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A Tool for Sourcing Sustainable Building Renovation: The Energy Efficiency Maturity Matrix

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Abstract: The success of sustainable building renovation is inevitably dependent on the capabilities of the involved stakeholders throughout the entire project. Therefore, any building client with intentions of sustainable building renovations must reflect on sourcing the adequate capabilities for a sustainable renovation project. The question in focus is: how to facilitate a sourcing strategy for energy-efficient sustainable building renovation and maintenance. This study on energy efficiency implementations shows that even in developed countries like Sweden, where energy efficiency is regulated by the EU, national legislation and other public policies, the municipal facilities management organizations need process guidance to navigate in decisions regarding in-house capabilities and collaboration with external service providers. A dialogue tool for the sourcing process, the energy efficiency maturity matrix, is developed to support future sourcing processes for energy-efficient buildings as a prominent part of the broader field of sustainable building renovation and maintenance. The future will show when building clients to a larger extent will embrace sourcing strategies instead of mainly focusing on specific technical improvements. The new International standards for facilities management (ISO18480 series) might support this change process, as it includes a sourcing approach, from a strategic level to an operational level, to add more value and to optimize costs.

Keywords: energy services; energy efficiency; facilities management; ISO 18480; knowledge management; professionalization; project management tool; public sector

1. Introduction

The residential and service sector, to which most of the building space belongs, accounts for almost 40% of the EU-28 final energy consumption [1]. Thus, across EU Member States, the sector needs to make major contributions towards upcoming and long-term objectives on the EU climate and energy policy agenda. The recasting of the Energy Performance of Buildings Directive (EPBD) requires that all new buildings erected after 2020 are nearly zero-energy buildings, and for new buildings occupied and owned by public authorities, it applies already after 2018 [2]. However, the greater challenge, as partially addressed by the Energy Efficiency Directive (EED) [3] and the preceding Energy Service Directive (ESD) [4], is how to achieve major improvements in energy performance in the existing building stock, which may be operational for decades or centuries to come. Unless this issue is well addressed through Energy Efficient Facilities Management (EEFM), creating a surge of renovations and daily operations that lead to considerable improvement in energy performance, the sector will fail to make the necessary contributions towards long-term energy-efficient and low carbon sustainable development with adverse effects on the economy, environment and social welfare.

For successful transition, in which the market for energy efficiency services is a main impetus, several stakeholders and perspectives need to be involved. Firstly, stakeholders on the energy demand side, in this case building owners, FM organizations, users and residents, will have to be adequately informed and motivated to undertake investments in energy-efficient building renovations and operations. The public sector is expected to set an example. Secondly, to govern private and public-sector decision making, government policies need to internalize externalities related to energy use and effectively remove other obstacles to close the energy efficiency gap [5]. Thirdly, providers of energy-efficient products and services need to be responsive to customer demands and create competitive offers and business models that overcome persistent market barriers [6].

This paper involves three main stakeholder categories. It provides an assessment of a Swedish state policy for stimulating municipal-level energy efficiency strategies (EES). It asks the question how the demand and supply side of the energy efficiency service market can be better matched. Key processes are identified for the assessment of municipal FM organizations' in-house capabilities in EEFM. As an output, it suggests an approach to engage municipal FM organizations, on behalf of building owners and users, in dialogue and collaboration with external energy efficiency service providers. Following this approach may lead to better service design based on in-depth understanding of customers' situation and preferences, strengths, weaknesses and improvement potentials in EEFM.

The study was funded by a research and market development project that aimed to bridge knowledge gaps between academia and small and medium size firms in southern Sweden and the Copenhagen region of Denmark [7]. It involved collaboration over eight months between the academic partners and "IMI EVU Energi & VVS Utveckling" (EVU), a Swedish-based consultancy firm and energy efficiency service provider with some 40 employees and a business background in engineering of heating, ventilation and air-conditioning (HVAC) systems. Thus, the project took as a starting point three challenges on the energy efficiency service market as perceived by EVU. Firstly, delivered and perceived values of energy efficiency services should become more visible among building owners and FM organizations to increase their willingness-to-pay. Links between energy performance, low operating costs and benefits such as property value ought to receive greater attention. Secondly, energy efficiency services are often regarded as isolated projects, with a beginning and end, rather than initiators of a continuous improvement process along a value chain. Thus, monitoring of results and decisions about succeeding steps can be neglected after first service delivery. Finally, customers' collection of energy and operational data is often insufficient for purposeful data management, e.g., to guide target formulations or investment decisions.

The European standard for guidance on quality in FM highlights among other things the need to clarify and understand quality issues [8]. According to [9], it is a matter of knowledge management to ensure that sustainable and, thus, energy-efficient FM strategies are developed and implemented at a professional level to achieve energy performance targets and desired quality objectives. The new international standards for facilities management, the ISO18480 series, promotes a sourcing approach, from a strategic level to an operational level, to contribute significantly to adding value and optimizing the costs of operations. This generic methodology currently lacks specific guidance regarding energy efficiency, which is why this article focusses on a tool for dialogues and decision support at all management levels: strategic, tactical and operational. Drawing from the traditions of quality management, a maturity model suggests that an organization should improve performance by systematically increasing the maturity of its key process areas [10]. Over time, this approach has found various applications. For instance, [11–13] have focused on maturity assessment in FM and real estate management. There have also been attempts to apply a maturity approach to energy management for compliance with international standard ISO 50001, e.g., [14], and maturity in relation to research and innovation [15]. However, to our knowledge, no one has developed a domain-specific maturity model of the capabilities for energy efficiency improvement in buildings by municipal-level FM organizations. A generic guideline for the development of maturity grids has supported our effort in this regard [16].

