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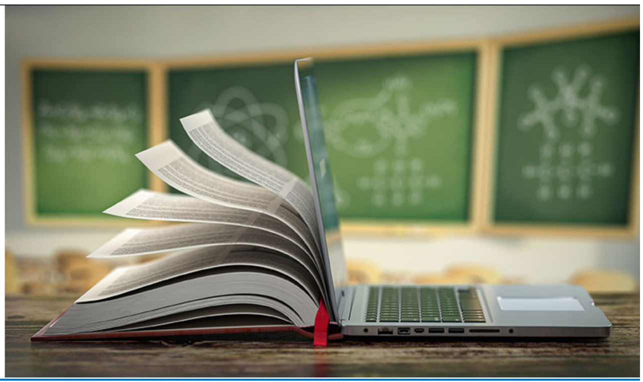

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A closer look at constraints, stakeholders and boundary definitions in Energy (Master) Planning between neighbourhood and district

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Abstract. This paper analyzes and contrasts the framing goals and limitations that must be considered when energy master planning is conducted for communities in six different countries. The analyses will be based on findings from countries participating in the International Energy Agency's "Energy in Buildings and Communities Program Annex 73". The paper covers design constraints such as emissions, sustainability and resilience goals, regulations and directives, and regional and local limitations such as available energy types, local conditions and different levels of stakeholders as well as community objectives. We illustrate how a comprehensive consideration of these constraints can be used to guide the planner toward design options that will lead to an optimum solution for an energy master plan. An analysis of the different constraints on different planning levels was done and the key stakeholders were identified characterized by different governance structures and thereby stakeholder constellations.

1. Introduction

Climate change challenge the ambitious goals that regulators have put in place by setting more and more aggressive building and community energy-related requirements based on the Sustainable Development Goals of the UN. The concept of Energy Master Planning (EMP) can help to initiate a better planning and implementation process to fulfill these goals. In the EU, reaching for the climate gas reduction goals of the Paris Agreement, stakeholders on all geographical and organizational levels from nations, regions, cities and communities are challenged. Following bottom-up approaches for energy planning on the neighborhood level is a promising attempt to reduce energy demand, increase efficiency and lower the carbon footprint in a multi-stakeholder approach.

In the context of the 2012 EU directive [1], several important measures have been adopted throughout the EU to improve energy efficiency. These include national long-term renovation strategies for the building stock in each EU country, mandatory energy efficiency certificates accompanying the sale and rental of buildings, the preparation of national energy efficiency action plans (NEEAPs) every three years, minimum energy efficiency standards and labelling for a variety of products, as well as obligation schemes for energy companies (to achieve yearly energy savings of 1.5% of annual sales to final consumers). However, Member States have yet to fully implement the Directive and additional support in building capacity and know-how is needed [2]. Significant additional energy savings, reduced emissions, and increased energy security can be realized by considering holistic solutions for the heating, cooling and power needs of communities, on neighbourhood and district scale, comprising collections of buildings. As a result, considerable literature has become available including both guidance and assessment tools aimed at EMP at the neighbourhood and district level as e.g. campuses [3-9]. But the existing guidance and tools do not seem to be fully solving the challenges. The energy planning consists in determining the optimal mix of energy sources to satisfy a given energy demand. The major difficulties of this issue lie in its multi scales aspect (temporal and geographical), but also in the necessity to consider the quantitative (economic, technical) but also qualitative (environmental impact, social criterion) criteria.

In addition, Schiefelbein et al. (2017) concluded in their investigation of case studies and energy guidelines for energy-efficient communities that "the primary challenges result from inefficient organizational processes and unsupportive framework for implementation" [10].

In order to be able to apply principles of a holistic approach to neighborhood and districts, often coined community energy planning in the literature, and to provide the necessary methods and instruments to master planners, decision makers, and stakeholders, it is essential to identify and frame the constraints that bound the options towards an optimized energy master planning solution [11]. Existing master planning guidance available indicates that identifying and establishing project goals is a critical first step [12]. In the specific area of "energy" master planning, similar but less abundant guidance supports this [1; 13-17].

