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A Perspective on the Valuation of Roofs: Incorporating Residual Land Value and Highest and Best Use principles to foster renewable energy generation

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Abstract

Purpose - Integrating sustainability considerations into valuation practices is essential for promoting sustainable real estate investments. However, a comprehensive understanding of how sustainability factors impact the value of real estate assets is required. This study addresses the growing importance of renewable energy and the underutilized potential of rooftops by proposing an innovative framework for the valuation of roofs when used for renewable energy production.

Design/methodology/approach - This study uses the concepts of residual value analysis and Highest and Best Use methodology, adapting them to create a new framework for rooftop valuation.

Findings - The value of a roof can be determined based on their energy generation capability, where the conditions for enhanced energy harvesting potential distinct a higher value to the host asset. This removes the hurdle for investors to use rooftops for renewable energy investments.

Originality - The novelty of this study lies in using the Highest and Best Use methodology in the valuation of roofs. To the best of our knowledge, no explicit valuation of roofs has been done in the context of renewable energy production.

Practical implications- This study contributes to innovative valuation methodologies by incorporating sustainable measures.

Social implications - Social implications include the evaluation of third-party investments in renewable energy on rooftops. This could lead to increased investments and higher renewable energy production, thereby lowering energy costs and enhancing the energy supply's reliability.

Keywords: Sustainability valuation, land valuation principles, residual value analysis, highest and best use, rooftop valuation, energy harvesting, real options

Paper type – Conference paper

1. Introduction

Real estate valuation and sustainability are interconnected concepts that have gained increasing attention recently. Academic research continues to explore the integration of sustainability considerations for real estate valuation practices. Studies have highlighted valuers' challenges in incorporating sustainability factors into their assessments, with earlier research indicating that more data could have helped the integration of sustainability into valuation practices (Hossain *et al.*, 2023). However, more recent studies have pointed out that a lack of knowledge and the inability to link sustainability attributes to value definitively continue to limit the explicit consideration of sustainability in valuations (Hossain *et al.*, 2023).

The integration of sustainability in real estate valuation practices has broader implications for the real estate industry and financial markets. Incorporating sustainability factors in valuation practices can influence the overall performance of real estate assets and impact financial markets with interests in real estate (Warren-Myers, 2012). Real estate and housing market sustainability have been described as an elusive criterion, indicating the complexity of integrating sustainability into real estate practices (Walacik *et al.*, 2020). Research has shown a relationship between innovation, sustainability, and real estate management. Innovation and sustainability are interconnected in real estate management, with the culture of innovation requiring risk-taking and experimentation, which can lead to sustainability improvements over time through cost reduction, increased productivity, and enhanced customer satisfaction (Kauko, 2019).

Additionally, studies have explored the impact of green building certification on commercial properties' cash flows and values. This indicates that surveyors may need help fully considering sustainability investments in property valuations in practice (Leskinen *et al.*, 2020). The concept of sustainable development goes beyond environmental concerns. It can add value to real estate analysis, mainly when based on assumptions of the highest and best use of properties (Abdullah Kamar *et al.*, 2022). Furthermore, the link between energy efficiency, sustainability, and publicly listed Real Estate Investment Trusts (REITs) performance has been studied, highlighting sustainability's importance in influencing real estate assets' operating and stock performance (Brounen *et al.*, 2021). Incorporating sustainability into analysing the highest and best use of real estate properties is crucial. It involves assessing the financial feasibility of alternative uses of assets to ensure adequate income or cash flow for income-producing properties, determining the economic benefits of property development, and considering the demolition costs for properties reaching the end of their economic life (Rymarzak *et al.*, 2022). Real Options Valuation has been identified as a valuable approach for assessing the value of assets, especially in uncertain scenarios, by considering a range of future possibilities and enhancing investor decision-making (Bilqist *et al.*, 2018). These studies showcase the varied angles to which the relationships between sustainability and real estate value can be drawn. This underlines the ambiguity in their relation and the complex challenge that every method is left to deal with.

Since the links between real estate valuation and sustainability are multifaceted, it raises the question of what would be comprehensive ways to understand how sustainability factors can impact the value and performance of real estate assets. This paper commences from the argument that integrating sustainability considerations into valuation practices is essential for promoting sustainable real estate development and enhancing real estate investments' overall resilience and value. As urban areas continue to expand and become denser, pressing concerns about energy scarcity and grid congestion require innovative strategies for maximizing renewable energy and grid utilization.