A challenge is how many and what sources of information are needed to create a municipal EEFM maturity model (the maturity matrix). The assessment of the Swedish policy support for municipal EES was considered a good starting point for scanning for evidence of ongoing efforts in this domain, and interviews could be conducted with municipal-level strategists and managers of FM organizations. In addition to this empirical basis, the paper draws on energy efficiency policy and market studies. A basic assumption is that EEFM in the municipal sector, and elsewhere, requires inputs and collaborations with external providers of energy-efficient services and equipment to optimize building operations. In 2004–2008, contractual arrangements like energy performance contracting (EPC) showed rapid growth in the Swedish public sector [17]. Besides underlying drivers—rising energy prices, favorable policies and climate change concerns [18]—EPC was facilitated by marketing and by being tailored to the value chain of energy efficiency services. In recent years, however, EPC has had setbacks [17]. There is no clear successor on the Swedish energy efficiency service market, but there are certainly many expectations about what buildings could provide to their owners, users and society at large. For existing buildings to become energy efficient and provide additional benefits, such measures must be valued accordingly [19]. Given the range of possibilities and risks involved, it is a matter of knowledge management for FM organizations to reach sound decisions about, e.g., when to hire expertise and how to collaborate to be adequately informed about viable and cost-effective solutions.

After this Introduction, the following sections are presented: the research and development methods and materials; the results of the investigation of eight Swedish municipalities' EES and implementation experiences; the maturity matrix is outlined in the Results Section and demonstrated in Appendix A; finally, the strength and limitations of the research are presented in the Discussion and Conclusions.

2. Materials and Methods

A participatory research approach [20], where an energy efficiency service provider (EVU) and the municipal strategists and managers of FM organizations, at the same time, are a part of the research object and at the same time co-producers of research knowledge, is important in sustainable and energy-efficient FM. It is deemed necessary when researchers are to suggest solutions for improvement in business and societal strategy and practice. Thus, the prime researcher collaborated closely with the EVU to observe the processes and value propositions in the relation between the consultants and their clients. This included spending one or two days a week with the firm, over a period of eight months, to support the desired change process towards learning to better initiate, demonstrate and sustain its partaking in energy-efficient real estate and FM. Activities involved interacting with management and staff to discuss market features, attending meetings with customers in the office and in the field and representing the project at exhibitions.

Within this participatory research approach, the scientific research method includes a four-step hermeneutic investigation:

1. A literature review and open explorative interviews in EVU on the phenomena of EEFM: The open explorative interviews were conducted in various ways and continued through the entire project period. The prime researcher's presence at EVU gave access to observations and dialogues about the HVAC consulting and energy efficiency market, insights about customers' problems and possibilities, formal meetings with management, as well as lunch break chats with management and staff, participation in customer meetings and energy efficiency service delivery in the field. Altogether, these continuous observations and dialogues significant inspired and supplied content to the maturity matrix.
2. An investigation of Swedish municipalities' EES and practices including a review of the scope, targets, selected measures, general approach and use of external expertise: The investigation of the obligatory EES documents consisted of a screening of documents from 27 municipalities in the most southern province of Sweden, which is also the main market for EVU. This was followed by qualitative interviews in eight (out of 27) municipalities (M 1–8) willing to take part

in the study. The municipalities varied in the number of inhabitants from 15,000 inhabitants up to 135,000 (more information on the municipalities is found in Table 1). The respondents were either designated energy efficiency strategists (in six municipalities) or managers of municipally-owned FM organizations (in two municipalities). The former category can be described as relatively young persons with an educational background in environmental studies, being tasked with municipal-wide coordination and communication of environmental and energy-related issues. Interviews were structured and prepared to center the dialogues on: (1) the objectives of the policy support for municipal EES and the approach taken for compliance in target-setting, scope and selected measures; (2) a categorization of models for energy efficiency improvement in municipal buildings with reference to four basic models presented in [21] and their two by two variations of direct/incremental energy efficiency improvements and the use of internal/external resources; and (3) the main phases and key processes that underpin the practical implementation of EEFM. A value chain of energy efficiency services, including aspects such as motivation, information/advice, planning, financing, installation, operation and optimization and monitoring, served as a framework for dialogue on the latter topic [22]. Each interview was recorded and transcribed, and respondents were invited to correct and comment on the transcription. The analyses of EES documents and the interview-based investigations of how strategies were conceived of and translated into practical actions documented variations in the eight municipalities' approaches and capabilities. This inspired the authors to develop a tool for assessment and dialogues about the in-house capabilities and eventual in-sourced capabilities from energy efficiency service providers. A tool for sourcing decisions can lead to a professionalization of FM organizations and energy efficiency improvement and sustainability in building renovations and maintenance.

3. Development of the energy efficiency maturity matrix following the roadmap with decision points and options for the development of maturity grids presented in [16]: The idea was to develop a dialogue tool for municipalities and service providers to reflect on their capabilities for EEFM with reference to the observations in the previous phase. The road map guided the authors through a process of:

   I. Planning: specify the audience, define the aim, clarify the scope and define the success criteria,
   II. Development: select the process areas, select the maturity levels, formulate the cell text and define the administration mechanism,
   III. Evaluation: validate and verify,
   IV. Maintenance: check the benchmark, maintain the results database and document and communicate the development processes and results.

Thus, with guidance from [16], we developed the energy efficiency maturity matrix consisting of four main phases and several key processes scaling from ignorance to professional. Further developments were made in dialogue with EVU management and staff in formal, as well as informal discussions, as described above.

