as a part of the property's cash flow is a fairly new concept, both in research and practice, a survey targeted at valuation professionals in the Finnish real estate market was conducted as a part of the current study. The online survey was sent to authorised property valuers (altogether app. 270 in Finland) via the Finland chamber of commerce's mailing list and to the members of the Finnish association for real estate valuation (250 members, of which half are authorised) in October 2019. The recipients hold several kinds of positions in surveying, consultancy and investment organisations. They were also requested to share the survey

link with their colleagues working with property valuations to expand the number of potential respondents.

Altogether, 73 property valuation professionals responded, which is a good sample size considering the number of valuers in Finland. Approximately, 80% of the respondents worked as surveyors and the rest in investment management, consultancy and real estate development. The majority of the respondents were authorised property valuers (app. 85%), and almost 90% had more than five years of experience in property valuation. Experience in valuations with PVs and heat pumps was rare, with almost 60% having no experience with PVs and over 40% having no experience with heat pumps. The survey consisted of questions investigating the current valuation practice, namely, how on-site energy production affects the property's cash flow parameters. The valuers were first asked to evaluate how on-site energy production affects the property's value in the discounted cash flow context in general, specifically in the Finnish real estate market, and then in the presented case study (Figure 1).

4. Results

This section presents the results of the commercial building case study and the survey targeted at valuation professionals working in the Finnish real estate market. The valuation professionals confirmed the presented value-influencing mechanism of renewable on-site energy production in the case study. On top of the decreased operating expenses, they also saw other benefits, such as an enhanced image of the property.

4.1 Case study results

Figure 2 presents both the production numbers (MWh) and savings (€) of the on-site energy investment for the first operating year. The first year's net savings on operating expenses of the on-site energy totals €101,000 of which 70% is because of the ground source heat pumps and 30% because of the of PVs. When estimated over the 30-year lifecycle of the system and capitalised with the prime logistics yield in the area [5.8% (Datscha, 2018)], the property value increases by €2.048m. The total capital expenditure for the system was €1.560m, meaning that the property owner immediately gains a benefit of approximately €490,000 from the investment. Compared with the results of traditional investment calculation methods, such as a payback time of over 14 years, the investment is very appealing from a real estate investment perspective. The return of the on-site energy investment amounts to 7.1%. The value increase of the property exceeds the investment costs when the return of the on-site energy investment is the same or exceeds the property's yield.

In addition to the base scenario, where energy prices were assumed to grow at the same rate as during 2000-2018, a sensitivity analysis with high and low energy price scenarios

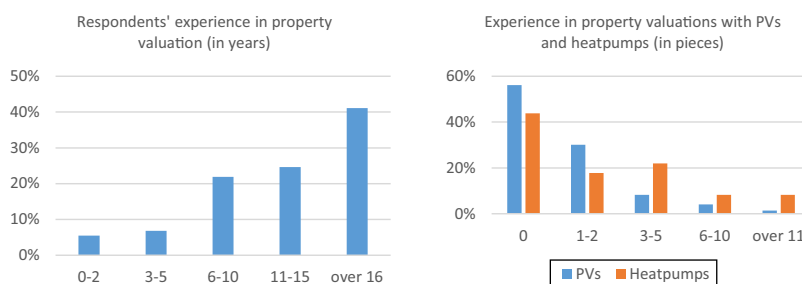


Figure 1.
Respondents' experience in property valuation and valuations with PVs and heat pumps

was calculated. In the low energy price growth scenario, energy prices were assumed to grow at the same rate as inflation (1.5%). Then, the value increase of the case property would total €1.396m. In the high energy price growth scenario, energy prices were assumed to grow 2% points faster than in the base scenario. Then, the value increase of the case property would total €2.707m.

