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Identifying stakeholders and key performance indicators for district and building energy performance analysis

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ABSTRACT

Integrated energy management at both the district and building scales can potentially improve multi-level energy efficiency, but such a solution requires the exchange and analysis of energy performance information from different stakeholders. With the complexities of energy management, there are numerous potential stakeholders and a considerable amount of information to consider. Therefore, a primary challenge is the development of a method that identifies the key stakeholders and extracts key information that supports their performance goals. In this paper, a systematic approach to identify stakeholders and key performance indicators (KPIs) is proposed to draw key information for multi-level energy performance analysis. Firstly, a three-task method for the identification and prioritization of stakeholders is suggested; secondly, a bi-index method to select the KPIs that underpin the stakeholders' performance goals is defined; finally, the proposed methodology is validated using a case study. The result demonstrates the feasibility of the methodology and illustrates that the selected KPIs contribute to the attainment of key information required to carry out a multi-level energy performance analysis.

1. Introduction

Urban areas cover approximately 2% of the Earth's surface, but are responsible for almost 75% of overall resource consumption [1]. The current process of rapid urbanization exerts additional pressure on energy resource supplies and increases CO_2 emissions [2,3]. As a result, urban energy planning and management will be pivotal for the realization of sustainable cities [4]. Such smart cities and communities have the potential for large-scale energy management through adoption of approapriate new energy technologies and ICT (information and communication technologies) [5]. In addition, increased penetration of renewable energy resources in energy distribution networks requires energy management at a district scale, thus enabling opportunities for integration of energy supply and end use [6,7]. One example of which is demand-side management: this involves actions that can influence energy consumption patterns of end-users with upstream benefits for electricy distribution and transmission networks [8]. Such large scale benefits align with the Digital Agenda for Europe [9] as one of the seven pillars of the Europe 2020 Strategy. Therefore, a series of EU funded projects use ICTs to facilitate district-scale energy management [10]. These include DoF (District of the Future) [11] and COOPERATE (Control and Optimisation for Energy Positive Neighbourhoods) [12].

The built environment consumes significant levels of energy in cities, and accounts for approximately 40% of final energy consumption in EU countries [13]. However, a considerable proportion of the building stock is designed or operated inefficiently. For example, more than 50% of residential buildings in the EU were built before 1970, thus failing to complying with any energy regulations. Approximately 1/3 were built between 1970 and 1990 which corresponds with the initial implementation of energy policies [14]. By improving the energy efficiency of existing buildings, total energy consumption could be reduced by 5–6%, and CO_2 emissions by 5% [15].

Energy management is an important process that, when implemented correctly, should improve energy efficiency and reduce operating costs in buildings [16]. A lack of energy management during operation typically results in an overconsumption of energy

Abbreviations: SVI, Stakeholder Vote Index; SPI, Stakeholder Prioritization Index; CI, Comprehensive index for KPI selection.

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when compared with design expectations [17]. Approaches that improve the energy efficiency of individual buildings with a view towards enhanced district scale performance is an ongoing societal priority [18]. Solutions that consider the energy efficiency of buildings in the context of community or district level can significantly contribute towards sustainable and smart cities. However, multi-level energy management that aims to improve energy efficiency on both the district and building scales is a complex information-driven process that requires stakeholder interaction through exchange and analysis of energy-related information [19].

Stakeholder involvement is a prerequisite for exchanging this information and promotion of integrated energy management [20]. As a result, energy management is an interactive process between stakeholders and should realize their respective energy performance goals. Energy management in the context of this paper is a complex yet collaborative process, involving numerous potential stakeholders and enormous volumes of information. In order to manage this complexity, a method by which to identify the key stakeholders and extract the key information that addresses the stakeholders' performance goals is critical.

The stakeholder concept was initially introduced into the management discipline in 1984 [21]. Stakeholders can be defined as persons or groups whom are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome [22]. Although the importance of stakeholders for the success of a project is indisputable, there is a present shortage of studies that identify stakeholders related to energy management from building to district level. The most common means by which to identify stakeholders in the energy field is through the study of similar projects. In most cases, stakeholders are chosen without carrying out a detailed analysis [23,24].