4. The practical relevance of the maturity matrix has been verified and validated on a conceptual level by representatives of municipal FM organizations and energy service consultants, also beyond the project group partners. In a later market development project, the tool has also been modified to suit the target group of Swedish private housing cooperatives, a segment of the residential sector where housing boards chaired by lay persons are responsible for FM tasks on behalf of members and residents. Thus, the tool has been exposed to and used by practitioners on different occasions between 2014 and 2017. At such occasions, the process has been guided by the authors of this article. It cannot be excluded, but we are not aware of cases where the tool has been spontaneously adopted and used by different target groups. A systematic evaluation of the tool in use is remaining.

3. Results

3.1. Municipal Energy Efficiency Strategies

Since 2010, a Swedish government policy has supported municipal EES [23]. The grant is between 30,000 and 45,000 Euro per year depending on municipality size, which partly covers the wage cost of a municipal energy efficiency strategist for coordination of the work. Beneficiaries should:

- establish and politically adopt an EES with targets intended to be achieved by 2014 and 2020,
- launch an action plan and actively implement the EES,
- undertake at least two out of six specific energy efficiency measures,
- report progress to the administrating authority, the Swedish Energy Agency.

The specific energy efficiency measures conform to the list of measures that public-sector bodies should apply to fulfil an exemplary role according to the EU ESD and national regulation [24]:

1. use financial instruments, e.g., EPC, that stipulate the delivery of measurable and pre-determined energy savings;
2. purchase energy-efficient equipment based on official lists of product specifications;
3. purchase equipment that is energy efficient in all modes, including standby mode;
4. replace or retrofit equipment with the equipment referred to in (2) and (3);
5. undertake energy audits and implement the recommendations therein,
6. purchase or rent energy-efficient buildings or parts thereof or replace or retrofit purchased or rented buildings or parts thereof to render them more energy efficient.

The EES shall cover the whole municipal organization, all buildings owned or managed by municipal administrations or companies. From a screening of formal strategy documents in eight municipalities, Table 1 compiles information about the scope of building space covered, set targets and selected measures as numbered above.

Table 1. Overview of energy efficiency strategies (EES) in the eight municipalities (M 1–8), the scope of building space covered, set targets and selected measures as numbered above (1–6).

Municipality (Inhabitants)	Scope of Building Space Covered (m^2, Heated Floor Area)	EE Target (Reference Year 2009)	Selected EE Measures
M1 (15,000)	Non-residential: 75,000 Residential: 40,000	2014: −10% 2020: −20%	(1), (2), (3) and (5)
M2 (16,000)	Non-residential: 75,000 Residential: 35,000	2014: −3% 2020: −5%	(2) and (4)
M3 (23,000)	Non-residential: 90,000 Residential: 0	2014: −18% 2020: −28%	(4) and (5)
M4 (32,000)	Non-residential: 150,000 Residential: 170,000	2014: −10% 2020: −20%	(5) and (6)
M5 (51,000)	Non-residential: 350,000 Residential: 100,000	2014: −10% 2020: −20%	(1), (3), (5) and (6)
M6 (82,000)	Non-residential: 700,000 Residential: 800,000	2014: −8% 2020: −16%	(2), (4) and (5)
M7 (116,000)	Non-residential: 700,000 Residential: 650,000	2014: −15% 2020: −30%	(2), (3), (4), (5) and (6)
M8 (135,000)	Non-residential: 650,000 Residential: 1,200,000	2014: −4% 2020: −8%	(5) and (6)

Findings from interviews about the three aspects are briefly mentioned here and in the subsequent discussion:

- Scope: Though strategies ought to be comprehensive, it was often found that activities focused on non-residential buildings occupied by the municipalities' own administrations or public services (e.g., schools, offices, sports facilities, etc.). Apart from annual reporting of energy use to the strategists, municipal housing companies appeared to operate autonomously from the EES.
- Targets: After initial uncertainty, there seems to be agreement among municipalities and the administrating authority that the target definition is understood as a percentage reduction of purchased energy relative to aggregated building space compared to the base-year 2009. It is not obvious that this interpretation is consistent with regulations. As shown in Table 1, there are quite large variations in ambition levels.
- Selected measures: The stipulated specific energy efficiency measures were often perceived as vague. The respondents found it particularly difficult to differentiate between (2), (3) and (4), and the general description of (6) allowed for a variation of interpretations.

Based on the municipalities' self-reported data, Figures 1 and 2 demonstrate trend developments in specific energy use for the average building stock of non-residential and residential buildings owned or managed by the municipal FM organizations. Specific energy use is here defined as purchased energy per square meter of heated (>10 degrees Celsius) building space per year (kWh/m^2, year). Our data source treats occupants' energy use differently for the two groups of buildings; it is included for non-residential buildings and excluded for residential buildings. Degree day adjustment is made to normalize specific energy use with regard to varying temperatures. Being self-reported, the data contain uncertainties. For instance, some municipalities report base-year (2009) figures differently in 2015 compared with 2014. Despite the unexplained discrepancy, the data source is deemed the best available for discerning trends in energy performance of the Swedish municipal building space [25,26].