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 [1; 15; 17; 18], but few mention constraint identifications related to energy technologies. Yet, options analysis or optimization is certainly influenced, perhaps very strongly, by project energy-related constraints. Sharp et al. (2020) compared EMP in several countries and analysed these constraints [11]. The results show that EMP framing constraints can be classified into natural and imposed constraints and then be further classified into these categories: locational threats, locational resources, energy and water distribution and storage systems, building and facility, indoor environment, and equipment in buildings and district systems.

Although the work of Sharp et al. is very useful, the focus was explicitly on single-owner districts like campuses or military garrisons. Not much work is available on the role constraints, stakeholders and boundary conditions in EMP for multi-owner, multi-stakeholder neighborhoods and districts.

As more and more countries push to improve the efficiency, environmental impact, and the resilience of their buildings and neighborhoods, the need for early and comprehensive energy master planning on neighborhood and district level is critically important. A 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.

2. Objectives

This paper fills this above mentioned gap by analyzing and contrasting the framing goals and limitations that must be considered when EMP is conducted for multi-owner, multi-stakeholder neighborhoods and districts. In addition, a mapping of the stakeholders involved will give insights in other constraints resulting in issues within the EMP that will need to be addressed.

3. Methodology

The analyses were based on findings from countries participating in the International Energy Agency's "Energy in Buildings and Communities Program Annex 73" [11]. The analysis was done in two steps, first focusing on the design constraints, then mapping the key stakeholders with specific focus on Norwegian cases.

3.1. Analysis of design constraints

The first analysis covers design constraints such as emissions, sustainability and resilience goals, and regulations and directives, and regional and local limitations such as available energy types, local conditions and different levels of stakeholders as well as community objectives. It then illustrates how a comprehensive consideration of these can be used to guide the planner toward design options that will lead to an optimum solution for a master plan.

3.2. Analysis of key stakeholders

The second analysis was based on the local constraints and site-specific goals. An analysis of the different constraints on different planning levels was done and the key stakeholders were identified characterized by different governance structures and thereby stakeholder constellations.

4. Results

The following constraints were identified and summarized in the following as shown in Table 1 [11].

Table 1: Energy master planning framing constraints [11]

Natural Constraints		*Imposed Constraints*				
Constraint Category	**Constraint***	**Constraint Category**		**Constraint***	**Constraint Category**	**Constraint***
1. Locational Threats	Regional or local air quality	***3. Energy & Water Distribution & Storage Systems***		Natural Gas	***5. Indoor Environ-ment***	Space temperature
	Low-lying area (flooding)			Electricity		Humidity[1]
	Extreme temperatures			Fuel Oil		Illumination levels
	Extreme humidities			Chilled water		Radon
	High winds			Hot water/steam		Ventilation
	Fire			Water		
	Lightning					
	Ground threats (volcano, mud,sinkhole,earthquake)	***4. Building and Facility***	*4a. Energy Use*	Energy use (site)	***6. Equipment in Buildings and District Systems***	Space heating
				Energy use (primary)		Space cooling
2. Locational Resources	Solar insolation			Energy efficiency		Ventilation
	Wind		*4b. Environmental*	Renewables		Humidity control
	Biomass			Emissions		Water heating
	Land area		*4c. Opera-tional*	Resilience		Food preparation
	Roof area			Financial/Cost		Waste handling
	Natural Gas			Maintenance limits		Control systems
	Electricity			(e.g., simple, low cost)		Electric generation
	Liquid fuels (oil, LPG, etc.)			Work force limitations		District steam
	Chilled water			Critical facility		District hot water
	Hot water/steam			Other planner/building		District chilled water
	Water			owner limiting factor		

* Constraint that could limit technology selection

4.1. List of constraints

As shown in Table 1, the constraints can be divided into the following five categories:

- Natural Locational Constraints – Resources and threats
- Distribution System & Storage Constraints
- Building and Facility Constraints
- Indoor Environment Constraints
- Building Equipment and District System Constraints

These constraints are specified in the following sections.

