The energy master planning process for districts

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Abstract

The energy master planning process for districts requires an analysis of different scenarios, which include new construction to different levels of energy efficiency, major renovation of all or some buildings comprising building stock under consideration with Deep Energy Retrofit of these buildings, minor renovations with energy-related scope of work, or demolition of some old buildings. Such analysis requires building energy modeling

Different baselines and constraints were compared for different countries as Australia, Austria, Canada, Denmark, Finland, Germany, Norway, UK and USA and were put into context (cultural and economic) and pattern were developed. In typical districts in city centres the dominant commercial buildings are often heated, cooled, and ventilated. Six performance concepts are identified which form the structure of the next sections, all with contextual relevance to energy use and supply of energy in districts.

Key Innovations

Concepts with functional element sub-division:

- Energy follows function
- Energy follows form
- Energy follows user needs

Concepts with organizational element sub-division:

- Energy follows stakeholders
- Energy follows organization
- Energy follows availability

Research Implications

A common approach to calibration of building models to existing energy use data available from metering and sub metering must take these sub-divisions into account in order to be able to include different stakeholder views, implementation plans and goals and visions.

Introduction

In many cities, the necessary legal and strategic frameworks for the realization of PED/PENs are not yet in place. Very often, there is also a lack of a planning culture in city administrations or the personnel resources available might be insufficient. In particular, the transformation of large (brownfield) areas to climate neutral city districts has a big potential for the development of PED/PENs but needs cooperation between administration, industry, and research. Especially in case of heterogeneous ownership structures, cooperative planning processes are indispensable. Far less common in EMP guidance and related literature is information on the identification of constraints that limit energy technology options and how stakeholders influence the decision-making process. Literature in this area mentions options analysis or prioritization, or optimization analysis (EED 2012; Jank, 2017; Fox 2016; Zhivov et al. 2014; Robinson et al. 2009), yet, options analysis or optimization is certainly influenced by project energy-related constraints. Sharp et al. (2020) compared EMP in several countries and analysed these constraints (Sharp et al. 20120). The results show that successful energy master planning is highly dependent on a thorough understanding of framing goals and constraints, both local and regional, and their associated limitations that will dictate the optimum master planning design. Haase and Baer (2020) pointed out that the need for early and comprehensive energy master planning on neighbourhood and district level is critically important (Haase and Baer, 2020). The energy master planning process requires an analysis of different scenarios, which include new construction to different levels of energy efficiency, major renovation of all or some buildings comprising building stock under consideration with Deep Energy Retrofit of these buildings, minor renovations with energy-related scope of work, or demolition of some old buildings. Such analysis requires building energy modeling.

In this research work we developed requirements for representative models of buildings and districts from several countries and compared the approaches.

Method

The development of districts requires a distinct understanding of the situation now as well as a vision of the future district to be able develop suitable pathways for this transition. In order to be able to do that a district needs to be modelled that consists of several buildings, sufficiently described so that the future district can actively manage their energy consumption and the energy flow between them and the wider energy system. An accurate determination of energy savings is a key condition for long term success of energy management projects. Energy savings are determined by comparing measured energy use before and after implementation of

https://doi.org/10.26868/25222708.2021.31154

an energy saving measurements. To perform these kinds of analysis, it was necessary to:

- Identify the market segments and the segmentation of the current energy performance requirements;
- define and select a sufficient number of reference buildings that are characterised by their functionality, characteristics and regional conditions;
- specify packages of energy saving- energy efficiency- and energy supply measures to be assessed;
- assess the corresponding energy-related investment costs, energy costs and other running costs of relevant packages applied to the selected reference buildings;
- use the established reference buildings and relevant packages to identify cost-optimal energy performance requirements for building elements and technical building systems.

The analysis from six different country case studies provided a good basis for determining the commonly used concepts. By further system analysis of boundaries and energy flows two concepts with each three sub-divisions were identified.

Results

Complex districts consist of buildings and outdoor spaces with specific needs. The use that different buildings and areas are put to affects energy consumption, whereas the different functional patterns and stakeholder groups influence energy use. They are also associated with specific requirements that make it relevant to consider different types of performance indicators.

Energy can be considered to follow function because energy in the end is used to meet requirements defined by the activities that take place in a district. In each district, requirements are diversified by the type of activities/functions (residences, commercial (shops, retail), service (schools, restaurants, cafes, etc.), by the sizes of tenants rental spaces, or by the type of spaces (public areas, offices, parking etc.). The different activities can be characterized by functional patterns for various groups; – opening hours for commercial buildings will differ from operational hours for technical services and lighting. Facility operation has to meet the requirements of staff in commercial and cultural or service buildings before they open to the public. In districts, many tasks are performed outside of opening hours which require maintaining health and safety for the workers. Examples are maintenance and cleaning, sanitation and supply infrastructures, mobility and transport. In relation to this, the ratio of full operation of HVAC and lighting vs. opening hours or service hours is one index that could be used as a performance indicator.