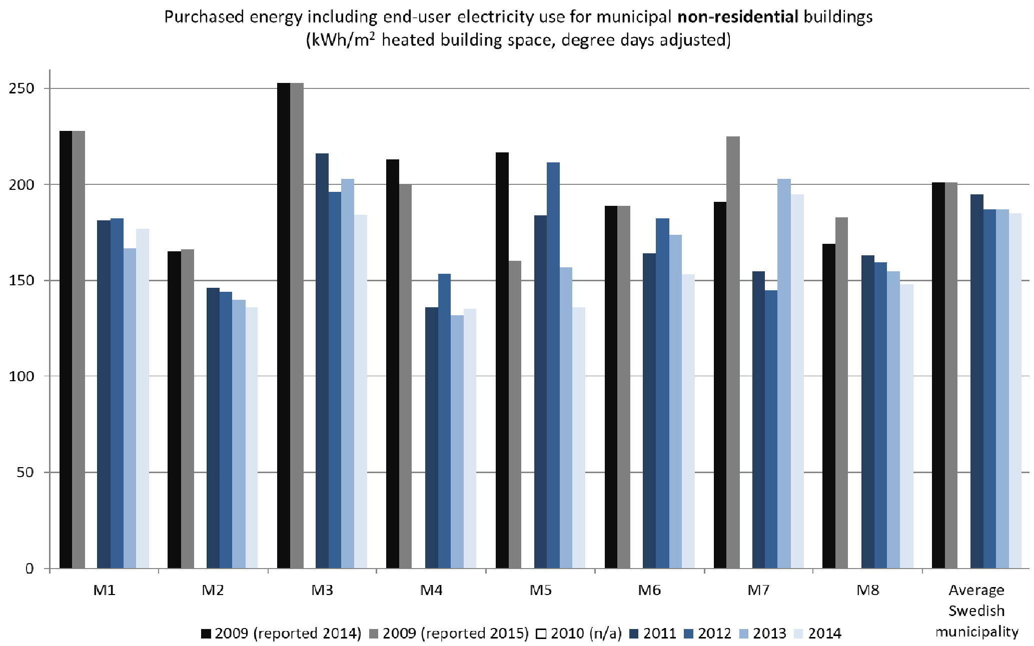

Figure 1. Purchased energy including end-user electricity use for municipal non-residential buildings. Source: [25,26].

In 2014 compared to 2009, the reported specific energy use for the average non-residential building stock decreased in seven municipalities, which puts them on track to fulfil or greatly over-shoot their energy efficiency targets for 2014 and 2020. Reported specific energy use increased in one municipality (M7), possibly influenced by a larger and relatively energy-intensive sports facility being closed for renovations in 2010–2012.

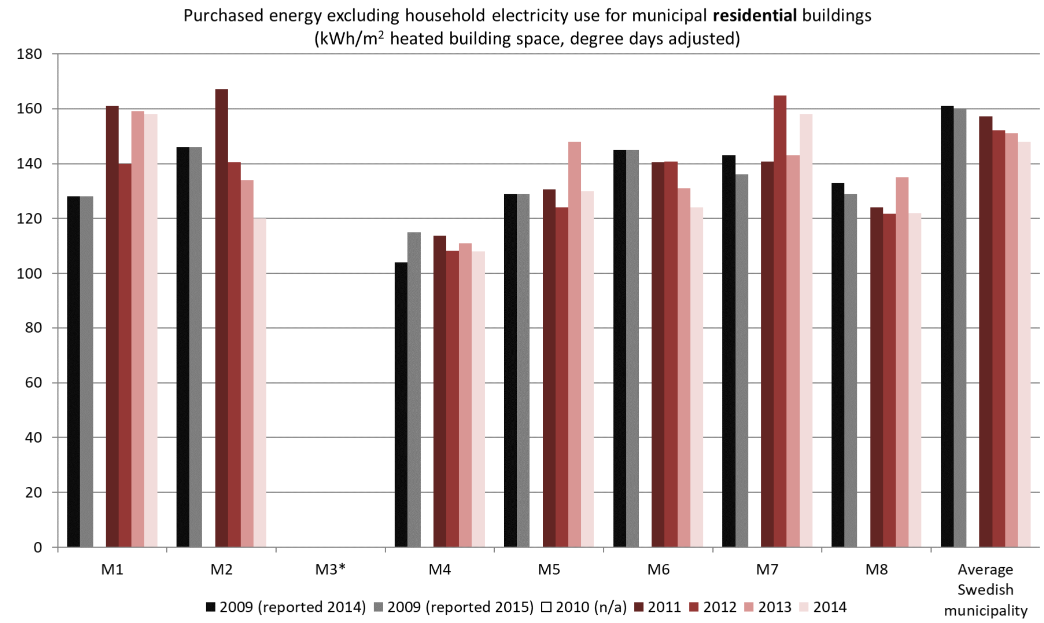

Figure 2. Purchased energy excluding household electricity use for municipal residential buildings (* M3 does not own residential buildings). Source: [25,26].

In 2014 compared to 2009, the reported specific energy use for the average residential building stock decreased in three municipalities, which puts them on track to achieve their energy efficiency targets for 2014 and 2020. However, only one municipality (M6) demonstrated a close to continuous annual decrease. Reported specific energy use increased in four municipalities and quite substantially in two of these (M1 and M7).

3.2. Models for Energy Efficiency Improvement in Municipal FM Organizations

The intended strategy can be different from the realized strategy, which is relevant in the case of municipal governments and bodies. Elected politicians ought to make principal and strategic decisions about public services, while administrations and employees are responsible for preparation and operation. Municipal FM organizations are relatively large and divided into administrations and municipally-owned companies with different areas of responsibility and with contractors and consultants hired for various tasks.

To examine the links between politically-endorsed strategies and actual operations, respondents were asked about which out of four proposed models describes the energy efficiency practices of the FM organizations. The models, shown in Figure 3, derived from a study of energy efficiency practices in Danish municipal buildings [21], but are further developed to reflect the identified approaches in the municipalities in terms of scope, targets, measures and sourcing strategy. The horizontal axis distinguishes between the involvements of internal or external resources, whereas the vertical axis distinguishes between an incremental or more direct rate of energy efficiency improvement.

In most cases, when respondents were municipal strategists, the answers about the utilized models related only to non-residential buildings. Respondents either lacked knowledge or appeared reluctant to give detailed accounts about the approach taken by municipal housing companies. In one municipality (M3), there was no public ownership of residential buildings. When respondents were managers of FM organizations (in M2 and M6), they were in a position to answer for the whole portfolio of buildings, residential, as well as non-residential, owned by the municipal company. Table 2 shows that optimization of operations (A) and maintenance and energy efficiency improvement (C) were often stated as currently applied and preferred models. On the other hand, some interviews revealed skepticism and disappointment related to the energy service company (ESCO)-solution (B), e.g., failing to deliver expected energy savings and negatively influencing other performance criteria, overly focused on least cost measures and troubled by technological and contractual lock-in effects.

