De-Risking Building Performance Investments by Certified Quality Management Services (QUEST)

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Abstract. Non-compliance with predicted, contracted or otherwise required aspects and levels of building performance can result in a wide range of problems. This includes sub-par quality of building functions and services, unsatisfactory indoor environmental quality, disappointing end-user experience, excessive energy use, excessive environmental emissions, increased maintenance and operational costs, operational start-up loss, component and system faults, difficulties in achieving targeted building certification levels, mismatch with business case, lack of adaptability and flexibility, expenses changed from capital expenditure to operational expenditure, facility not meeting regulatory requirements, as well as increased risk and liability. This is often referred to as the building performance gap.

Compliance with ambitious levels of resource efficiency, energy performance, decarbonisation and circularity goals, as well as other key objectives defined by the EU Taxonomy for sustainable activities will be essential criteria for the sustained future success of businesses throughout the building sector.

Building performance investments, including investments in energy efficiency, can generate significant environmental benefits, while also increasing financial returns. The key goal of the EU-funded project Quality Management Investments for Energy Efficiency (QUEST) is to promote private investments and financing in quality management services to ensure sustainability and energy-efficiency of building projects. To that end, a toolkit, with the QUEST data engine as the core data source, has been developed that will enable financial institutions to determine key factors influencing risk in the design, development and operations of energy-efficiency and sustainability projects, as well as the impact of quality management services. This will allow them to reduce risk, increase financial performance and therefore significantly increase investment volumes.

Keywords. QUEST Model, QUEST Tool, Quest Engine, Certified Quality Management Services, De-risking, Investments, EU Taxonomy, Buildings, Building Performance, Real Assets, Financial Performance
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1. Introduction

Non-compliance with predicted, contracted or otherwise required aspects and levels of building performance can result in a wide range of problems, including excessive energy use, excessive emissions of carbon and other green-house-gases, increased maintenance and operational costs, operation start-up loss, sub-par quality of building functions and services, unsatisfactory indoor environmental quality, component and system faults, difficulties in achieving targeted building certification levels, disappointing end-user experience, mismatch with business case, lack of adaptability and flexibility, expenses changed from capital expenditure (CAPEX) to operational expenditure (OPEX), facility not meeting regulatory requirements, as well as increased risk and liability. This is often referred to as "The Performance Gap, see Figure 1, [1].

Fig. 1. A facilities manager's typology of performance gaps in new buildings, [1]

Recent studies indicate that only about 25% of new Swedish multifamily buildings (including those designed for high-energy-performance) comply with predicted energy use ([2], [3]).

Similar examples of non-compliance with predicted performance have been extensively documented by previous research ([4], [5], [6], [7], [8], [9], [10], [11], [12]).

Compliance with ambitious levels of resource efficiency, energy performance, decarbonisation and circularity goals, as well as other key objectives defined by the EU Taxonomy for sustainable activities, [13], will be essential criteria for the sustained future success of businesses throughout the building sector.

In the last decade, much research has focused on the impact of various sustainability characteristics such as green certifications on real estate values and other key real estate economic performance variables. In a review study, green certificates were found to have the potential to increase the rental income and decrease the operating expenses, vacancy, and risks of a property, resulting in higher net operating income growth rates and lower risk premiums, altogether resulting in increases in property values [14].

2. Quality Management in Buildings

Colloquially, *quality* is often used as a synonym for "good" or "high" quality. In the field of engineering or business, however, *quality* also refers to the degree to which a unit, e.g. a product or a service, meets the requirements placed on it. Quality management is a process to support the fulfillment of requirements. In addition to the definition of requirements, the process of testing the degree of fulfillment - consisting of the definition and application of the testing methodology - is a central component of the quality management process.

In the construction and real estate industry, the first Quality Management Services (QMS) have been established on this basis in recent years. And to varying degrees, they are taking advantage of the opportunities offered by digitization, making them technically and economically feasible on a larger scale.

2.1 The objective of the QUEST project

The objective of the QUEST project, [15], is to support the understanding of QMS and of their value-add and to support their application in real estate projects. The QUEST project developed tools to easily calculate a prognosis for cost and financial value add of QMS thus supporting early investment decisions into QMS as an essential part of the green transformation of the European building stock.