The international industrial energy management standard, ISO 50001, specifies the requirements for establishing, implementing, maintaining, and improving an energy management system [25]. However, this standard fails to include stakeholders' engagement in energy management. The standard requires that organizations create energy objectives before implementing an energy management plan. The mechanism through which this is achieved is the identification of appropriate energy performance indicators (PIs) that track energy performance and ensure continuous improvement. Generally, the energy objectives should comply with relevant regulatory requirements yet represent stakeholders' goals. ISO 50001 provides guidance on the identification of energy PIs but fails to include guidelines relating to how indicators underpin stakeholders' goals. Additionally, numerous PIs can be identified, especially for district-scale energy management. Assigning a weighting to each indicator is essential when aiming to identify the key performance indicators (KPIs) that underpin overarching stakeholders' performance goals.

KPIs are useful for dealing with complex contexts such as districts and buildings. KPIs represent critical pieces of actionable information and help to evaluate and track the key aspects of performance within an organization [26]. KPIs are widely implemented in numerous disciplines such as construction and facility management. Currently, the identification of KPIs is commonly carried out using methods such as a literature review, stakeholder validation or discussion with industry players and experts [27,28]. However, these methods are predominantly qualitative. Although the method of stakeholder validation considers stakeholders' involvement, this method only takes place after the KPIs have been selected. KPIs validated by the stakeholders can support their performance goals to some extent. Nevertheless, a more favorable outcome should be attainable if stakeholders have the ability to select their specific KPIs at the beginning of the selection process.

This paper proposes a systematic approach to identify stakeholders and KPIs for multi-level energy management, at both the district and the building scales. Section 2 outlines the proposed methodology. Sections 3 and 4 elaborate the detailed methods that identify and prioritize stakeholders along with their corresponding KPIs. Section 5 demonstrates the proposed method via a case study while Section 6 discusses the main findings eminating from the results.

2. Methodology

The systematic approach adopted to identify the stakeholders and the KPIs for multi-level energy management comprises 11 tasks, as illustrated in Fig. 1. Tasks 1–3 identify stakeholders and their respective priorities. In doing so, these tasks determine the relevant stakeholders and rank them in terms of their importance for the task at hand. The concept of intervention points [29] is introduced for identifying the stakeholders. Stakeholders become involved in energy management through these points. In order to identify a complete list of stakeholders, roles are identified, instead of highlighting the specific actors. Relevant stakeholders are therefore related to each role and are classified into internal and external stakeholders [30]. Not all stakeholders are equally important. Therefore, the performance goals of some stakeholders take precedence over others. For this reason, a prioritization analysis identifies the key stakeholders.

Tasks 4–6 involve the identification of PIs and the selection of KPIs. By doing so, KPIs transform the stakeholders' performance goals in such a way that they can be measured and tracked to represent key performance information. KPIs are selected from an overarching set of PIs; and they include those that represent critical performance. The definitive set of PIs is identified through district and building energy reviews, including features such as energy structure, energy systems and energy flow analysis [25,31]. Therefore, these PIs reflect the basic performance concerns in the specific energy management context.

Tasks 7 and 8 focus on the identification and collection of master data, in addition to the calculation of the selected KPIs. The ever-increasing volume of monitored data relating to energy management is attributed to the accelerated adoption of ICTs. As a result, the concept of master data is introduced to represent the insightful core data that provides valuable information [32]. Precedents exist for the identification of key data using indicators and metrics [26,33], and such approaches are also applicable to master data collection. Master data include the key data for KPI calculation and performance analysis. It is sometimes necessary to review the existing data sources and to carry out further data collection. Additionally, KPI benchmarking against performance targets is especially important. If the performance targets are achieved, the final step would be to carry out an experiential study. Otherwise, tasks 9 and 10 need to be conducted in order to ascertain the performance problems and take measures to improve these. The approach proposed involves a process of continuous improvement until the final energy performance targets are achieved.

3. Stakeholder identification and prioritization analysis

This section presents a detailed method that identifies and analyzes stakeholders in the context of building to district scale energy management. Firstly, current practices for the identification and analysis of stakeholders are reviewed in Section 3.1. Thereafter, a newly developed three-task method (tasks 1–3 in Fig. 1) for identifying and prioritizing stakeholders is illustrated in Section 3.2. The key components of which are the identification of intervention points for energy performance, the identification of stakeholders' roles and the prioritization of stakeholders.