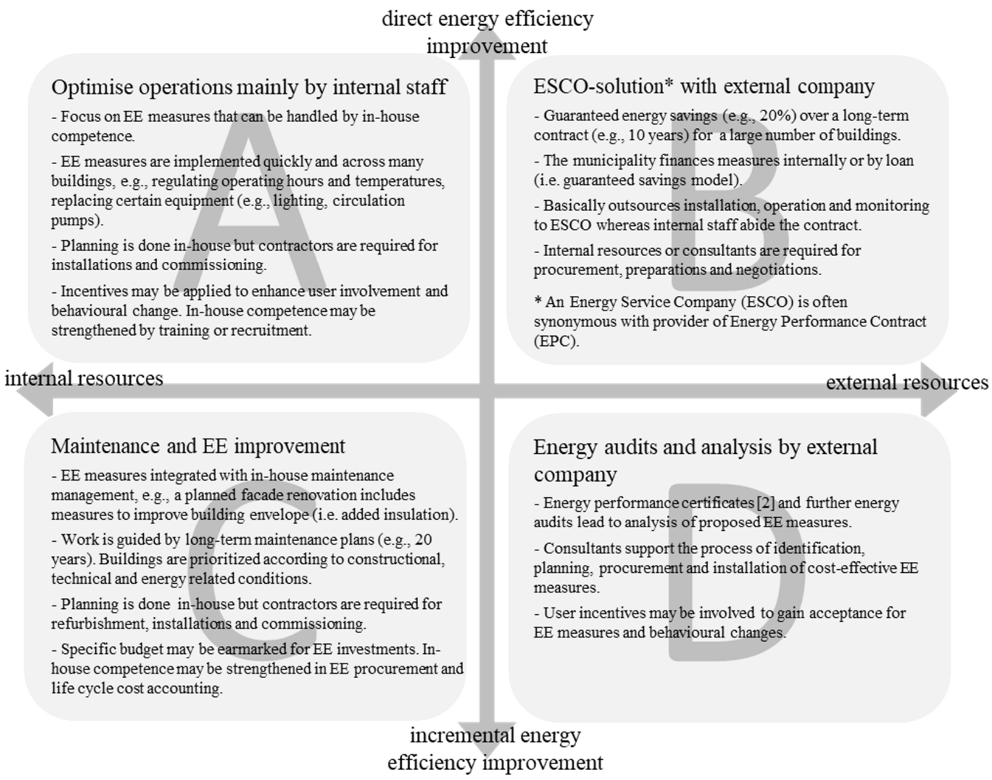

Figure 3. Models for energy efficiency in municipal buildings. The figure is a development of a simpler version presented in [21].

3.3. A Maturity Approach to Energy-Efficient FM

In search of the capabilities of EEFM, the interviews probed the concept to identify its phases and key processes. Structured by the value chain of energy efficiency services [22], the interviews provided input to develop and translate the maturity matrix into four main phases; similar to the plan-do-check-act approach common for management systems and also used to manage and measure added value in facilities management and corporate real estate management [27]. The phases form an EEFM value stair-case starting from the basic orientation about problems and solutions extending up to the demonstration of results from the implemented measures. Each phase consists of underlying key processes that through interviews and supportive literature are suggested as important constituents of EEFM.

For each key process, municipal FM organizations should be assessed against a descriptive yardstick and assigned a maturity level (e.g., from "ignorant" to "professional"). Awareness-raising about the current situation and maturity improvement potentials should support decisions about steps to take in-house and in collaboration with energy efficiency service providers. The process designations are particularized under their phase headlines below. Appendix A is the full version of the energy efficiency maturity matrix.

1. Orientation phase:

- Awareness of problems from excessive energy use, e.g., economic, environmental, social.
- Perceptions of energy efficiency as a viable and cost-effective problem-solver.
- Access to information/data on the buildings' energy use and energy baseline.
- Access to and handling of information on buildings' energy efficiency potentials.

2. Planning and implementation phase

- Procurement procedures to ensure energy performance of equipment and services.
- Procedures for energy-efficient project planning of new buildings or renovations.
- Ability to identify and secure financing solutions for energy-efficient investments.
- Preparation, installation and commissioning of measures on energy using equipment.

3. Operation and supervision phase

- Technical operation for optimization of energy use.
- End-user involvement for energy efficiency improvement via behavioral measures.
- Measurement and verification of energy efficiency measures and results.

4. Performance and demonstration phase

- Performance-based indicators, e.g., purchased energy for the aggregated building stock or certain building types (kWh/m^2, heated floor area). The indicators of the maturity matrix are relevant for a Swedish context, but will probably need to be adjusted by users to suit other national contexts.
- Translation and communication of energy efficiency results in terms of multiple benefits beyond energy cost reduction, e.g., job creation, environmental aspects, poverty reduction.

Table 2. Current and preferred future models for energy efficiency. A = optimize operations mainly by internal staff; B = ESCO-solution with external company; C = maintenance and EE improvement by mainly internal staff; and D = energy audits and analysis by external company. FM, facilities management.