2.2 Quality management, technical monitoring, and commissioning

"Quality management" is thus a process of supporting the fulfilment of specified requirements. In the building sector, Technical Monitoring and Commissioning have evolved as reliable quality management services for buildings and are becoming increasingly popular. Technical

Monitoring (TMon) applies procedures to compare measured values from building operation versus design target values providing a transparent result to the owner. TMon can predominantly be carried out digitally. Commissioning (Cx) allows the owner to check in detail whether the building delivered complies with the Owners' Project Requirements. Cx requires to a significant extent skilled expert work. Since quality management starts with the definition of requirements, it obviously should start in the earliest stages of any project. Although quality management can be applied even after a building is completed, building owners should not wait until they incur the problems and costs of a failing project. Both TMon and Cx are most powerful and cost effective when initiated in the very beginning of a project, ([16], [17]).

3. The QUEST Model and its impact on real estate financial performance

An increase in the financial profitability of real estate investments is a key financial motivation for implementing the QUEST model. Due to the large size of the real estate assets, and the many important economic and sustainable finance linkages between the real estate markets, the debt and financial markets, and the wider society, the importance of accurate assessments of the linkage between buildings' technical and financial performance are key for increasing the flow of funds and other resources necessary for the sustainable development of real estate and financial markets.

3.1 Quality management reduces technical risks

The real estate investment community has difficulty statistically evaluating technical risk on specific construction and real estate investments. In this context, the term "technical risk" refers to technical building services like heating or ventilation. Malfunction or failure of these technical systems negatively impact building performance, increase CO_2-emissions, and thus become a risk for real estate investments.
Lower technical risk should be transmitted to improved financial performance of real estate investments. Therefore, real estate stakeholders who have successfully implemented quality management activities that de-risk a building's technical performance should also be rewarded by decreased financial risks and improved financial performance.

The QUEST model contributes with transparency in relation to what it costs to handle the technical risks through quality management on the individual construction project and on the return on investment of this investment.

4. QUEST Tool: Value-add Impact of Certified Quality Management Services

Within the context of the QUEST Project, the QUEST Tool was created to evaluate the quantitative impact of certified quality management services on value-add of real estate financial performance. While a particular situation may have an innate level of technical risk, that risk can be reduced by application of standardized and verifiable processes.

To achieve internationally replicable, scalable and trusted technical risk modulation via Quality Management, QUEST relies on Certified Quality Management Services.

- *Certified Technical Monitoring* verifies the correct functioning and operation of installed technical systems
- *Certified Building Commissioning* verifies compliance with Client Project Requirements through planning, design, construction/renovation & installation, and initial operation of a new or existing building.
- Certified Sustainable (or Green) Building Certification verifies compliance with specific schemes of environmental and related standards with some degree of commissioning involved.

Certified QMS are international third-party building certification processes (conforming with e.g. EN ISO 17065) that can impact buildings' net operating incomes, capitalization rates and ultimately their market values.

4.1 QUEST Tool algorithm

The QUEST Tool applies an algorithm to technical and financial data of investments into these Certified Quality Management Services. Investors can risk-grade investments and select the most profitable quality management services to de-risk projects.

Figure 2 shows a schematic illustration of the algorithm. A main feature and important contribution of the QUEST Tool is to integrate detailed information about how different levels of technical risk, which typically is excluded from real estate financial analysis calculations.

Even when technical risk is considered, it is often limited to aggregated and standard figures, and thus does not reflect the true technical risks and how they should be translated into the financial performance or real estate investments.

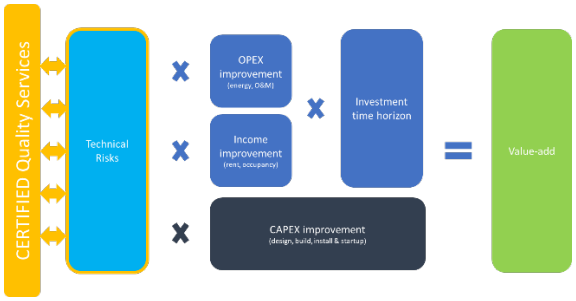

Fig. 2. Schematic illustration of the algorithm(s) applied to technical and financial data of investments into Certified Quality Management Services.

