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A comparative assessment of building sustainability schemes in Norway

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Abstract. Various schemes are established to evaluate the sustainability of buildings during their life cycle. These schemes introduce a range of evaluation criteria and indicators and are periodically revised to align with current sustainability trends. This study reviews leading schemes in Norway, and compares their scope, similarities, limitations, and advantages. The review is carried out against a proposed office building in Oslo, Norway. The paper evaluates how the schemes comply with the EU taxonomy and Norwegian building regulations. The schemes are assessed through a literature review and interviews with programme operators. Common sustainability criteria are identified and reviewed. In addition, a comparison of how the schemes address the United Nations Sustainable Development Goals is conducted. The comparative assessment provides a valuable and practical reference and decision support for project owners in Norway to select the appropriate scheme for their construction project.

1. Introduction

The construction sector plays an important role in economic growth, providing the needs of society and improving human life quality through safe and healthy environments [1]. Conversely, this sector is also responsible for environmental degradation by excessive resource consumption, greenhouse gas (GHG) emissions, noise pollution, waste generation, and air pollution [2][3]. Many building sustainability schemes are developed to rate and certify building projects based on their environmental, social, and economic impacts [4]. There are approximately 600 green rating systems and programs for buildings globally and this number is continuously growing [5]. All these schemes introduce a range of evaluation criteria and indicators and are periodically revised to align with sustainability trends in the built environment [4]. One of the most prominent sustainability schemes for buildings in Norway is BREEAM-NOR, adapted from BREEAM (Building Research Establishment Environmental Assessment Method) International to Norwegian regulations and climate [6]. Other Norwegian building sustainability schemes include, but are not limited to, FutureBuilt [7], Powerhouse Paris Proof [8], the Research Centre for Zero Emission Buildings (FME ZEB) [9,10] and the Research Centre for Zero Emission Neighbourhoods in Smart Cities (FME ZEN) [11,12].

The objective of this paper is to review and compare the leading Norwegian building sustainability schemes outlined above through exploring their scope, similarities, limitations, and advantages. The authors of this paper are using the term 'building sustainability schemes' to cover all types of green building certification systems, programmes and activities from research centres, and rating schemes. The Norwegian building regulations (TEK) are taken as a baseline for assessing the breadth and ambition level of the schemes. The results are discussed in terms of a proposed office building (Fv1B) in Oslo, Norway. The paper also evaluates how these schemes compare with the EU Taxonomy and the United Nations (UN) Sustainable Development Goals (SDGs). Since these national sustainability schemes have either undergone a recent revision or are newly established, this comparative analysis provides an up-to-date practical reference and decision support for project owners in Norway when choosing the appropriate scheme for their construction project.

2. Background

Internationally, the popularity of building sustainability schemes is increasing in line with the increasing interest in environmental, economic, and social issues in society, the construction industry and academia. In response, the schemes are continuously updating their criteria [13]. However, it is unclear how certified buildings from various systems can be compared to each other as well as help project owners in choosing the appropriate scheme. Previous studies have compared the building rating systems from different perspectives. The first international building sustainability scheme was established in the 1990s with BREEAM. The scheme is based on target values for different sustainability criteria and has become a popular tool to assess a building's environmental performance [14]. Another prominent international building sustainability scheme is Leadership in Energy and Environmental Design (LEED), which was launched by the United States Green Building Council in 1998 and has been used globally for evaluating sustainability in the construction sector [14]. Other sustainability schemes are specifically tailored to suit the building industry in different regions/countries, such as LEED Canada, France's HQE (High Environmental Quality), Germany's DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen e.V.), Australia's Green Star, NABERS (National Australian Built Environment Rating System), Japan's CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), and New Zealand's Green Star [4].