Municipality (Incl. Residential and/or Non-Residential Buildings)	A	B	C	D	Comments and Preferences about Current (as of 2014) and Future Model(s)
M1 (non-residential buildings)		X			70% of non-residential is in (B), a long-term contract with guaranteed cost performance. It has been disappointing, and the FM organization is dissatisfied with the situation. Wants to reach (C) after thorough audits and analysis (D).
M2 (residential and non-residential buildings)	X		X	X	Believes all three selected models should be considered as part of a total approach to achieve tangible energy efficiency results. Wants to continue to combine (A), (C) and (D). Shows aversion to the ESCO-solution (B).
M3 (non-residential buildings)	X			X	Focus on optimization measures (A) combined with energy auditing (D) to identify measures to be implemented according to an investment plan until 2020. Thus, continuation of (A) and (D) is expected for some time ahead.
M4 (non-residential buildings)	X		X		Combines (A) and (C) to mix larger investment projects with operation and maintenance, and training and recruitment has enhanced in-house capacity. Wants to continue combining (A) and (C). Shows aversion to the ESCO-solution (B).
M5 (non-residential buildings)		X			Most of the non-residential buildings have been in (B), an EPC since 2009. There is uncertainty, but ongoing investigations will support decisions about future approaches.
M6 (residential and non-residential buildings)	(X)		X	(X)	Focuses on (C) as the main model, but (A) and (D) are also entered. Is confident that in-house capacity is best suited for the task. Consultants are hired for well-specified demands. Wants to continue focus on (C).
M7 (non-residential buildings)	X		X		A combination of (A) and (C) describes the approach. Twenty five percent of non-residential buildings were previously in (B), but the FM organization left the increasingly criticized EPC ahead of plan in 2011. Wants to continue with (A) and (C).
M8 (non-residential buildings)	X		(X)		Foremost (A), but has outsourced the task to contractors that are incentivized to optimize operations. Users are also engaged to take house-keeping measures. The current set-up with (A) and occasionally (C) is foreseeable in the near term.

The maturity matrix can also be used by energy efficiency service providers that want to make value propositions that match customer demands. For instance, areas where a customer's internal resources are scarce can be determined by the maturity matrix and support a tailor-made service offer based on selected processes. Thus, interaction, negotiation and cooperation between customer and service provider is key to reach a complete EEFM value stair-case coverage.

4. Discussion

The management literature contains many perspectives on the strategy concept and has claimed that heterogeneity is needed to pose fundamental questions about organizations [28]. Thus, a municipal EES is potentially rich in content, and the assessment results lend themselves to a discussion about scope, targets and selected measures as stipulated by policy.

4.1. Scope

Despite policy intentions about comprehensive EES, the interviews showed that most municipalities focused on non-residential buildings. Some strategists could not provide relevant information about municipally-owned housing companies, and silo mentality appears to hinder some from establishing municipal-wide cooperation. Symptoms are:

- lack of communication between strategists, responsible for coordination and reporting, and managers in FM organizations, responsible for building operations,
- low awareness and interest in common targets and politically-endorsed measures,
- conflicting views about which division should receive the grant for EES.

Whenever the communication and collaboration has been rewarding, a combination of personal skills and organizational stability appears to be the success factor. When comparing the two subsets of buildings, the self-reported data reveal a trend of improvement in specific energy use for non-residential buildings. However, there is no clear trend for the residential building stock. One explanation could be that strategic efforts have indeed focused on non-residential buildings. A rationale could be that in non-residential buildings, the tenants are their own municipal administrations. Thus, politically-regulated rents could create pressure to reduce operating cost through cost-efficient energy efficiency improvement measures. In the residential sector, municipal housing companies can more easily pass high operating costs from excessive energy use to the private tenants/households.

4.2. Targets

After initial uncertainties around baseline issues and absolute versus relative targets, interviewed municipalities regarded their targets as percentage reductions of purchased energy relative to the aggregated space of non-residential and residential buildings. Targets of −10% by 2014 and −20% by 2020, compared to 2009, are common, but there are outliers on both ends of the scale. Normalization of temperature variability has been applied to adjust annual heating demand. However, municipalities do not appear to consider how structural changes in building portfolios (e.g., divestments and new constructions) influence average specific energy use and target fulfilment. A "strategy" could be to divest buildings with poor energy performance and achieve targets without taking tangible energy efficiency improvement measures in existing buildings. Neither the Swedish Energy Agency nor the Swedish Association of Local Authorities and Regions have considered baseline issues in the monitoring of municipalities' self-reported data [25,26]. Thus, estimates about policy impact in terms of energy savings are uncertain. For qualified estimates on energy efficiency improvements in municipal buildings, future research and policy evaluations could analyze disaggregated datasets by regression or decomposition methods.

4.3. Measures

According to formal EES documents, all eight municipalities selected at least two energy efficiency measures from the prescribed list. However, the respondents gave diverse answers about implementation. In one municipality, the respondent was unaware about this obligation, and in two municipalities, respondents browsed their papers for some time before answering hesitantly. Some municipalities had selected measures that were implemented before the grant was received, and other municipalities carried out other measures than those initially stated. In four municipalities, it was clear that selected measures had been translated into tangible energy efficiency actions implemented by the FM organizations. The mixed outcome could relate to stipulated measures being perceived as vague, allowing for interpretations about compliance. The practical implications of stipulated measures are uncertain and disparate.

4.4. Usability and Usefulness of a Maturity Approach to Energy-Efficient FM

The article has presented the development of the maturity matrix aimed at assessment, awareness-raising and improving capabilities for EEFM in public FM organizations (and among energy efficiency service providers). Key processes have been identified, and the content has been formulated at each maturity level. For a process-based maturity model to become an applicable tool, it must be well received by the intended users, i.e., municipal strategists and FM organizations, but also service providers that want to initiate, demonstrate and sustain its partaking in EEFM. In terms of usability, users should understand the terminology and concepts applied to explain processes and maturity levels. In terms of usefulness, users should find the tool effective and fit-for-purpose in supporting assessment, awareness-raising and contributing to improved capabilities in EEFM.