As shown in Figure 2, QMS investments result in positive value-add effects through lowering technical risks, which in turn result in lower and more stable annual operating expenses (in the figure denoted OPEX Improvement), higher and more stable annual revenues (in the figure denoted Income Improvement) and finally lower and more stable construction and renovation costs (in the figure denoted CAPEX Improvement). The investment time horizon is time factor in year units that is multiplied with the OPEX and Income effects. This time factor takes into account the fact that an initial certified quality service investment might have effects on revenues and costs, and ultimately on market values for several years ahead.

4.2 Technical risk indicators

A key innovation of the QUEST methodology is to include numerical figures of technical risk indicators. Initially the risk inputs relied on self-assessment of different technical risks in a building or building project:

- Technical risk impact on energy consumption and costs
- Technical risk impact on operation & maintenance work and costs
- Technical risk impact rental income
- Technical risk impact on occupancy rate

In order to reduce variability of this self-assessment, QUEST has decided to propose technical risk profiles which depend on user feedback regarding:

- Building type (ex. laboratory deemed higher risk profile than residential property)
- User confidence/experience in the technical teams managing the project.

QUEST is designing a solution for financial stakeholders who do not have the expertise to directly assess building technical risk. However, they can evaluate their risk perception of technical management teams based on their experience and/or confidence in these teams. Work together on, and results from, past projects can contribute to this assessment.

4.3 Inputs to QUEST Tool

The QUEST Tool ask users to input six project characteristics (see figure 3):

- Building type
- Experience/confidence in the technical teams
- Project build cost ➔ Capital saving calculation
- Building systems operating cost ➔ Cost improvement calculation
- Rental income ➔ Income improvement calculation integrating rent and occupancy impacts
- Time horizon of investment ➔ Capital saving calculation

The QUEST Tool proposes default values for each element in case the user fails to enter their values.

Your building project	
DE-RISK INVESTMENTS IN CONSTRUCTION & SUSTAINABLE BUILDINGS	**Input values**
What is the type of building?	Office
How do you rate the experience in the technical teams managing the project?	Medium confidence
What is the estimated project cost (per m²)? (Build/renovation/refurbishment/technical installation including design work)	1 000 €
What are the expected operating expenses per m² per year (OPEX/ m²/ year)? (Energy, operation & maintenance)	20 €
What is the expected rental income (per m² per year) If there is no rent value (ex. hospital or public building), use local Office rent values and adjust upwards to reflect sophistication of the building	400 €
Define the time horizon that the rating should consider for your QM-investment (5 to 20 years; the value is used to capitalise annual savings)	10

Fig 3. Inputs to QUEST Tool

4.4 Output of QUEST Tool Output

Based on the inputs, the QUEST Tool predicts value-add of different Certified Quality Services (see figure 4). The following value-add forecasts are available:

- Value-add prediction based on OPEX improvement from energy and operation & maintenance savings;
- Value-add prediction based on rental income and occupancy rate improvements from better buildings;
- Value-add prediction based on all cost and revenue improvements in 1 and 2 above.

The QUEST Tool also provides indicative investment costs for Certified Quality Services including expert audit costs and certification fees.

De-risking solutions		Value-add (per m²) over investment lifetime of 10 years		
CERTIFIED SERVICES*	Investment cost**	OPEX improvement	Rent & Occupancy improvement	TOTAL: OPEX + Rent & Occupancy improvement
Certified Technical Monitoring (ex. COPILOT)	1 €	4 €	52 €	**57 €**
Certified Building Commissioning (ex. COPILOT)	10 €	36 €	139 €	**175 €**
Certified Green Buildings (ex. LEED)	20 €	4 €	157 €	**161 €**

* Certified quality services provided by independent third parties to approved certification rules

** Indicative costs (verification by accredited expert + certification fees) based on Building > 2000 m² with significant project cost

Fig. 4. Outputs from Quest Tool

5 The QUEST data engine

In 2021, the European Commission adopted a package of measures to increase the flow of financial capital towards sustainable activities across the European Union, [18]. One of the packages is the (proposal for a) Corporate Sustainability Reporting Directive (CSRD), which will amend the existing Non-Financial Reporting Directive (NFRD). According to the European Commission, the CSRD "aims to improve the flow of sustainability information in the corporate world. It will make sustainability reporting by companies more consistent, so that financial firms, investors and the broader public can use comparable and reliable sustainability information."