Haapio and Viitaniemi [19] explore the differences between sixteen schemes by classifying them according to general criteria. A study by Nguyen and Alten [20] represents a comprehensive review on BREEAM, LEED, and CASBEE, amongst others to select the best scheme based on commercial features (i.e., user-friendliness, availability, applicability, popularity), and concludes that LEED and BREEAM are most frequently used. Doan et al. [4] conduct a systematic review of the development of building sustainability schemes and identifies the similarity, difference, strength, and weakness of LEED, BREEAM, CASBEE and Green Star NZ. The review confirms that BREEAM and LEED are more dominant, and mentions indoor environment quality, energy, and material as core common categories for all compared rating systems. Suzer [21] examines the correlation between LEED and BREEAM and shows a strong correlation between the scores of dual certified projects, and higher expectations in BREEAM-certified projects in comparison to LEED. Shan and Hwang [22] review fifteen prevailing building sustainability schemes used worldwide and finds energy, site, indoor environment, land and outdoor environment, material, water, and innovation as seven essential evaluation criteria.

BREEAM-NOR [6] is Norway's most widely used building sustainability scheme. It was established in 2010 and is aligned with Norwegian standards and regulations on energy and environment. It contains nine categories that ensure all aspects of sustainability are considered. These categories are management, health and wellbeing, transport, water, pollution, energy, land use and ecology, waste, and materials. Each category contains criteria which provide points, and each category has a weighting that indicates its relative importance in the BREEAM-NOR certification scheme. Projects are awarded a BREEAM rating based on the number of points accumulated. Minimum requirements in key categories ensure that basic sustainability considerations are taken care of. A building can be certified with BREEAM-NOR on five levels: Pass, Good, Very Good, Excellent and Outstanding. On average, the certification level for projects certified in Norway is "Very Good". The BREEAM-NOR manual was launched in 2016 and has since undergone two minor revisions. The latest revision of the manual for new buildings, BREEAM-NOR v6.0, was published in March 2022 [6]. The revision includes changes to weighting, building types, minimum requirements, and innovation as well as compliance to the EU taxonomy.

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FutureBuilt [7] is an innovation programme that started in 2010 with the aim of promoting climate friendly urban development and reducing GHG emissions. The programme introduces criteria for net GHG emissions of buildings (or urban areas) over their lifetime that can contribute to national and international climate goals [23]. FutureBuilt aims to realise 100 pilot projects proving that reductions in GHGs are possible following FutureBuilt criteria. With the latest update in 2021, the main criterion in the FutureBuilt programme is a minimum 50 percent reduction in GHG emissions from energy and material use. There are five mandatory criteria (urban environment and architecture, social sustainability, GHG emissions, innovation, and the environment), and four optional criteria (circular buildings, biodiversity, stormwater management and plus-energy). All FutureBuilt projects must fulfil the mandatory criteria and two to three optional criteria. A project which fulfils the FutureBuilt criteria receive a certificate, media coverage and are considered as a FutureBuilt pilot project.

Powerhouse [8] was established in 2019 and aims to design and realise buildings that are net energy-positive over their lifetime [24].The Powerhouse definition states that a building will generate more renewable energy during its lifetime than it will use during the production of building materials, construction, use and demolition. In 2019, Powerhouse sharpened its requirements from plus-energy to include carbon neutrality to meet the Paris Agreement's ambitions [25]. This new standard, Powerhouse Paris Proof, aims for maximum CO_2 emissions per square metre which are tightened over time and includes the whole life cycle [24]. Powerhouse Paris Proof is still under revision, and the new methodology is not yet published. Powerhouse emphasises energy efficiency, renewable energy production, sustainable building practices and climate-friendly building materials. Powerhouse encourages seeing the energy system from a neighbourhood perspective and includes ‘smart’ solutions.

The Research Centre for Zero Emission Buildings (FME ZEB; 2008-2016) developed a definition of zero-emission buildings [9,10]. A zero-emission building (ZEB) is an energy-efficient building that produces local renewable energy to compensate for the building's GHG emissions throughout its life cycle. Six different ZEB ambition levels are defined based on the scope of the system boundary, starting with the lowest ambition level of ZEBO÷EQ, which means the building's renewable energy production compensates for GHG emissions from energy use in operation (O) of the building, except for electrical equipment, plug loads (EQ); to the highest ambition of ZEB-COMPLETE which means the building's renewable energy production compensates for GHG emissions from all phases of its lifespan: construction (C), operational energy use (O), material production and replacement (M), use, maintenance, repair and rehabilitation in the operational phase (PLET), and end of life of building materials (E). FME ZEB also sets other criteria concerning indoor environment, comfort, and operational energy needs. In addition, energy production from the building must be adapted to reduce unnecessary imports and exports of energy [26].