Validation of usability and usefulness should involve intended user groups and preferably other stakeholders (e.g., experts from academia and practice). The interviews with municipal strategists and managers of FM organizations included some validation activities. Starting with the less detailed value chain of energy efficiency services, respondents were asked to comment on proposed key processes, terminology and relevance related to their situation. Based on this input, the structure and content was gradually refined through a participatory and iterative procedure. Some strategists expressed a demand for supportive tools to raise their own and stakeholders' awareness about EEFM and to assess the performance of FM organizations. Some considered introducing a municipal-wide energy management system in compliance with international standard. The maturity approach could guide such an important and potentially costly decision and contribute to the plan-do-check-act approach.

Presentations to EVU gave feedback on processes related to their core business. It was affirmed, not without disagreements, that the suggested approach could be a viable tool to initiate customer dialogues and to extend the remit and provision of energy efficiency services along the value chain. Additional review was provided in academic seminars with researchers from the FM discipline and from energy systems analysis, which attested that essential issues were covered and that content was understandable. Furthermore, a focus group validation was conducted during a meeting for municipal strategists, where they self-diagnosed their organizational maturity in EEFM.

A preliminary version of the maturity matrix was presented at the European Facility Management Conference in 2015 [29] to an audience of practitioners and researchers. This article is however the first scientific article of the final version of the energy efficiency maturity matrix. Due to the timespan between the completed project and the present, we expected to be able to report more on the usability and usefulness of the sourcing tool. However, this has proven to be too optimistic, primarily for two reasons. Firstly, to become a generic EVU-tool, it would take some effort and resources to refine the matrix to marketing material and to adopt the matrix as a common practice in dialogues with customers, and so far, there is not investment in this kind of dedicated resource. Secondly, the clients for energy efficiency services are currently interested in executing specific projects about why the demand for consultancy tasks on strategic level (including sourcing) is perceived as immature and therefore less important for the current business.

The maturity matrix is developed to a conceptual level and can be used as it is or modified to better fit the actual user context. From a research perspective, this research adds to the growing, but still limited literature on sustainable facilities management [30], where research on organizations' capabilities is still an understudied phenomenon [31]. The maturity matrix was developed in a Swedish-Danish context; however, the challenges of EEFM are generic and worldwide in terms of assessing current practices, awareness raising and capacity building. Our claim is that it is a sourcing tool that will be useful globally. Future research could document the use of the matrix and evaluate the outcome of using the matrix in deliberate sourcing processes. This could inform the profession about the strengths and weaknesses of various sourcing strategies in search of more successful implementations of EE policies and targets; including a systematic approach of assessing if private-public-partnerships (PPP) compared to capacity building in in-house municipal organizations.

5. Conclusions

The investigation of municipal EES shows that these are less comprehensive than stipulated by policy. Contributing factors can be perceptions about vague policy objectives and prescriptions, but also internal obstacles to communication and collaboration across the organizational borders of municipalities. Realized strategies and measures have been foremost involved non-residential buildings, sometimes with substantial impacts on reported specific energy use. Untapped energy efficiency improvement potentials are likely to reside in residential buildings managed by municipally-owned housing companies.

The study confirms changes in the Swedish energy efficiency service market. Municipal FM organizations increasingly demand collaborations with energy efficiency service providers that deliver real and perceived values. The somewhat idealistic solution is collaborative and trustful relationships rather than long-term and sophisticated contractual arrangements. Through dialogue, service providers could learn to know their customers and refine custom-made offers.

Several identified key processes of EEFM are currently underdeveloped in municipal FM organizations. This provides the opportunity for new value propositions and alliances on the energy efficiency service market. The suggested maturity matrix supports a dialogue around this, for FM organizations and energy efficiency service providers to better match capabilities in EEFM, as the result of a deliberate sourcing process for energy-efficient sustainable building renovation and maintenance.

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Appendix A

Energy Efficiency Maturity Matrix

Main phases	Processes	Level 0: Ignorance	Level 1: Awakening	Level 2: Knowledgeable	Level 3: Professional
Orientation phase	Awareness of problems that are related to an excessive energy use (e.g. economic, environmental and social)	No awareness or denial of such problems.	Awareness and acceptance of some problems.	Acceptance of problems and feeling of responsibility for problem solving.	Confident that change is necessary and possible; see many courses of actions that are aligned with own strategic orientation.
	Perceptions about energy efficiency improvement as a viable, effective and cost-effective problem-solving technique	Energy efficiency is not a solution.	Energy efficiency could be one of many available solutions (e.g. energy supply, property divestments etc.).	Energy efficiency is a relatively effective solution, manifested by target(s) and some cost-effective measures are also taken.	Have established well-considered strategic energy efficiency objectives and targets, action plan(s), and practices to monitor the progress.
	Access to information/data on the buildings' energy use and energy baseline	No access or unaware of such information/data.	Have some, but incomplete information (e.g. lacking for some objects, periods, energy carriers) based on e.g. billing data.	Access to information on building level for previous years, based on billing data or regular meter readings for all major energy carriers.	Regular and automatic meter readings provide energy baselines as well as real-time and detailed information on building operations and energy use for all major energy carriers.
	Access to and handling of information about buildings' energy efficiency improvement potential	Energy audits have not been undertaken or otherwise been forgotten (e.g. report stuffed in desk drawer).	Some energy audits have been undertaken but further site-specific analysis are needed to assess techno-economic energy efficiency potentials.	Energy audits have been undertaken for most buildings and further analysis have also been undertaken for a selection of prioritized buildings.	Energy audits and analysis are undertaken for all buildings. Information on techno-economic energy efficiency potentials is used to integrate measures in long-term maintenance plan. Monitoring of buildings' energy use also contributes to prioritize buildings for energy efficient renovation.