The QUEST data engine provides an iterative loop to collect building data on a large number of characteristics regularly. It is intended to collect data from a large number of buildings monitored over time. Thus, the quest data engine will create a panel data set that can be used for deeper empirical analysis of the main drivers (such as QMS) of technical, financial, and sustainable performance of buildings.

The QUEST data engine adapts to CSRD to support the European Union's sustainability goals, in which property owners and its equity and debt investors need comparable and standardized data from the real estate industry. The QUEST data engine aims to be the industry standard in its field with standardized vocabulary and definitions of data variables.

5.1 Benchmarking analysis with QUEST data engine

The QUEST data engine can be used for internal and external benchmarking across buildings. By performing internal benchmarking, property owners can analyze and compare the performance of each of their buildings' performance over time. The internal benchmarking analysis can give answers to questions such as how and why various degrees of investments in QMS affect the financial and technical performance of its buildings.

With external benchmarking analysis, property owners make comparisons of the performance of their buildings with competitors.

5.2 QUEST data engine and effect of QMS

A key scientific research question is to quantify the effect of certain QMS activities on buildings' financial and technical performance. By studying how the QMS evaluation variables affect the QMS impact evaluation variables, important knowledge of the impact of QMS is obtained. The QUEST data engine can be used to analyze how large effects QMS activities have on technical and financial risk and performance variables. The financial variables that various QMS activities might impact on include

- Annual energy costs
- Annual Q&M costs
- Rent levels
- Occupancy level
- Handover time
- Legal claims
- User acceptance.

There are many other variables that also affect a building's technical and financial performance. Therefore, it is important to also include so-called control variables to mitigate problems with selection bias and omitted variable bias. The goal is to statistically obtain unbiased and/or consistent estimation of the QMS implementation effects. For instance, if the implementation effect analysis yields that buildings in which a certain QMS has been applied on average generate 10% higher annual financial performance (or value-add) compared to buildings where no QMS were applied, it is essential that the extent of the positive financial effect (10% here) can be trusted.

Relevant control variables can be building specific (property type such as hotel, office, residential, shopping mall, age, design, levels), location, neighborhood, and city characteristics (CBD, attractive area), urban economic, regional economic and macroeconomic variables. The economic variables are important to consider when the data set includes buildings located in different cities across different countries.

Location variables are also important since the changes in energy cost savings from one year to another may be highly related to annual local climate conditions. Therefore, certain climate variables should also be included as key control variables. For instance, if a building has received QMS that indeed has resulted in considerably more efficient energy usage, the building's energy costs may still have increased since if average outdoor temperature was significantly lower the year the QMS was applied. By adding local climate control variables, more accurate estimates of the impact of QMS on energy savings will be obtained.

6 On-going data analysis to improve QUEST model's financial impact and QUEST Tool

Once enough QUEST data for several buildings have been collected, the QUEST data engine can be used to build statistical (econometric) treatment effect models using panel data to scientifically estimate the size of QMS activities on buildings' financial and technical performance.

Currently there is a great need to develop the transparency in the commercial real estate market based on data. The QUEST data engine has therefore been created as an additional tool to gather more and precise data to overcome this deficit. The QUEST tool is therefore only a starting point.

6.2 Simple simulation to demonstrate QUEST data engine use

With the data of several buildings gathered using the QUEST data engine, empirical hedonic panel data models can be built and estimated, [19] . That is, in hedonic models, the variation in market values is determined by several property characteristics including if they have been subject to various QMS treatments.

The panel data approach to analyse the effect of various quality management services on a buildings' technical and financial performance requires many repeated observations on buildings. This is an on-going work.