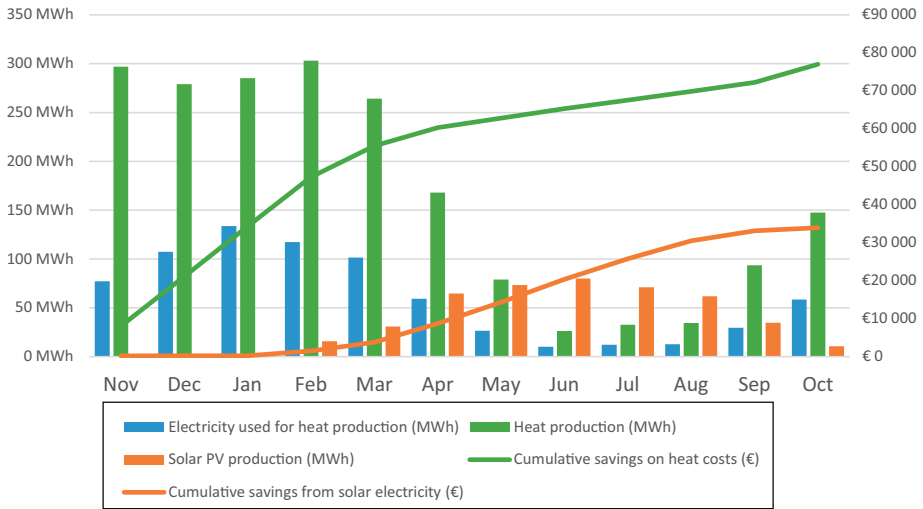
In addition to the savings in operating expenses, the sustainability of the case property increases. The on-site energy investment reduces the annual CO₂ emissions by approximately 430 t CO₂, based on average emissions of 247 kg CO₂/MWh for the district heating system (Local energy company, 2019a), 158 kg CO₂/MWh for electricity system (Motiva, 2019) and 35 kg CO₂/MWh for solar energy (Fthenakis *et al.*, 2008).

4.2 Survey results

The survey respondents were asked to assess whether climate change affects property values. Approximately, 23% of the respondents were of the opinion that climate change has no impact on property values, even in the long run. This is surprising considering the lively and ongoing debate regarding climate change threats and the ever-tightening environmental regulations. The valuation professionals were also asked if renewable energy production is reported in valuations. Here, 51% of the respondents answered that renewable energy production is reported seldom or never as part of the valuation process. However, 90% of the respondents say that the existence of on-site energy production in properties already is or will become the norm; this indicates the need to develop reporting practices. Furthermore, it is an interesting question of how this change should be considered in all valuations (Figure 3).

The valuation professionals were asked what kind of impact on-site energy production has on different cash flow parameters in general in the Finnish market. The influence level was measured using a five-point scale ranging from “significant decrease” to “significant increase” for the value of the different parameters. Figure 4 shows that respondents felt that on-site energy production had the largest positive impact on the image of the property

Figure 2.
Heat and solar
production (MWh)
with cumulative
savings (€) of the on-
site energy
investment in the
case property
consisting of
approximately
20,000 m²



(84%). The pronounced importance of reputation is in line with the previous findings, for instance, how consumers make decisions that enhance their environmentally responsible behaviour ((Delmas and Lessem, 2014; Sexton and Sexton, 2014). The next largest positive impact was seen on decreased energy costs (78%), increased saleability (78%) and increased leasability (64%). Here, 46% saw that the risk of obsolescence should decrease and 32% said that the yield should decrease. Rents and rental growth instead were assessed as staying almost unchanged, with rent level even decreasing in the overall results (average), which is quite surprising. Because on-site energy production positively affects almost all cash flow parameters (rental growth being the only unchanged parameter), it is natural that the value of the property increases. Indeed, 71% of respondents agreed with the value increase, which is a smaller share than the answers related to operating expenses would indicate.