4.1.1. Natural Locational Constraints – Resources and threats.

Threats such a flooding, high winds, lightning, storms, and earthquakes typically influence the way a technology is installed (e.g., hardened), and not the down selection of technology options. Some locational threats do have the potential to affect technology selection and should, therefore, be evaluated to narrow solution options. Local air quality conditions and their limits may eliminate the use of combustion-based heating or power generation systems especially in more urban areas. Other examples are extreme cold temperatures which can eliminate the use of air-to-air heat pumps and areas with significant humidity which can constrain or eliminate evaporative-type cooling systems.

4.1.2. Distribution System & Storage Constraints.
Limitations in existing distribution and energy storage systems will certainly influence technology selection. Electric feeders, and local transformers and conductors limit the capacity to distribute electricity. And there may be limitations on connecting renewable energy sources to existing distribution lines. Local gas lines, if they exist, have fixed sizes and distribution pressures that limit the amount of gas that can be distributed. And on-site fuel storage systems have limited capacities.

4.1.3. Building and Facility Constraints.
A common building level constraint is an energy use limit. More common in EU countries, these limits are usually based on a maximum energy use per unit of floor area (energy use intensity or EUI) by building type. While robust energy use targets have been recently developed for climate zones in the U.S., they have not been adopted on a significant scale to date in local energy codes to turn them into constraints. Generally, energy use limits push you to select more efficient versions of a technology and do not eliminate technologies. But if the limit is based on building site energy use, an energy use limit can much more profoundly affect technology selection.

4.1.4. Indoor Environment Constraints.
Indoor environment constraints mainly address the thermal comfort of building occupants from the aspect of personal needs. It aims at providing more comfortable indoor conditions to improve health benefits and work productivity. Indoor environment is a complex concept and involves a variety of factors that can influence environmental quality and energy use. Based on the national conditions, each country sets its own requirement and constraints on the indoor temperature, humidity, lighting illumination levels, radon and ventilation. Thereby, energy use can vary due to the different demand.

4.1.5. Building Equipment and District System Constraints.
Most existing limits for building equipment and district system constraints are minimum equipment efficiencies by system type. Minimum equipment efficiencies exist to ensure that efficient equipment is installed and by themselves, do not eliminate competing technologies. Equipment efficiency when combined with fuel cost, emissions, or other factor considerations may eliminate a technology but generally not equipment efficiency alone.

4.2. List of stakeholders.
For the analysis it was chosen to identify the stakeholders in EMP for each level of constraints.

Local stakeholders are interested in natural locational constraints, but also planners who relate their design on locational constrains as climate data on wind access, solar radiation, air temperature distribution and time series, water temperatures (and wind temperatures).

The distribution system & storage constraints are mostly important for local maintenance staff and facility managers, but larger thermal storages could be visible and important for inhabitants as well. Also, the level of noise of the distribution system could impose interest to inhabitants and users of the neighborhood.

When it comes to the building and facility, there are planners and architects involved. The end users or inhabitants play a limited role as they are often unknown and therefore categorized (according to building typology and use of the facility). Here, building codes have the role to define minimum requirements that shall ensure a comfortable use of the building. Even more so in the next set of constraints which is in particular concerned with the indoor environment. Again, minimum requirements are established through building codes and standards. The building owner can decide on the level of indoor comfort, typically choosing between different levels/classifications (low, medium, high).

When it comes to the equipment in buildings and district systems the technical functionality is defined in building codes and related standards. Planners and architects have the expertise to define them. However, some technologies can be chosen by the building owner or investor, e.g. if the building shall have a certain heating technology (underfloor heating) or specific façade technology (double-skin façade).