The Research Centre for Zero Emission Neighbourhoods in Smart Cities (FME ZEN) runs from 2016-2024 and builds upon FME ZEB by developing solutions for future buildings and urban areas, as well as solutions that help realise a zero-emission society. The definition for a zero-emission neighbourhood (ZEN) is still under development but aims to reduce a neighbourhood's direct and indirect GHG emissions toward net zero within its analysis period [11,12]. The definition focuses on the following categories: GHG emissions, energy, power, mobility, urban form, and economy.

TEK was revised in July 2022 [27]. The revision introduces GHG emission accounting of new or refurbished buildings and, increases the construction waste sorting grade from 60% to 70%. The revision of the Norwegian building sustainability schemes evaluated in this study do not consider these changes. The EU Taxonomy [28] was established in 2020 and is a classification system defining what an environmentally sustainable activity is, to help guide financial investments towards more sustainable projects. The Taxonomy contains six environmental objectives: climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control and protection and restoration of biodiversity and ecosystems. To classify as sustainable under the Taxonomy, an activity must substantially contribute to at least one of the six environmental goals and not be of material harm to any of the other environmental goals (the ‘do no significant harm’ or DNSH principle). The classification system is not a certification scheme but provides a common framework for reporting a project's sustainability. A key objective of the Taxonomy regulations in the construction industry is to turn investments towards more energy-efficient buildings and stimulate investments in buildings that contribute to reducing energy consumption. The Taxonomy is still under development; at the time of writing only the criteria for climate change mitigation and adaptation have been published [29], with criteria for the other objectives expected later in 2022. The SDGs were adopted by the UN in 2015 as a "a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity" [30]. The 17 SDGs goals and their respective 169 targets and indicators are formulated at a global level and progress is monitored and reported annually by the UN.

Existing comparisons in the literature show that building sustainability schemes have differences in evaluation methods and criteria, and weighting of different indicators, which can lead to different outcomes for a particular building [4]. The selected schemes, and the applied framework for comparative analysis vary considerably among the studies. There is also a need to evaluate different sustainability schemes in terms of the SDGs since it is likely that regional and national governing bodies will soon require reporting on SDGs. In addition, few studies evaluate and compare the recently revised or newly established sustainability schemes in Norway [24].

3. Methodology

A qualitative comparative assessment is carried out on BREEAM-NOR v6.0, FutureBuilt, Powerhouse Paris Proof, FME ZEB and FME ZEN. This is achieved through a literature review and conducting semi-structured interviews with programme operators. For each scheme, the official documentation and guidelines are evaluated, and all criteria are entered into a matrix along with information on whether the criterion is mandatory for receiving accreditation. The interviews with programme operators provide clarifications where needed and give an in-depth understanding of specific sustainability focuses of each scheme. The interviewees are provided with the interview manuscript beforehand, and interviews are carried out digitally. Once all criteria are collected, they are clustered into a set of common sustainability criteria. These criteria are selected to reflect the themes covered by the building sustainability schemes, with some adjustments to prevent overlap and to ensure consistency. Fifteen common sustainability criteria are identified in Table 1, and are in line with the most common criteria in literature [22]:

Table 1. Common sustainability criteria

Common sustainability criteria	Description
Management	Conceptual development, project optimalisation, life cycle costs and lifetime planning, responsible building practice, commissioning and delivery, trial operation and follow-up
GHG emissions	GHG emissions from the whole life cycle according to the Norwegian Standard method for GHG emission calculations in buildings (NS 3720)
Pollution	Impacts on air, water, soil, and health, including noise and light pollution
Circular buildings	Adaptability, reuse, and reusability of the building and its materials
Materials	Environmental sustainability of building materials and procurement policies
Waste reduction	Waste reduction and waste handling measures during construction and use
Energy	Energy usage and reduction measures in the use phase of the building
Health and wellbeing	Indoor impacts on physical and mental health
Urban environment and architecture	The wider urban context of the building and its placement
Social inclusion	Social impacts throughout the planning, construction and use phases of the building, including stakeholder engagement and social functions
Innovation	Requirements on novelty and innovation
Biodiversity	Conservation, restoration, and improvement of local biodiversity
Climate change adaptation	Risk assessment and mitigation of climate change-related vulnerability

Water consumption	Water use and reduction measures
Transport	Mobility services and provisions to and from the building

The criteria above represent the most common categories in Norwegian building sustainability schemes. A qualitative grading system is used to ascertain to what degree each criterion is included in the scheme. The level of inclusion is indicated as ‘not assessed’, ‘indirectly assessed’ or ‘directly assessed’, and mandatory criteria. Note that this analysis does not evaluate the specific criteria, but rather the level of emphasis on a criterion within the scheme. In other words, two schemes with the same indication (e.g., ‘directly assessed’ for GHG emissions) may still set different specific criteria (e.g., GHG emission reduction of 30% or 50%). Results are displayed in a colour-coded classification system matrix. The same evaluation is completed for TEK (to provide a baseline) and the EU Taxonomy, based on reviews of official documentation. Finally, the rating schemes are qualitatively evaluated according to how well they align with SDGs, with a qualitative indication of ‘no impact’, ‘limited impact’, ‘some impact’, or ‘significant impact’. These levels are based on information published by the schemes and supplemented by interviews with programme operators [31,32].

The results from the comparative assessment are used to select the most relevant scheme for a proposed office building (Fv1B) located in Oslo, Norway. Construction of Fv1B will start in 2023 and the building will have 15,000m^2 gross heated floor area with 2,500m^2 of laboratories and will be designed for up to 450 users. The project owner's sustainability goals are identified through interview and are focused on sustainable materials, energy efficiency, fossil or emission free construction site, solar energy, space flexibility, company visibility, technology for a better society, increased employee and customer satisfaction, and good management. An additional concern relates to additional investment costs associated with implementing building sustainability schemes contra conventional building practice (TEK).

Expected additional investment costs for Fv1B according to the evaluated schemes are ascertained through interviews with programme operators and actual cost data available from completed projects, with the caveat that these were built under the old versions of the schemes. The costs are given as a percentage increase relative to the cost of building according to TEK.

Fv1B is also used as an example for a simplified calculation of the operational energy costs and savings associated with different building energy standards included in the building sustainability schemes. The energy standards evaluated are TEK [33], Passivhus [34], near Zero Energy Building (nZEB) [35], ZEB-O [9] and Plusshus [36]. The annual net energy demand is calculated according to heated floor area. The energy demand for ZEB-O is set at zero for this analysis, with the assumption that the actual energy demand is offset by on-site energy generation over the course of one year, although the authors acknowledge that there will be a mismatch in energy demand and energy generation on an hourly resolution [9]. The reduction in net energy demand of each rating scheme (E_x) is calculated relative to the energy demand of TEK (E_{TEK}) using equation (1):

$$1 - \frac{E_{\mathrm{x}}}{E_{\mathrm{TEK}}} \tag{1}$$

To calculate energy costs, it is assumed that the total energy use consists of 25% district heating and 75% electricity, based on data from an existing neighbouring office building. The energy prices (excluding tax) are based on the most recent data for service industries from the Norwegian Central Bureau of Statistics (SSB), namely 113 øre/kWh for electricity [37] and 101.7 øre/kWh for district heating [38], whereby 10 øre corresponds to 1 NOK, and 1 NOK is equal to 0,1 EUR [39]. The cost savings are calculated by subtracting the TEK energy costs from the costs of each energy standard.