After a general assessment of the impacts of on-site energy on cash flow parameters, the survey presented the case study and asked the valuation professionals to evaluate whether the savings are fully capitalised into the value of the case property and if on-site energy production also affects other cash flow parameters. Almost, 80% of respondents stated that the savings in the operating expenses are fully capitalised into the value of the case property, corresponding well with the general assessment. The rest approached the question

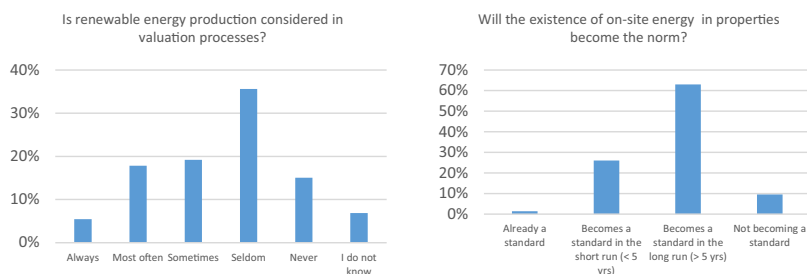


Figure 3.
Consideration of renewable energy production in valuation processes and a timeline when on-site energy production becomes the standard in the industry

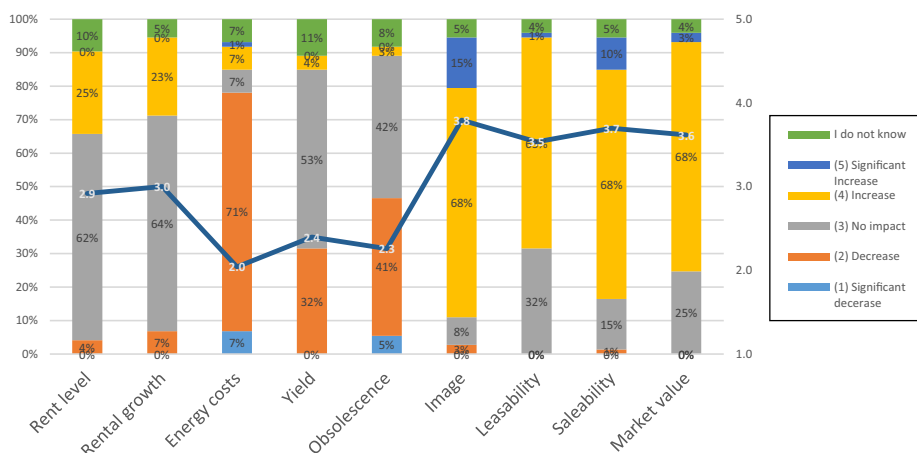


Figure 4.
The impact of on-site energy on properties' cash flow in general in the Finnish market

a bit more conservatively, considering only a part of the savings in the capital value of the case property. Only one respondent would not capitalise on the savings at all. These findings confirm the presented value-influencing mechanism. However, changes in other cash flow parameters were seen in slightly different ways in the case property than in the general assessment. Approximately, 65% of the respondents claimed that the market rent level will not change because of the investment, while 26% saw a slight increase. Three-quarters of the respondents expected rental growth to remain unchanged, and only 16% expected a slight increase. Both of these variables were impacted slightly less in the case study than in the general assessment. Perhaps, some of the respondents assessed only the current lease agreements, even though the (future) market rent level was the topic of the question. Current leases were announced to be gross leases. In a gross lease structure, the lessor gains the benefits of savings in operating expenses, while in net leases, this is reversed, and lessees may be willing to pay higher rent to reflect the lower expenses. Eventually, the owner will extract the same value regardless of the lease structure (Reichardt, 2014; Fuerst and McAllister, 2011). On the other hand, better future leasability should have been reflected in the rental growth rate. The impact on the yield was estimated to be a bit more positive in the case study than in the general assessment: 49% claimed on-site energy has no impact on yield, while 40% felt that the yield should slightly decrease. This is rational because a slight decrease in the yield can be more easily justified when there is poor availability of market data on other cash flow variables.

Figure 5 breaks down the reasons for the increased leasability and saleability of the property. Increased leasability was seen to be mainly because of the property's improved image and attractiveness. Further, the number of potential tenants was assessed as growing and the risk of obsolescence as decreasing even more than in the general assessment. These improvements should also affect the occupancy ratio positively. Increased saleability was clear because of an increase in the number of potential buyers. Some of the respondents commented that this was also the main reason they felt that it was reasonable to decrease the yield.