Table 2: Constraints and stakeholders

Constraints	Stakeholders	Comments
Locational threats	planners, architects, engineers, private investors, private companies and corporations, lawyers, scientists, inhabitants	Conflicting priorities, Uncertainties on effectiveness.
Locational resources	inhabitants, planners, architects, engineers, private investors, private companies and corporations, lawyers, scientists, Inhabitants	Rethink buildings, Rethink spaces between buildings, meeting spaces, public spaces; physical data is often not available (e.g. wind on-site and around the building), hindered by privacy and/or measurability issues.
Energy and water, distribution and storage system	inhabitants, planners, architects, engineers, private investors, private companies and corporations, lawyers, scientists Inhabitants	Need to adapt organization and procedures, Purpose unclear, Need to adapt legal constraints, Need to adapt policy.
Building and facility	inhabitants, Owners, planners, public authorities, municipalities, Inhabitants	Need to adapt organization and procedures, Need to adapt legal constraints, Need to adapt policy.
Indoor environment	planners, architects, engineers, private investors, private companies and corporations, lawyers, scientists, Inhabitants	Rethink requirements of buildings, specific use, flexibility, physical data is often not available, hindered by privacy and/or measurability issues, Need to adapt organization and procedures, Need to adapt legal constraints, Need to adapt policy.
Equipment in buildings and district systems	planners, architects, engineers, private investors, private companies and corporations, lawyers, scientists, Inhabitants	Rethink buildings, physical data is often not available, hindered by privacy and/or measurability issues, Need to adapt organization and procedures, Need to adapt legal constraints, Need to adapt policy.

It is worth noting that the constraint categories listed in Table 2 can be divided into subcategories which sometimes involves different stakeholders. As an example, Table 3 summarizes the imposed constraints of buildings and facilities and lists the stakeholders involved.

5. Discussion

The stakeholders involved can be framed into different categories, like private and public, professional and administrative. We propose a classification in the following categories based on the analysis of stakeholders involved:

- Professionals (planners, architects, engineers, private investors, private companies and corporations, lawyers, scientists),
- Administrative (public authority, planning department, environmental department, health department, municipality employees, public investors, public transport, energy providers),
- Political (governmental, policy maker, mayors).

Table 3: Imposed constraints (building and facility)

Constraint	Stakeholders	Comments
Energy use (site)	Landowners, planners, public authorities, municipalities	Different stakeholders will value sustainability criteria differently depending on their objective. Different stakeholder perspectives may result in an unclear nature of the problem.
Energy use (primary)	Landowners, planners, public authorities, planning agency, municipalities	Different stakeholders will value sustainability criteria differently depending on their objective. Different stakeholder perspectives may result in an unclear nature of the problem.
Energy efficiency	Landowners, planners, public authorities, municipalities	Ambiguity in purpose and values. Different stakeholder perspectives may result in an unclear nature of the problem.
Renewable Energy Supply	landowners, planners, public authorities, municipalities	Ambiguity in purpose and values. Different stakeholder perspectives may result in an unclear nature of the problem.
Emissions	landowners, planners, public authorities, municipalities	Different stakeholders will value sustainability criteria differently depending on their objective. Different stakeholder perspectives may result in an unclear nature of the problem.
Resilience	landowners, planners, public authorities, municipalities	Ambiguity in purpose and values, may lead to conflicting objectives.
Financial/cost	landowners, planners, public authorities, facility manager, municipalities	Ambiguity in purpose and values, may lead to conflicting objectives.
Maintenance limits	Landowners, planners, facility managers, public authorities, municipalities	Different stakeholder perspectives may result in an unclear nature of the problem.
Work force limitations	landowners, builder, facility manager	Are these as key performance indicators introduced.
Critical facility	landowners, planners, public authorities, municipalities	Different stakeholder perspectives may result in an unclear nature of the problem, ambiguity in purpose leads to a lack of clarity about successful outcomes. This may lead to conflicting objectives.
Other limiting factors	landowners, planners, builder, public authorities, municipalities, politicians	Unclear policy responsibilities and ambiguous values to address climate change.