Finally, a simple calculation is performed to estimate how long it takes to reach a ‘break-even point’ between the increased investment costs and the reduction in energy costs. The absolute additional investment costs (converted from percentage to NOK assuming an average construction for a 15,000 m^2 office building in Norway of 153 million NOK [40]) are divided by the annual energy cost savings for

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each energy standard, resulting in the number of years needed before the energy cost savings equal or exceed the additional investments.

4. Results

The results from the comparative assessment of Norwegian building sustainability schemes are presented in Table 2 and show to what degree TEK, EU taxonomy, FutureBuilt, BREEAM-NOR v6.0, Powerhouse Paris Proof, FME ZEB and FME ZEN consider various sustainability criteria. FutureBuilt sets the most mandatory and comprehensive sustainability requirements followed by BREEAM-NOR, whilst Powerhouse Paris Proof, FME ZEB and FME ZEN have a narrower focus. The criteria of GHG emissions, materials and energy are common to all schemes, while social inclusion is only assessed in FutureBuilt (mandatory) and FME ZEN (indirectly). TEK places emphasis on GHG emissions, waste, energy, and indoor climate, only indirectly setting requirements for other sustainability criteria. Biodiversity, built environment and architecture, and social inclusion are only mandatory in FutureBuilt, whilst there are no mandatory criteria on pollution or transport in any of the schemes.

Table 2. Colour-coded classification system matrix of Norwegian building sustainability schemes against sustainability criteria (Grey (-) is not assessed, yellow (+) is indirectly assessed, green (++) is directly assessed, and * is mandatory)

Criteria	TEK	EU Taxonomy	FutureBuilt	BREEAM-NOR v6.0	Powerhouse Paris Proof	FME ZEB	FME ZEN
Management	-	++	++*	++*	-	+	+
GHG emissions	++*	++	++*	++*	++	++	++*
Pollution	-	+	++	++	-	-	-
Circular buildings	+	++	++*	++*	+		+
Materials	+	++	++*	++*	++	++	++
Waste	++*	++	++	++	+	+	+
Energy	++*	++	++*	++*	++*	++*	++
Indoor climate and health	++	+	++*	++*	++	+	+
Built environment and architecture	-	+	++*	+	+	+	++
Social inclusion	-	-	++*	-	-	-	+
Innovation	-	+	++*	++*	+	+	++
Biodiversity	-	++	++*	++	+	-	-
Climate mitigation	+	++	++*	++*	+	-	-
Water	+	++	++*	++*	-	-	-
Transport	-	-	++	++	-	-	++

Table 3 shows the level of SDG alignment from the sustainability schemes. It should be noted that FME ZEB is not included in Table 3 since the programme was developed before SDGs were published in 2015. Similarly, TEK is not included as the Norwegian building regulations are not designed to respond to the SDGs. The results show that all SDGs are addressed to some extent in all schemes, except for SDG 6 (Clean water and sanitation), which is not impacted by Powerhouse Paris Proof or FME ZEN. All schemes have significant impact on SDGs 3, 7, 9, 11, 12, 13 and 15. FutureBuilt has the highest level of alignment with SDGs, although the difference between the schemes is small.

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Table 3. Colour-coded classification system matrix of Norwegian building sustainability against SDGs (grey (-) has no impact, yellow (+) has limited impact, light green (++) has some impact, dark green (+++) has significant impact).

UN Sustainable Development Goals	EU Taxonomy	FutureBuilt	BREEAM-NOR v6.0	Powerhouse Paris Proof	FME ZEN
1. No poverty	++	++	++	++	++
2. Zero hunger	+	+	+	+	+
3. Good health and well-being	+++	+++	+++	+++	+++
4. Quality education	++	++	++	++	++
5. Gender equality	+	+	+	+	+
6. Clean water and sanitation	+++	+++	+++	-	-
7. Affordable and clean energy	+++	+++	+++	+++	+++
8. Decent work and economic growth	+	+	+	++	+++
9. Industry, innovation and infrastructure	+++	+++	+++	+++	+++
10. Reduced inequalities	+	+	+	+	+
11. Sustainable cities and communities	+++	+++	+++	+++	+++
12. Responsible consumption and production	+++	+++	+++	+++	+++
13. Climate action	+++	+++	+++	+++	+++
14. Life below water	+	+	+	+	+
15. Life on land	+++	+++	+++	+++	+++
16. Peace, justice and strong institutions	+	+	+	+	+
17. Partnerships for the goals	++	+++	++	+++	+++