Those valuers ($n = 49$), who had experience in valuations with either heat pumps or PVs, saw on-site energy slightly more positively both in the general assessment and in the case study than the rest of the respondents ($n = 24$). However, the differences are not statistically significant.

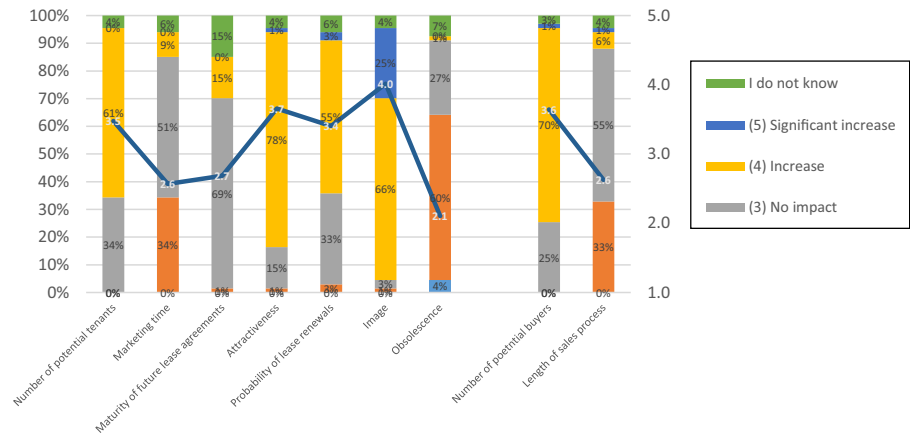


Figure 5.
The effect of on-site
energy production on
leasability and
saleability of the case
property

4.3 The implications of the survey results on the case study

In the presented case study, the value increase of the property is based on the capitalised savings in the operating expenses. The survey results imply that there may be positive effects on other cash flow parameters as well. Improved attractiveness and image of the property, as well as a higher number of potential tenants, would imply higher rents. A higher number of potential buyers and decreased risk of obsolescence would imply a lower yield. The base assumption is that the yield is 5.8% and that the gross rent level is 10 €/sqm/month (median operating expenses in the area being 2.65 €/sqm/month) before the on-site energy investment; these figures are hypothetical but are based on prime logistics market data in the area (Datscha, 2018; KTI, 2017). Approximately, 30% of the respondents answered that the yield would decrease. Over half of them estimated the yield within the range of 5.5-5.7%. That 25 % of the respondents who claimed that the rent level should increase estimated the (gross) rent levels to be from 10.5 to 12 €/sqm/month. Table 1 shows the impact of the higher rent level and lower yield on the property value in addition to the capitalised savings.

5. Discussion

The purpose of this study was to shed light on the value-influencing mechanism of on-site energy production and its effect on property values and to verify it from the perspective of real estate valuation professionals. When on-site energy investments are evaluated as part of the property's cash flows, the profitability of on-site energy investments increases. There is significant financial potential in on-site energy production investments that is not yet widely acknowledged. In the presented case study, the value increase (€2.048m) in the property exceeded the investment costs (€1.56m) by over €490,000 when decreased operating expenses were capitalised into the value of the property. According to the results of the survey, valuation professionals confirmed the presented value-influencing mechanism of on-site energy production; this indicates that it is profitable to invest in on-site energy production when its return exceeds the return of the property, that is, the increase in property value exceeds the investment costs. On-site energy investments are more likely to be profitable in urban areas with well-functioning property markets and low initial yields. Using the property's yield as the discount rate when evaluating the economic viability of on-site energy investments reveals the spatial variation in profitability. This might be obvious in the real estate industry, but it is not widely understood in the energy industry.