When it comes to energy master planning, there are different levels for appliance within an urban context: starting from the city level, followed by the neighborhood and then the district. At the end is the group of buildings with their building regulations.

Low solar insolation, wind, biomass, and space resources can quickly eliminate many renewable technologies from consideration. If certain fuels are not available or limited, some fuel-fired technologies may get eliminated and this may be even more pronounced if there is a dual-fuel capability desired for resilience. If we want to reach climate gas reduction goals, we need to make use of the potential at all levels. Therefore, it is important to analyze the potential reduction goals as also Fox pointed out [16]. These should be discussed ideally on different levels with the relevant stakeholders in different constellations. A stakeholder forum would encourage a top-down approach, however in some cases a bottom-up approach seems more promising which was also discussed by Jank [13]. There is an intrinsic problem that different stakeholder perspectives may result in an unclear nature of the problem since stakeholders at different levels view the problem differently. Architects and planners must rethink buildings and spaces; public authorities need to adapt organization and procedures; lawyers need to adapt legal and policy adaptation, etc. This can cause a lack of a unique problem statement and the choice of inadequate solutions for emission reduction.

However, various valid objectives possibly conflicting on short to medium terms require prioritizing (carbon-free cities; cheap affordable energy for all; regional energy self-sufficiency; job promoting energy system; fully renewable energy sources; etc.). This problem is intensified by the dynamic nature of energy planning parameters (energy price fluctuation; evolving new technologies; population growth; high urbanization rates; changing political actors and agendas; etc.).

The quality of physical data is often not available, hindered by privacy and/or measurability issues. This aspect is enhanced by a vast set of technology options, uncertainties on effectiveness and constantly evolving new solutions at different technological readiness level.

Ambiguity in purpose leads to a lack of clarity about successful outcomes which was e.g. discussed by Jank in more detail [13]. This may lead to conflicting objectives. On the other hand, ambiguity in values prevents the clear assessment of outcomes. Different stakeholders will value sustainability criteria differently depending on their objective (societal benefits of clean energy opposed to the need for low investment costs, the "landlord- tenant" dilemma; top-down planning or bottom-up collaborative planning; etc.). Therefore, it is eminently important that key performance indicators are introduced, and their weighted values are agreed upon in the beginning of the process as also Haase and Lohse concluded [20].

Identified framing constraints should be evaluated as either hard or soft [20]. If not, constraints that can be overcome may be missed and promising technologies stripped out of a final EMP solution.

To maintain consistent quality in the EMP process, it is recommended that the identification of framing constraints and their limits, and perhaps their evaluation, be standardized (perhaps starting in checklist form). If identifying constraints and applying their limits were standardized, the results here could perhaps help establish a baseline that can be used by others, built upon experiences, and improve to establish a standardized process.

From the political level we find often unclear policy responsibilities and ambiguous values to address climate change as well as disagreement on societal effectiveness of climate change policy. With growing complexity of urban problems, a range of urban actors replace linear approaches with iterative, global and spatial ones as also Cajot et al. (2015] discussed [21]. This is enhanced on the administrative level with ill-defined responsibilities budgets and implementation procedures, no established standardized way on the definition, the monitoring and reporting of key performance indicators. On top of it, governments need to reach sustainability targets and safeguard public interest while energy providers need to make benefit and individuals need to reduce expenses.

6. Conclusions

The energy master planning on neighborhood and district level is confronted with constraints from higher and lower level. A city consists of several districts or neighborhoods which have to have a consistent energy plan within the municipal EMP. This strategic level from urban planning as well as natural constraints are limiting options from the top, while a number of imposed constraints limit technology selection from the bottom. This understanding should be taken into consideration when EMP is conducted. Stakeholders involved play a crucial role when it comes to EMP and implementation. The main barriers identified play a strong impact on EMP and are all influential by the stakeholders involved. However, due to the complexity of urban planning and energy master planning there remain some issues. These issues point to a wicked problem which needs to be solved. The main issue is linked to how to involve different stakeholders in the EMP process in a best way. Which tools are needed to facilitate the stakeholder involvements? How to communicate and visualize analysis results in the decision-making group?