The results from interviews show that FutureBuilt and Powerhouse have an expected additional investment cost of up to 5%, EU Taxonomy between 2 - 5%, and BREEAM-NOR up to 2% plus the registration fee, certification fee and BREEAM advisor costs. The total cost for registration and certification ranges between 68,000 – 190,000 NOK depending on the size of the building and whether the project owner is a member of the Norwegian Green Building Alliance [41]. The costs for a BREEAM advisor vary widely depending on the size of the project, their level of involvement, and the rates they charge. No additional investment cost data is currently available for FME ZEB or FME ZEN. Table 4 displays a simplified calculation of net operational energy demand, costs, and savings for selected energy standards. TEK is the minimum requirement for all new buildings in Norway; Passivhus is a minimum requirement in Powerhouse; nZEB is used in FutureBuilt and BREEAM-NOR; ZEB-O is used in FME ZEB; and Plusshus is used in Powerhouse, FME ZEB, FutureBuilt and BREEAM-NOR.

Table 4. Simplified estimate of operational energy demand, costs, and savings relative to TEK for Fv1B when different energy standards are used.

Energy standard	Net energy demand (kWh/m^2/yr)	Reduction in energy demand compared to TEK (%)	Operational energy costs (NOK/yr)	Energy cost savings (NOK/yr)	Energy cost savings (EUR/yr)
TEK	115	0	1 803 540	0	0
Passivhus	75	36	1 160 539	643 001	64 300
nZEB	40	65	627 318	1 176 222	117 622
ZEB-O	0	100	0	1 803 540	180 354
Plusshus	-2	102	- 31 366	1 834 906	183 491

The energy cost reduction is substantial for all energy standards that go beyond TEK requirements, and a Plusshus can even bring in revenue (under the assumption that the surplus energy generated locally is sold back to the grid at the same price as buying from the grid). Given the reported 2-5% increased investment costs for the evaluated sustainability schemes, the additional costs for Fv1B can be earned back through lower energy costs within 2 - 12 years.

5. Discussion

The results show that TEK has a very narrow sustainability scope, which is unsurprising since this is the minimum performance expected by Norwegian building regulations. FME ZEB, FME ZEN and Powerhouse Paris Proof have a pronounced focus on GHG emissions and energy which is reflected in the criteria that they set. BREEAM-NOR and FutureBuilt define themselves as sustainability initiatives and accordingly take a much broader perspective of sustainability. FutureBuilt as an innovation programme is the most ambitious in terms of scope and is most flexible in adjusting and creating new criteria. Since conducting this analysis, several new sets of FutureBuilt criteria have been published, including criteria for carbon-negative landscapes and plastic use. FME ZEN is the only assessed scheme that explicitly targets neighbourhoods instead of individual buildings, although other schemes may also reward a broader outlook. For example, Powerhouse Paris Proof explicitly mentions provision of energy to external services (e.g., allowing city busses to charge using the surplus energy generated by a building). BREEAM-NOR also provides a neighbourhood-scale version (BREEAM-Communities), and FutureBuilt provides additional criteria for neighbourhood projects.

Several of the Norwegian building sustainability schemes refer to each other for various criteria, the most extreme example being FutureBuilt which requires projects to fulfil BREEAM-Excellent criteria as a minimum. BREAAM-NOR in turn refers to the FutureBuilt ZERO methodology and FutureBuilt criteria for circular buildings, nZEB and Plusshus. In practice there is overlap in the implementation of these building sustainability schemes. For example, Powerhouse Kjørbo [46] in Sandvika and Powerhouse Brattørkaia [47] in Trondheim are certified BREEAM-Outstanding and are FutureBuilt and FME ZEB projects. This indicates that the various schemes have a high degree of compatibility. The higher the sustainability ambition, the easier it becomes to achieve multiple accreditations as optional criteria can be chosen to fulfil mandatory criteria in another scheme (e.g., FutureBuilt's Plusshus criteria are optional in FutureBuilt and BREEAM-NOR, but mandatory for Powerhouse Paris Proof).