Furthermore, the latest amendment to the Energy Performance of Buildings Directive EPBD by the European Parliament (2023) underscores the importance of sustainability in real estate. The amendment incorporates the "European Solar Rooftops initiative" requirements (Art. 28b), mandating solar installations on every public and commercial building by 2026, on all residential structures by 2029, on non-residential buildings undergoing significant renovations by 2027, and on all existing public buildings gradually by 2030. These regulatory changes highlight the need to capture the value of rooftops for renewable energy production.

With this backdrop, we explore the relationship between sustainability starting from an often-overlooked real estate attribute: Rooftops. Despite their potential, rooftops have been notably undervalued and underutilized, frequently sidelined in conventional property valuation methodologies. Therefore, they offer a novel empirical case for redefining property value paradigms. This paper develops a novel method by infusing principles of residual land value and highest and best use (HBU) into the valuation, which draws and tests from the empirical features of the rooftops.

A few impacts from this article can be highlighted. First, it is uncovered that integrating renewable energy into a building can challenge determining the property's highest and best use. This challenge arises from the discrepancy between the lower investment cost in renewable energy and the higher cash flows generated by the PV installation over its lifetime. However, adding cashflows to the cashflow statement is often not considered. Even more seldom is the inclusion of the real option value of the roof to hold renewable energy production. In furtherance of this, a fundamental options approach can be employed to value the roof space as a valuable asset capable of housing renewable energy installations. Following this, we propose a methodology to calculate the roof's value and ability to house renewable energy production. The initial benefits of this valuation are multifaceted. For the building user and owners, the energy consumption cost can be lowered, and it can even be leased out to other parties willing to invest in renewable energy and thus generate cash flows. The benefits can also be encountered beyond these direct financial advantages. For societal stakeholders, like urban planners, policymakers, and developers alike, some of the more broad benefits include the extended production of renewable energy, the added value for congestion, the affordability of energy, and the certainty of supply.

2. Literature Review

A residual method is often used when valuing land. It hypothetically defines a project on the land that is being appraised. The present value of the cost of this hypothetical project is being calculated, including all margins and overhead. This total cost is subtracted from the possible market value of the hypothetical project, where market value is defined as "The estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion" (International Valuation Standards Council (IVSC), 2021). The residual amount resulting from this subtraction is the land value. This methodology is named the 'Highest and Best Use (HBU)'. It is a fundamental concept in real estate valuation, emphasizing the optimal land use that results in the highest value. The idea of "Highest and Best Use" in real estate valuation can be linked to optimizing resources for maximum profitability. In real estate valuation, the highest and best use refers to the most profitable use of a property that is legally permissible, physically possible, financially feasible, and maximally productive (Pearsall, 2013). Appraisers are advised to maintain objectivity and fairness, adhering to the principle of HBU during valuation processes (Konowalczuk, 2017). The concept of HBU has been a cornerstone in the real estate market for almost a century, highlighting the importance of maximizing a land's potential to achieve the highest value (AbdulJabbar and Neubert, 2019).

Existing buildings are being appraised most often for the utility they bring in either 1) comparison to other transactions on the market, 2) the replacement cost of the asset with a comparable utility, or 3) the income the asset is expected to generate during its lifetime. For non-residential assets, the income approach is the standard method of valuing the market value of an asset. This approach, on a basis, concerns the identification of the cashflows in and out and calculating the net present value using the appropriate discount rate. Under the driving force of becoming more sustainable (and the prevailing regulation concerning sustainability), integrating renewable energy into buildings is ubiquitous and business as usual.

The residual land value model, a mainstay in property economics, determines potential land value after factoring in all pertinent costs and profits. Concurrently, the HBU principle denotes the most financially viable, legally permissible, and physically feasible use of a property that yields the most significant gain. By fusing these principles, we establish a foundation for assessing rooftops based on their economic viability and use appropriateness. By applying an options analysis, the value of the roof space can be determined not just based on its current use but also on its potential future uses, such as hosting renewable energy installations. This approach allows for considering the flexibility and value of the roof space in accommodating different uses over time, akin to valuing a real option. Real options analysis enhances project value and decision-making by identifying the optimal strategy and timing for utilizing the roof space for renewable energy installations. The International Valuation Standards has recognized the incorporation of real options theory into the income approach for real estate valuation since 2011. This recognition underscores the importance of considering real options, such as the potential for integrating renewable energy, in valuing real estate assets accurately.

3. Modelling

Different factors need to be considered when integrating renewable energy onto a roof. The feasibility of the integration depends on the technology being implemented, the prevailing regulations, and technical constraints. The valuation model being created considers that these factors have been checked and that the technology being considered for the highest and best use complies with these factors.