In addition to (the capitalisation of) decreased operating expenses, renewable on-site energy production might also have other tangible and intangible benefits, on which the respondents agreed. However, in the actual valuation of the case study, the benefits did not fully translate into an increase in valuation. In her studies concerning the Australian property market, Warren-Myers (2013, 2016) ended up with similar results concerning

Table 1.

The value increase of the case property (in millions) with increased net market rent level and decreased yield

Yield Net rent level				
	5.8 (%)	5.7 (%)	5.6 (%)	5.5 (%)
7.35 €/sqm/mo	€2.048	€2.581	€3.134	€3.707
7.85 €/sqm/mo	€4.117	€4.687	€5.277	€5.888
8.35 €/sqm/mo	€6.186	€6.792	€7.420	€8.070
8.85 €/sqm/mo	€8.255	€8.897	€9.563	€10.252

sustainability investments: valuers may not be fully aware of the value-influencing mechanism; therefore, property values may not fully reflect these investments. Several possible explanations can be identified. Firstly, valuers would need more detailed market data to reliably alter cash flow parameters transparently. Secondly, gathering sustainability information during the whole life cycle of properties (planning, construction, management, etc.) would also play an important role (Lützkendorf and Lorenz, 2011). Currently, valuers may be lacking sufficient information to consider sustainable property features in valuation processes. Thirdly, the definition of the market value excludes some key implications of sustainability (Lorenz and Lützkendorf, 2008): the market value is affected only by direct monetary impacts and accounts for sustainability only to the extent to which the market position of the property has improved. Sustainability may also have non-monetary benefits, not to mention environmental and social advantages at the societal level. Fourthly, regarding on-site energy specifically, it may not be regarded alone as a sufficient element to turn the property green, which is a fair judgement. Nevertheless, on-site energy production alongside other sustainability information should be considered more systematically in valuation processes and reports, also by law. International and local property valuation associations have also an essential role in spreading information and facilitating discussions between surveyors, investors and academics. Valuation practice will not change without the support and consistent view (on how to evaluate on-site energy investments) of the property valuation community.

Transitioning to renewables will deeply affect properties through requirements for demand side management, energy conservation and integration of renewable on-site energy production. Including these issues to valuation reports is very important, as they are most likely to benefit properties, as this study suggests. Taking sustainability into account also applies to properties that are not considered green. As sustainability becomes mainstream, regular properties will be those that suffer the most from potentially tightening regulation and fluctuating energy prices (RICS, 2013; Lorenz and Lützkendorf, 2011). It is not only a question of how much more valuable sustainable properties are compared to regular ones but also how much less worth regular properties will be compared to sustainable ones. If these aspects are not currently considered, are all properties mispriced and if so to what extent (Lützkendorf and Lorenz, 2005)?

Even though investment in on-site energy production would be economically feasible when calculated as part of the property's cash flow, property investors may not carry out these investments. The following explanations have been identified: firstly, property owners traditionally focus on improving the income side of properties' cash flow rather than optimising operating expenses, which might require sophisticated technological or operational understanding. The share of operating costs of rental income is approximately 5-15% (Christersson *et al.*, 2015), of which energy costs represent around 30% (Wiley *et al.*, 2010). Hence, the value increase generated through decreased energy costs is quite low in absolute terms. Secondly, the value increase is theoretical until an investor sells the property or an objective surveyor approves the decreased operating costs. Thirdly, property investors may not carry out investments because of poor leasing prospects and high vacancies of the property. If there is no expected positive net cash flow, there is no reason to invest more in the property. Fourthly, property owners may not be motivated to make investments in net lease properties, where tenants receive the benefits, at least in the short run. On the other hand, in the long run, tenants should be willing to pay more base rent as a result of decreased operating expenses, which should motivate real estate owners to make sustainability investments in properties with net lease structures. Finally, investing and

managing on-site energy production requires a certain expertise that property investors might not have. This provides new business opportunities for energy technology specialists.