Although all cost calculations are simplified, they give a good indication of the relative financial benefits and drawbacks of the evaluated schemes. The energy prices used in Table 4 do not reflect the recent energy price hike, which is expected to last for the foreseeable future [48]. With current high energy prices, the cost savings for higher energy standards are even greater than estimated here, and the payback time of investment costs decreases. It is thus important to take a long-term perspective when weighing up the financial costs and benefits of the different schemes. More detailed cost calculations and collecting real cost data from Norwegian building projects warrants scope for further work.

A potential barrier to adoption of sustainability rating schemes is access to information and documentation. For example, Powerhouse does not provide a public list of criteria, instead initiating the certification process through an exploratory workshop. BREEAM-NOR and FutureBuilt make their criteria freely available on their websites, whilst FME ZEB and FME ZEN have published criteria in open access technical reports. The lack of transparency from Powerhouse on specific requirements at the outset may prevent project owners from committing to the scheme, as it is not clear how much effort is required to comply with the scheme. On the other hand, the personalised workshop approach may appeal to those who perceive the detailed criteria from FutureBuilt or BREEAM-NOR as being too rigid or complex. Either way, the varying levels of transparency complicate project owners' efforts to make an informed decision on which scheme best fits their sustainability goals. This study alleviates this issue by providing a simple, visually oriented snapshot of how the selected schemes compare to each other. Further work could involve interviewing project owners who have implemented the schemes to ascertain their motivations for choosing one scheme over the other.

The green transition also requires a change in mindset among all stakeholders involved in the life cycle of the building to overcome scepticism over the necessity, success, and compatibility of sustainability rating scheme requirements with expectations of end-users of the building. For example, several schemes reward measures to promote green mobility, but ultimately the success of these measures depend on building users switching from private to public or active forms of transport.

The comparative assessment performed in this study is not exhaustive but does cover the leading building sustainability schemes in Norway. It serves as a useful guide for project owners to make an informed decision on which scheme aligns most with their own sustainability goals, especially as most of the schemes assessed have recently been published or revised. This study is also the first to evaluate these schemes against the EU Taxonomy and SDGs, putting them in a wider sustainability context. Nevertheless, this study remains a qualitative and subjective assessment of the different building sustainability schemes, whereby lack of information availability, and lack of data on the success of completed projects hinders a more quantitative approach. Moreover, this assessment looks at the scope, and not ambition level, of the schemes. While the breadth of sustainability criteria addressed as an indicator of ambition, this assessment does not indicate which scheme will result in a more 'sustainable' building, for example in terms of GHG emission reductions or biodiversity gains. All schemes have a range of optional criteria which can be mix-and-matched according to the priorities and ambitions of the project owner. Some of the schemes provide scoring or certification creating a broad spectrum of achievable results within the same scheme (e.g., BREEAM Pass versus Outstanding), while others supply a single label (e.g., FutureBuilt) regardless of which criteria sets are fulfilled. In addition, despite various efforts to express sustainability measures quantitatively, there is no consensus as to their relative value either among the evaluated schemes or in wider literature. Further research is needed to identify how the schemes can become more ambitious in their sustainability goals or align closer with local conditions and regulations, the EU taxonomy, and SDGs.

6. Conclusion

This paper has reviewed and compared leading Norwegian building sustainability schemes FutureBuilt, BREEAM-NOR, Powerhouse, FME ZEB and FME ZEN against sustainability criteria, TEK, EU taxonomy and SDGs. The results from the review and cost assessments are discussed in terms of a proposed office building (Fv1B) in Oslo, Norway. This review is useful since each of the schemes have either undergone a recent revision or are recently published. This comparative assessment can be used as a practical reference and decision support guideline by project owners in Norway to select the appropriate scheme for their construction project based on their sustainability goal focus.

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