Variables:

A : Roof area [m²] activated

I_t : Investment at time t [€], including investments to improve stability, accessibility, wind protection,... any investments that need to be made to implement the renewable energy installation.

C_t : Cost at time t [€]

$opex_t$: Operating and maintenance costs at time t [€]
R : Revenue from energy production at time t [€]
$E_{prod,t}$: Energy production at time t [kWh]
L : The lifetime of the installation [year]
n : Number of measurements in 1 year
r : Discount rate [%]
S : Subsidy or incentive amount [€]
$E_{cost,t}$: Energy price at time t [€/kWh]
$G_{cost,t}$: Energy grid feed-in tariff at time t [€/kWh]
T : Tax impact [€]
t : time [years]
e : Efficiency of the renewable energy technology [%]
s : Renewable energy input [kWh/m²/year]
auto : Auto-consumption factor [%]
IRR : The market expectation for an investment in renewable energy installations [%]
RE_{min} : The percentage of the maximal capacity of renewable energy, that was integrated into the building as a minimal amount of renewable energy to comply with (local) regulations [%]

3.1. Energy Production Estimation

As a mathematical function with a complete list of the variables, the annual energy production $E_{prod,t}$ use is:

$$E_{prod,t} = (1 - \mathrm{RE}_{\mathrm{min}})\, A\, e\, s$$

Area A is the area being activated by the renewable energy system. This does not necessarily be the m² of roof. For instance, a wind turbine can only use 1 m2 of roof surface for its installation but does need 5m of free space in every direction for its normal functioning (and thus activates practically 80 m^2 of roof).

In this case, the energy production being determined here is calculated discretely, being t determined yearly. However, for other renewable energy inputs in which a constant is not available (i.e. wind inputs for wind roof turbines), it would be possible to calculate this energy production continuously using:

$$E_{prod} = \int_1^L E_{prod,t}\, dt = \int_1^L (1 - \mathrm{RE}_{\mathrm{min}})\, A\, e(t)\, s(t) dt$$

Here, the efficiency of converting the renewable input source, e, and the renewable input source, s, will become time-dependent.

3.2. Revenue Calculation

Similarly, the revenue, R, from the energy production is calculated by:

$$R = \int_1^L R_t \, dt = \int_1^L (E_{prod,t} \, E_{cost,t} \, auto_t + E_{prod,t} \, G_{cost,t} \, (1 - auto_t)) \, dt$$

Here, it is essential to calculate the revenue continuously or in a time-dependent, discrete way. On most energy grids, the energy component and the power part are essential in determining the feed-in tariff (e.g., capacity tariff on electricity grids). In practice, this value will most often prove to be some 15-minute value that is measured and settled, or an average price determined for the duration of the measurement. In the given formula, the time-discrete step is denoted as n.

$$R = \sum_{t=1}^{L} \sum_{n=1}^{n} \frac{R_n}{(1+r)^t} = \sum_{t=1}^{L} \frac{\sum_{n=1}^{n} (E_{prod,n} \, E_{cost,n} \, auto_n + E_{prod,n} \, G_{cost,n} \, (1 - auto_n))}{(1+r)^t}$$

Auto is the auto-consumption factor, which will be time-dependent (discrete). A percentage of how much of the produced energy is consumed on-premise (first part of the sum) and how much energy is injected (second part of the sum) into some 'public' distribution system. Public is being mentioned in quotes as the distribution system can be privatized. What is meant is the distribution onto some supra system that will transport the energy to some other location to be consumed there and where a price is paid (or has to be paid) to transport and settle the energy cost.

3.3. Cost Model

The total cost over the lifespan includes initial investment, ongoing maintenance, operational expenses (fuel, electricity, insurance, ...), and (replacement) investments:

$$Total\ cost_{PV} = \int_0^L C_t \, dt = \int_0^L (I_t + \frac{opex_t}{(1+\ r)^t}) \, dt$$

Or, in discrete terms:

$$Total\ Cost_{PV} = \sum_{t=0}^{L} (\mathrm{I}_t + \frac{opex_t}{(1+\ r)^t})$$

The total cost in present value terms means that the time value of money has been taken into account by discounting the cash flows using the discount rate r. Operational expense is a lump sum parameter that captures all operational expenses.

3.4. Profitability Analysis (Net Present Value)

The Net Present Value (NPV) of the roof is calculated as:

$$NPV = R - Total\ Cost_{PV} + \sum_0^{t_s} \frac{S}{(1+r)^{t_s}} + \sum_0^{t_t} \frac{T}{(1+r)^{t_t}}$$

A positive NPV suggests that the project is financially viable. Because the time limits for the sum of the subsidies and the tax benefits can be different, they are separated in the calculations.