Energy use and flows in complex districts

Complex districts consist of buildings and outdoor spaces with specific needs. The use that different buildings and areas are put to affects energy consumption, whereas the different functional patterns and stakeholder groups influence energy use. They are also associated with specific requirements that make it relevant to consider different types of performance indicators.

As a result of the underlining complexity of performance requirements in districts, it may also be useful to distinguish between causes of energy use within a functional sub-division, meaning energy divided by the functions which it is used (by end use or supply system), and organizational sub-divisions of energy use distinguished by who pays for the energy and thus is related to billing practice, building owner and tenant agreements, and contracts with energy supply carrier companies.

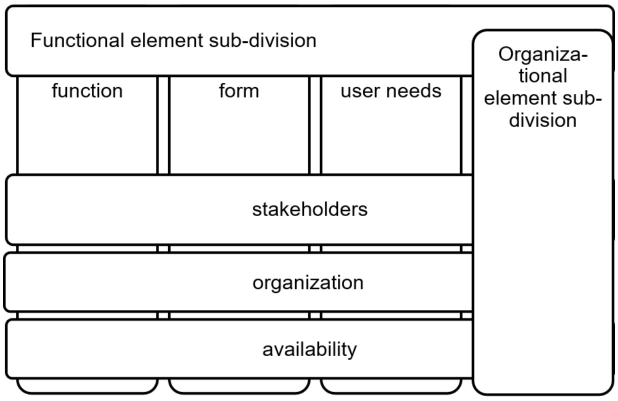

Figure 1: Functional and organizational concepts with sub-divisions

The first three divisions are mainly linked to the demand side and indicators that represent the requirements that can be found in norms, standards, and the like. While different stakeholder groups, organisation and contextual aspects like climate and energy availability, also define the relevance of performance indicators, and suggest which priorities should be given when performance requirements are in conflict. The latter interest groups and contextual aspects also form billing practices, sub-metering, and indicators for dividing the operational energy costs.

Conclusion

Nowadays, it is a challenge to transform current districts. Energy Master planning can help to optimize the districts energy system. The renewable energies and efficient solutions can overcome the oversizing problem of the electrical infrastructure for meeting the energy demand peaks as well as the energy transmission losses. It is important to operate with KPIs that can help to distribute energy production within the district. However, the incorporation of renewable system in districts must take into account that interaction between buildings and the grid will occur. When determining these interactions, several concepts of energy use in districts have to be taken into consideration. Computer-based energy performance models that are currently available for general use buildings are not sufficient and the need for a clear reporting structure of key performance indicators became evident. They need to be further customized to function as archetypes to predict energy use in districts and adapted to different climate conditions and energy use requirements. To be used for community planning, all prototype models must be fully parametrized for common modeling inputs in order to be able to build in energy

https://doi.org/10.26868/25222708.2021.31154

efficiency measures. A common approach to calibration of building models to existing energy use data available from metering and sub metering must take these sub-divisions into account in order to be able to include different stakeholder views, plans and goals.

Acknowledgement

This short paper is written within the project “PEB – Ebnung des Weges hin zu Energiepositiven Bezirken” with thematic support of the EBC programme of the International Energy Agency. Financial support from the Swiss Federal Office of Energy (SFOE) is applied for.

References

Fox, K. 2016. *Energy Master Planning Perspectives and Best Practices, presentation to the Federal Utility Partnership Working Group*, May 2016, Cincinnati, OH.

Haase, Matthias; Baer, Daniela, 2021. Constraints, stakeholders and framing goals in energy master planning between neighbourhood and district. In: Bisello, Adriano; Vettorato, Daniele; Haarstad, Harald; Borsboom-van Beurden, Judith, Hrsg., *Smart and Sustainable Planning for Cities and Regions : Results of SSPCR 2019.* 3rd International Conference on Smart and Sustainable Planning for Cities and Regions 2019 (SSPCR 2019), Springer. Green Energy and Technology.

Jank, R. (2017) Annex 51: Case studies and guidelines for energy efficient communities. *Energy and Buildings* 154: 529–537.

Robinson, Darren et al. 2009. CITYSIM: Comprehensive Micro-Simulation of Resource Flows for Sustainable Urban Planning, *Building Simulation 2009*, Eleventh International IBPSA Conference, Glasgow, Scotland. July 2009.

Sharp, T., Haase, M., Zhivov, A., Rismanchi, B., Lohse, R., Rose, J. Nord, N. (2020), Energy Master Planning: Identifying Framing Constraints That Scope Your Technology Options, ASHRAE Transactions. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc

Zhivov et al. 2014. Energy Master Planning Towards Net-Zero Energy Communities/Campuses, *ASHRAE Transactions*. Atlanta: ASHRAE Engineers, Inc.

https://doi.org/10.26868/25222708.2021.31154