The very simple simulation presented here aims at demonstrating an example of how panel data, building on longitudinal (in this case several years) observation of a chosen set of buildings, can be used to show the value-add financial impact of QMS.

To demonstrate a key usage of the QUEST data engine, such as quantifying the effect of various QMS services on buildings financial performance, e.g., the value add of certified QMS, the simulation is based on following simplified assumptions.

- 10 office buildings in a certain location.
- Data on the buildings have been observed over 5 years.
- 5 of the buildings have been subject to the identical measure of improvement (e.g. total (deep) refurbishment) when entering year 1 in the data collection process; they have identical technical characteristics.
- 5 of the buildings have not been subject to any measure of improvement when entering year 1 in the data collection process; they have identical technical characteristics.
- All buildings start (year 1) with identical rental situation (tenants, rental contracts): 300 €/(m^2a).
- All buildings start (year 1) with identical OPEX: 60 €/(m^2a).
- All buildings start (year 1) with same net operation income: 240 €/(m^2a).
- For year 2 – 5, the 5 buildings that have been subject to some measure of improvement, the Net Operating Income (NOI) will grow faster relative to the 5 buildings that have not been subject to a measure of improvement. This is assumed to be a result of lower Operating Expenses (OPEX) (e.g., due to improved energy efficiency) and higher rental incomes (e.g., due to higher occupancy rates and lower vacancies).
- For year 2 – 5, the 5 buildings that have been subject to some measure of improvement will have (relatively) lower financial risk premium and higher net operating income growth rates implying lower capitalization rates and therefore higher market valuations.
- For year 2 – 5, an identical type of QMS has been applied to 3 of the 5 buildings that have been subject to some measure of improvement. The other 7 (2 + 5) have not received any QMS at all.
- For those 3 buildings that have received QMS, the NOI growth rate is higher than all other buildings. Furthermore, the risk premium and the capitalization rates are the lowest for these 3 buildings.
- NOI growth rate for the 5 buildings that have not received any measure of improvement: 1.5% per annum.
- NOI growth rate for the 2 buildings that have received measure of improvement but not received QMS: 3.0 % per annum.
- NOI growth rate for the 2 buildings that have received both measure of improvement and QMS: 4.5 % per annum.
- Capitalization rate year 4 for buildings that have not received any measure of improvement: 7%.
- Capitalization rate year 4 for the 2 buildings that have received measure of improvement but not received QMS: 5.5 % per annum.

- Capitalization rate year 4 for the 2 buildings that have received both measure of improvement and QMS: 4.0 %.

Given the above assumptions, the valuations obtained, and above all, the quantified value-add of measure of improvement and QMS are:

- Market value year 4 for 5 buildings not subject to any measure of improvement = NOI year 5 / cap rate year 4 = 254.54/7.0% = 3 636 €/m^2.

- Market value year 4 for 2 buildings that are subject to a measure of improvement but not received QMS= NOI year 5 / cap rate year 4 = 270.12/5.5% = 4 911 €/m^2.

- Market value year 4 for 3 buildings that are subject to a measure of improvement and have received QMS= NOI year 5 / cap rate year 4 = 286.01/4.0% = 7 150 €/m^2.

Although the above calculations are very simplified, they show what type of final results that the QUEST data engine can yield. The QUEST data engine can not only to empirically establish the value-add of various measures of improvements. In more realistic settings, the buildings included in the QUEST data engine will be heterogenous in many different aspects. With detailed information on the different characteristics of the buildings, sophisticated hedonic panel data regression analysis can be conducted to empirically establish the size of QMS on buildings financial and technical performance, while controlling the differences among the buildings' characteristics.

Conclusions

Investments in building performance, including energy efficiency, can generate substantial economic and environmental benefits, while also increasing financial returns. The main goal of the EU-funded QUEST project is to promote private investments and financing in sustainability and energy-efficiency projects. To that end, a simple toolkit was developed that enables financial stakeholders and institutions to determine relevant factors that influence risk in the design, construction and operations of energy-efficiency and sustainability projects. This allows them to reduce risk and increase investment levels, while supporting compliance with EU Taxonomy requirements.