3.5. Roof valuation

Up until now, nothing has been done other than a business-as-usual investment analysis on a renewable energy installation. To determine the value of the roof, the installations will be installed upon, the following reasoning is made:

IRR is the discount rate that makes the NPV equal to 0.

$$NPV = R - Total\ Cost_{PV} + \sum_{0}^{t_s} \frac{S}{(1+IRR)^{t_s}} + \sum_{0}^{t_t} \frac{T}{(1+IRR)^{t_t}}$$

$$\sum_{t=1}^{L} \left(\frac{\sum_{n=1}^{n}(E_{prod,n}\, E_{cost,n}\, auto_n + E_{prod,n}\, G_{cost,n}\,(1-auto_n))}{(1+IRR)^t}\right) - \sum_{t=0}^{L} \left(I_t + \frac{opex_t}{(1+IRR)^t}\right) + \sum_{0}^{t_s} \frac{S}{(1+IRR)^{t_s}} + \sum_{0}^{t_t} \frac{T}{(1+IRR)^{t_t}} = 0$$

The market expects a certain IRR for investments in renewable energy installations.
A value factor can be included in the profitability calculation of the sustainable energy investment.

$$\sum_{t=1}^{L} \left(\frac{\sum_{n=1}^{n}(E_{prod,n}\, E_{cost,n}\, auto_n + E_{prod,n}\, G_{cost,n}\,(1-auto_n))}{(1+IRR)^t}\right) - \sum_{t=0}^{L} \left(I_t + \frac{opex_t}{(1+IRR)^t}\right) + \sum_{0}^{t_s} \frac{S}{(1+IRR)^{t_s}} + \sum_{0}^{t_t} \frac{T}{(1+IRR)^{t_t}} - Value\ roof = 0$$

To calculate the value of the roof, the formula needs to be transformed to become:

$$Value\ roof = \sum_{t=1}^{L} \left(\frac{\sum_{n=1}^{n}(E_{prod,n}\, E_{cost,n}\, auto_n + E_{prod,n}\, G_{cost,n}\,(1-auto_n))}{(1+IRR)^t}\right) - \sum_{t=0}^{L} \left(I_t + \frac{opex_t}{(1+IRR)^t}\right) + \sum_{0}^{t_s} \frac{S}{(1+IRR)^{t_s}} + \sum_{0}^{t_t} \frac{T}{(1+IRR)^{t_t}}$$

This value for the roof is the maximal amount an investor can pay in total for the roof while maintaining the desired (market) profitability (IRR) for the investment in renewable energy installation.

4. Testing the model

In this example, the value of a roof will be calculated for a PV installation. The following parameters will be used to calculate the value:

A	: 1000 m^2
I_t	: 320 000 €
$opex_t$	: 5 000 €/a
R	: 32 000 €
L	: 25 years
r	: 4.5 %
y	: 5.5 %
S	: 10 000 €, once at time 0
$E_{cost,t}$	: 0.15 €/kWh
$G_{cost,t}$	: 0.05 €/kWh
T	: 4224 €/a for 10 years (year 1 up to and including 10)
e	: 21 %
s	: 1300 kWh/m²/year
auto	: 75 %
IRR	: 8.5%

Energy production:

$$E_{prod,t} = A\ e\ s$$

$$E_{prod,t} = 1000\ 0.21\ 1300\ =\ 273\ 000\ \frac{kWh}{a}$$

Value roof:

$$Value\ roof = \sum_{t=1}^{L} \left(\frac{\sum_{n=1}^{n}(E_{prod,n}\ E_{cost,n}\ auto_n + E_{prod,n}\ G_{cost,n}\ (1 - auto_n))}{(1+IRR)^t}\right) - \sum_{t=0}^{L} \left(\mathrm{I}_t + \frac{opex_t}{(1+\ IRR)^t}\right) + \sum_{0}^{t_s} \frac{S}{(1+IRR)^{t_s}} + \sum_{0}^{t_t} \frac{T}{(1+IRR)^{t_t}}$$

$$Value\ roof\ =\ 387\ 458.42 - 376\ 770.46\ +\ 10\ 000 + 27\ 715.13$$

$$Value\ roof\ =\ 48\ 403.09$$

This is the total amount an investor can pay for the roof, taking the desired IRR into account. Appropriate payment (cash flow) planning needs to be set up, or a payment at once. In this case, a yearly payment of 3301.15 € (at a yield of 5.5%, aside from inflation) would lead to a value of 48 403.09 €. The property's yield is being used to recalculate the value towards yearly cash flows (being additional rent for the building).