Figure A1. Key processes of the orientation phase.

Main phases	Processes	Level 0: Ignorance	Level 1: Awakening	Level 2: Knowledgeable	Level 3: Professional
Planning & implementation phase	Procedures for energy efficient procurement to improve energy performance of equipment and/or services.	Never considered energy performance in procurement process.	Aware of existing guidelines for energy efficient procurement but requirements have hardly been made in practice.	Have occasional experiences of making explicit requirements on energy performance or to base procurement decisions on life cycle cost assessment.	Have formally adopted procedures to require and procure equipment and services of an energy performance that should lead to life cycle cost optimization.
	Procedures for energy efficient project planning of new buildings or larger renovations.	Never considered energy performance in project planning.	For new buildings the energy performance should at least go beyond the requirements made by national building code.	Have formulated specific energy performance guidelines for some components and installations (e.g. building envelope, HVAC etc.).	Have formally adopted energy performance guidelines for the main components and installations (e.g. building envelope, HVAC, appliances and lighting). Guidelines are updated to reflect state-of-the-art in energy performance.
	Ability to identify and secure financing solutions for energy efficiency investments	Never considered specific financing solutions for energy efficiency.	Energy efficiency measures are typically covered by maintenance budget or operation budget. Tries to keep informed about, and exploit, relevant state-level investment subsidies.	An earmarked energy efficiency fund simplifies financing of larger energy efficiency investments. Can secure relatively good credit terms on financial market. Exploits relevant EU or state-level investment subsidies.	Have good credit terms, earmarked energy efficiency fund, and make sure to exploit investment subsidies. In addition, examines and applies other financing solutions e.g. performance contracts, project bundling, revolving fund, BOT, PPP.
	Preparation, installation and commissioning of measures related to energy using equipment	No in-house capacity for preparation or control of installation and commissioning contracts.	In-house capacity of craftsmen (e.g. plumber, electrician, carpenter) used for basic preparatory assessments of installations and commissioning contracts.	In-house capacity of craftsmen and engineers skilled in technology systems (e.g. lighting, HVAC, building management system etc.) to do preparatory assessments and quality controls of larger installations and commissioning contracts.	In-house capacity of craftsmen and engineers highly skilled in technology systems to do preparatory assessments and quality controls of larger installations and commissioning contracts. Relevant staff are trained to be updated with energy efficient technology and advancements.

Figure A2. Key processes of the planning and implementation phase.

Main phases	Processes	Level 0: Ignorance	Level 1: Awakening	Level 2: Knowledgeable	Level 3: Professional
Operation & supervisions phase	Technical operation for optimization of energy use	Not considered by in-house capacity or contractor.	In-house capacity or contractor for general repairs upon service request. Visual inspections by housekeepers and users is the main operational control mechanism beyond the mandatory inspections of e.g. ventilation and pressure vessels.	In-house capacity or contractor is trained and expected to identify and implement operational EE measures such as adjusting operation hours and temperatures. Monitoring of meter readings also contributes to operational controls and corrections.	The monitoring and supervision of real-time data on energy use detects abnormal operation and excessive energy use. It leads to immediate corrective measures taken by contractor or in-house capacity depending on scope. HVAC systems are regularly balanced, and operation hours and temperatures are adjusted to demand, to ensure energy efficiency and other performance criteria.
	Energy end-user involvement for energy efficiency improvement from behavioral measures	No initiatives to inform or involve users by any means.	Users are provided with general information about energy efficiency housekeeping measures (e.g. through website or municipal energy advisor).	Relevant user groups are trained to follow energy efficiency check-lists and are offered some sort of incentive to do so (e.g. through "green leasing" or similar agreement).	Users are given correct incentive whenever applicable, e.g. via sub-metering non-residential users pay their own electricity bill, individual metering and billing for domestic hot water use. The energy price signal is combined with advice and services for energy efficiency improvement.
	Measurement and verification (M&V) of energy efficiency measures and results	Have not really considered the follow-up of EE measures.	Make follow-up to ensure that agreed EE measures are implemented. Monitors average annual energy performance on building level compared to a base-year.	Result of EE measures are determined by measuring energy use before and after implementation, with adjustments for changes in conditions compared to baseline period.	EE results are determined by measuring energy use before and after implementation, with adjustments for changes in conditions compared to baseline period. M&V plan contains procedures for building and installation level M&V practices. Operational verifications (e.g. sub-metering) are done to ensure persistence to EE results, and compliance with performance criteria.

Figure A3. Key processes of the operation and supervision phase.

Main phases	Processes	Level 0: Ignorance	Level 1: Awakening	Level 2: Knowledgeable	Level 3: Professional
Performance, demonstration & translation phase	Performance based indicator 1: annual average purchased energy for municipal non-domestic buildings [kWh/m2, heated floor area]	>250	200-250	150-200	<150
	Performance based indicator 2: annual average purchased energy for municipal residential buildings [kWh/m2, heated floor area]	>180	140-180	100-140	<100
	Translation and communication of energy efficiency results in terms of multiple benefits that go beyond energy cost reduction (e.g. job creation, environmental improvement, health and wellness, poverty reduction).	Not aware of any multiple benefits from EE measures (i.e. EE is only a matter of energy cost reduction).	EE measures and results are seen as contributors to environmental management program and objectives. Yet, its significance is not really estimated or reported.	Various environmental as well as other relevant multiple benefits coming from EE measures have been estimated and reported with success .	Context specific multiple benefits from EE are identified in co-operation between practitioners from different disciplines. Such multiple benefits are closely monitored and estimated, and consciously communicated to appeal to relevant stakeholders.

Figure A4. Key processes of the performance, demonstration and translation phase.

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