There are some limitations and uncertainties related to the results of the case study and the associated survey. The data in the case study only covered one year (of which two months were based on a forecast). There will likely be some variations in the energy production from year to year, which was partially accounted for by using weather-normalised data for ground source heat pumps. In the case of solar energy, the annual average production per kilowatt peak was close to long-term solar irradiation. The pricing used for both heat and electricity in the base scenario was based on current pricing with realised growth rates during 2000-2018. Growth rates can change over time, which is why we added a sensitivity analysis of low and high energy price growth scenarios. Historically, both heat and electricity prices have increased faster than the consumer price index in Finland ([Statistics Finland, 2019a, 2019b](#)). This indicates that on-site energy's profitability will actually increase faster than that of properties and protect property owners against rising energy prices. As we did not have access to real maintenance costs, we based our cost estimations on the findings of earlier research. It is likely that the estimated maintenance costs are too high, which decreases the profitability of the investment. Industry often reports lower operating costs for these kinds of systems. As the old district heating system was replaced in connection with the extensive energy renovation of the case property, the costs of the old system are also eliminated from the real cash flows. This is not considered in our analysis, which also decreases the profitability of the investment. Furthermore, the case study did not include the possible impacts of on-site energy investments on cash flow variables other than decreased operating expenses. According to the reviewed past research and the survey results, improved sustainability may also affect other cash flow parameters, namely, rents, rental growth rate, vacancy ratio, obsolescence and depreciation, as well as current and exit yields through potentially decreased risks. Favourable changes in these parameters would further increase the value of the case property. As explained earlier, sustainability investments may also lead to several intangible benefits such as increases in the tenants' satisfaction, tenants' willingness to renew leases and sign longer leases and increases in the property's saleability.

Related to the limitations of the conducted survey, recruiting a representative sample is difficult. In the current study, the survey was distributed via several channels to improve the representativeness of the sample. The only requirement for the respondents was that they are involved in valuating real estate properties. However, those valuers who responded to the survey may have been more interested in the theme than those who did not answer. There may be some bias in the findings because the valuers who responded may have been more aware of how to take on-site energy production and sustainability in general into account when making valuations. In addition to the self-selection bias of the respondents, they might fall victim to desirability bias, i.e. stating opinions that will be viewed in a favourable light. However, we did not emphasise the connection between on-site energy-generating investment and enhanced sustainability. Desirability bias may have been avoided by asking the respondents to evaluate the case property before and after the investment. On the other hand, this would have extended the length of the survey and limited the number of respondents. Further, the respondents had extensive experience in property valuation, but not in on-site energy investments, as [Figure 1](#) shows. Stratifying the respondents among those with and without relevant experience did not reveal statistically significant differences between the groups. Some of the respondents may not have understood the questions. This risk was mitigated by testing the questionnaire with an

expert panel consisting of three valuers and one assistant professor who was not involved in the research.

The same or a similar survey could be conducted in other markets to gain an international perspective. Further, the number of case studies and the sophistication of financial modelling could be increased. Even using statistical analysis may be possible in the future, as the availability of empirical data increases. Comparing the valuers' and investors' insights would be another interesting topic. Further research could also attempt to specify the reasons for the widely acknowledged benefits of on-site energy production (or in a wider context, investments improving properties' sustainability) not translating into higher valuations in the discounted cash flow framework. Although the valuers agreed (in this study) that decreased operating expenses should be capitalised into the value of the property, enhancements in other cash flow parameters such as rents, vacancy rates and yields, have an even wider impact on the value. Valuation professionals and property investors should be interviewed to gain a profound understanding of the obstacles in the current investment analysis and valuation practice. The study was based on the assumption that on-site energy investment is financed by equity. However, if banks can offer debt financing for on-site energy investments with the same conditions as the property, the profitability would be further enhanced. The debt financiers' perspective and properties' ability to serve as collateral in the financing of renewable on-site energy would require more consideration. On-site energy investments may also have the potential to evolve as new investment products within the real estate industry. Indeed, the energy industry has an opportunity to offer services related to on-site energy production to property investors.

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