5. Discussion

5.1. Valuation Methodology

The integration of renewable energy technologies into rooftops necessitates a departure from traditional valuation methodologies. The cost and comparable approaches traditionally used in real estate valuation often fail to account for the full economic and sustainability benefits of renewable energy installations. This paper advocates for the residual land value and highest and best use (HBU) principles to provide a more accurate reflection of the value of rooftops equipped for renewable energy production. By doing so, it acknowledges the evolving role of sustainability in real estate and the need to align valuation practices with broader environmental and economic goals.

5.2. Economic and Sustainability Impacts

Renewable energy installations on rooftops, such as photovoltaic (PV) systems, offer substantial economic benefits through energy cost savings and potential revenue from energy sales. Additionally, these installations contribute significantly to sustainability by reducing dependence on non-renewable energy sources and decreasing carbon emissions. The traditional valuation methods may underestimate these benefits, leading to a misrepresentation of the property's true value. The proposed methodology addresses this gap by incorporating the potential future cash flows generated by renewable energy installations into the valuation process, thereby providing a more comprehensive assessment of the property's value.

5.3. Challenges in Current Valuation Practices

One significant challenge in current valuation practices is the perceived risk associated with renewable energy investments. This risk perception can deter valuers from fully incorporating these assets into their assessments. Additionally, the lack of standardized methods for quantifying the added value of sustainability features further complicates the integration of these elements into property valuations. The complexity of sustainability in real estate, coupled with the evolving regulatory landscape, underscores the need for valuation methodologies that can adapt to these changes and provide a more accurate representation of property values.

5.4. Proposed Methodological Enhancements

To address these challenges, this paper proposes leveraging the residual land value and HBU principles, coupled with real options valuation (ROV). The ROV framework allows for assessing the flexibility and potential future benefits of renewable energy installations, which are often overlooked in traditional valuations. This approach enables valuers to consider the various future scenarios and the potential value of different uses of the roof space over time. By doing so, the economic benefits of renewable energy installations can be better captured, providing a more accurate valuation of rooftops.

5.5. Sensitivity Analysis and Market Implications

Initial analysis suggests a prevalent underutilization of rooftops, attributable to the absence of a marketplace that encourages installing renewable energy sources on roofs other than one's own (third-party investments). Sensitivity analysis is crucial to understanding the impact of different variables on the valuation outcome. For example, in logistic buildings, the integration of renewable energy installations can significantly increase the property value, potentially by up to 10%. This highlights the need for a detailed sensitivity analysis to understand the implications of various assumptions and parameters on the valuation results.

The adoption of improved valuation methods has significant implications for the real estate market. Valuers, urban planners, and policymakers must consider the long-term benefits and sustainability contributions of renewable energy installations. The integration of renewable energy into real estate valuation represents a transformative shift in property appraisal, demanding a reassessment of traditional methodologies. By adopting a methodology that considers the potential future cash flows generated by renewable energy installations, valuers can more accurately determine the economic value of these enhancements.

5.6. Legal and Regulatory Considerations

Legal compliance and the timing of this compliance are critical factors in the valuation process. For instance, obtaining permits for renewable energy installations can be time-consuming, and these delays must be reflected in the cash flow statements. The methodology assumes the highest and best use of the property, but it is essential to avoid overly optimistic assumptions. All assumptions must be well-documented and evaluated to ensure a realistic and accurate valuation.

6. Conclusion

This paper introduces a fresh perspective for building users, urban planners, policymakers, and developers to evaluate and maximize the latent potential of rooftops. By considering rooftops as extensions of land and recognizing their highest and best use, the residual value can be computed to enhance urban landscape value and productivity. Additionally, the roofs can reduce energy consumption costs for the user and generate revenue through leasing the roof for renewable energy.

The transition towards sustainable real estate practices necessitates a paradigm shift in valuation methodologies. By integrating principles like residual land value and HBU specifically tailored to assess the potential of renewable energy installations, the real estate sector can enhance both its economic and environmental performance. This approach not only aligns with global sustainability goals but also offers a practical pathway for capitalizing on the untapped potential of rooftops, ultimately fostering a more sustainable urban development.

The analysis highlights the potential for rooftops to contribute significantly to renewable energy generation and economic value. By redefining property value paradigms to include the potential of rooftops for renewable energy installations, the economic and environmental performance of the real estate sector can be enhanced. This approach aligns with global sustainability goals and offers a practical pathway for capitalizing on the untapped potential of rooftops, ultimately fostering a more sustainable urban development. The transition towards sustainable real estate practices necessitates a paradigm shift in valuation methodologies, and their proposed framework provides a robust foundation for this transformation.

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