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References

[1] EED - Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, Energy Efficiency Directive, https://ec.europa.eu/energy/en/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive, access data: 04.12.2019
[2] EPBD. 2018. Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENGASHRAE Std. 90.1-2016. Energy Standard for Buildings Except Low-Rise Residential Buildings, https://www.ashrae.org/technical-resources/bookstore/standard-90-1, access data: 04.12.2019
[3] U.S. DOE 2013. Guide to Community Energy Strategic Planning, https://www.energy.gov/eere/slsc/guide- community-energy-strategic-planning
[4] Huang, Zishuo & Yu, Hang & Peng, Zhenwei & Zhao, Mei, 2015. "Methods and tools for community energy planning: A review," Renewable and Sustainable Energy Reviews, Elsevier, vol. 42(C), pages 1335-1348.
[5] NZP Tool. Net Zero Planner, https://www.rti.org/impact/net-zero-planner-integrated-modeling-tool, access data: 04.12.2019
[6] EnergyPlan. Energy systems simulation tool. https://www.energyplan.eu/, access data: 04.12.2019
[7] CASBEE. Comprehensive Assessment System for Built Environment Efficiency, http://www.ibec.or.jp/CASBEE/english/
[8] BREEAM, Building Research Establishment Environmental Assessment Method, https://www.breeam.com/, access data: 04.12.2019
[9] LEED, Leadership in Energy and Environmental Design, http://leed.usgbc.org/leed.html, access data: 04.12.2019
[10] Schiefelbein et al. 2017. Implementation of energy strategies in communities – Results within the context of IEA annex 63, 30th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, ECOS 2017 - San Diego, CA, United States.
[11] Sharp, T., Haase, M. et al. Energy Master Planning: Identifying Framing Constraints That Scope Your Technology Options, accepted for publication *ASHRAE Transactions*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (to be presented at ASHRAE winter conference, Orlando, U.S., February 1-5 2020).
[12] NASEO 2018. National Association of State Energy Officials, https://www.naseo.org/, access data: 04.12.2019
[13] Jank, R. (2017) Annex 51: Case studies and guidelines for energy efficientcommunities. Energy and Buildings 154: 529–537.
[14] Strømann-Andersen, J. B. 2012. Integrated Energy Design in Master Planning. Kgs. Lyngby: Technical University of Denmark. Byg Rapport, No. R-254.
[15] Fox, K. 2016. Energy Master Planning Perspectives and Best Practices, presentation to the Federal Utility Partnership Working Group, May 2016, Cincinnati, OH.
[16] Zhivov et al. 2014. Energy Master Planning Towards Net-Zero Energy Communities/Campuses, *ASHRAE Transactions*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
[17] 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.
[18] Zhivov et al. 2017. Technologies Integration to Achieve Resilient, Low-Energy Military Installations. Proposal No. EW18-5281 to the U.S. Department of Defense Environmental Security Technology Certification Program.
[19] IEA EBC Annex 73. Towards Net Zero Energy Public Communities, http://annex73.iea-ebc.org/
[20] Haase, M. and Lohse, R., Process of Energy Master Planning of Resilient Communities for comfort and energy solutions in districts, IOP Conference Series: Earth and Environmental Science, Volume 352, Number 1, IOP Publishing Ltd, https://iopscience.iop.org/article/10.1088/1755-1315/352/1/012019
[21] Cajot, S., Peter, M., Bahu, J.-M., Koch, A., Maréchal, F., Energy planning in the urban context: challenges and perspectives, Energy Procedia 78 (2015) 3366 – 3371.