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References

[1] Rasmussen H.L. and Jensen P.A. (2020), "A facilities manager's typology of performance gaps in new buildings", Journal of Facilities Management, Vol. 18 No. 1, pp. 71-87. https://doi.org/10.1108/JFM-06-2019-0024.

[2] Martinac I. et al. (2017): Brukaranpassad, hållbar byggnadsdrift med fokus på inneklimat och energiprestanda i kontorsbyggnader – en kunskapssyntes (User-adapted, sustainable building performance management with focus on indoor environment end energy performance in office buildings – a knowledge synthesis. In Swedish). Final Report, Energimyndigheten (Pnr 42639-) & SBUF (Pnr 13293). Stockholm.

[3] Kempe P. (2020): Förstudie: Stegvis verifiering av delsystem - Exempel VVC-system. Lågan Rapport.

[4] Månsson L-G et al (1997): IEA Annex 17: Building Energy Management Systems – Evaluation and Emulation Techniques.

[5] Fisch M. N. et al. (2007): EVA - Evaluierung von Energiekonzepten für Bürogebäude: (Gesamt-) Abschlussbericht. Braunschweig / Hannover, Technische Informationsbibliothek u. Universitäts-bibliothek.

[6] Fraunhofer ISE (2011), ModBen – Endbericht: Modellbasierte Methoden für die Fehlererkennung und Optimierung im Gebäudebetrieb. Freiburg.

[7] Baumann O. (2005): OASE – Optimierung der Automationsfunktionen betriebstechnischer Anlagen mit Hilfe der dynamischen Simulation als Energie-Management-System. Abschlussbericht zum Vorhaben OASE, Förderkennzeichen 0327246D. München.

[8] Plesser S., Gräff S., Rozynski M. and Fisch M. N. (2012): www.EnBop.info - Netzwerk für Betriebsoptimierung. Intelligente Architektur XIA 04-06 2012, Seite 066-071, Leinfelden-Echterdingen. 2012.

[9] Franzke U. and Schiller H. (2011): Untersuchungen zum energieeinsparpotenzial der Raumlufttechnik in Deutschland. ILK Dresden, Fachbericht ILK-B-31-11-3667, Dresden.

[10] Crowe E. et al (2020): Building Commissioning Costs and Savings Across Three Decades and 1,500 North American Buildings. LBNL, Energy Technologies Area.

[11] Coyner R., Kramer S. (2017): Long Term Benefits of Building Commissioning: Should Owners Pay the Price?, Creative Construction Conference, Primosten, Croatia.

[12] Wen J., Chen Y., Regnier A. (2020) Building Fault Detection and Diagnostics. In: Baillieul J., Samad T. (eds) Encyclopedia of Systems and Control. Springer, London. https://doi.org/10.1007/978-1-4471-5102-9_100080-1.

[13] European Commission (2021): EU Taxonomy for Sustainable Activities. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities en, as accessed 21/5/2021.

[14] Leskinen, N., Vimpari, J. and Junnila, S. (2020). A Review of the Impact of Green Building Certification on the Cash Flows and Values of Commercial Properties, Sustainability.

[15] European Commission (2019): Quality Management Investments for Energy Efficiency (QUEST). Horizon 2020 Grant Agreement ID 846739, https://cordis.europa.eu/project/id/846739, as accessed 21/5/2021.

[16] Federation of European Heating Ventilation and Air Conditioning Associations: HVAC Commissioning Process. Guidebook No. 27, Brussels.

[17] Federation of European Heating Ventilation and Air Conditioning Associations: Quality Management for Buildings. Guidebook No. 29, Brussels.

[18] European Commission (2021): Sustainable Finance Package, Proposal for a Corporate Sustainability Reporting Directive (CSRD). https://ec.europa.eu/info/publications/210421-sustainable-finance-communication en#csrd, as accessed 21/5/2021.

[19] Fuerst, F. (2008): Office Rent Determinants: A Hedonic Panel Analysis. SSRN Working Paper Series, DOI:10.2139/ssrn.1022828.