# Optimization of energy planning strategies in municipalities

## Are community energy profiles the key to a higher implementation rate of renewable energies?

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# Optimization of energy planning strategies in municipalities: Are community energy profiles the key to a higher implementation rate of renewable energies?

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## Summary

The paper evaluates the current status of community energy planning in northern Europe via a review of literature, practice and the performance of a barrier analysis for successful community energy planning. Main findings of the paper are that current community energy planning lacks a systematic approach, suffers from insufficient information, tools and resources. Municipalities are often unable to take on a steering role in community energy planning. To overcome these barriers and guide municipalities in the pre-project phase, a decision-support methodology, based on community energy profiles (CEP), is presented. The methodology was applied in a case study in Germany. With CEPs, a possibility to merge qualitative data from local settings into generic energy modelling is shown, which could contribute to improved community energy strategies.

**Keywords:** Community energy planning, infrastructure and energy concepts, implementation of renewable energies, community energy profiles

## 1. Introduction

Energy - its efficient use and its CO2 neutral provision - will become a major task for urban development. Communites will be a main field of action to transform cities into sustainable spatial structures, because many technical synergies can be realized, promising scale effects be reached, and decision makers be mobilized to act in their common interest. With urban planning largely being carried out at community scale, municipalities should facilitate this transition and link urban and energy planning. Community energy planning can be an important strategy to reach this target; the current paper sets out to ascertain how this could be achieved, which barriers for successful community energy planning do exist and how these could be bypassed.

## 2. Methodology

In the first research phase, based on grounded theory, a review of community energy planning literature and 10 Community Energy Concepts (CEC) was executed. The assessment of the state of community energy planning enabled a barrier analysis for successfull community energy planning, which lead to the development of a decision-support methodology. The second phase tested the methodology on a case study: the author developed a CEC to supply a community solely with renewable energies and suggested a planning methodology based on the outlined decision-support methodology. Following, the author, as an external consultant, accompanied the process from generation of the technical energy concept until the final decision about the implementation of the energy strategy. The data was collected via active participant observation.

## 3. Results and Conclusion

Two major mismatches have been identified. First, CECs and the available literature are too technical and rarely consider qualitative factors that are crucial for implementation of energy strategies. Thus, there is a general gap between literature, CECs and implementation. Second, municipalities lack knowledge on energy planning and ensuing a guideline on choosing adequate planning procedures to implement technical concepts. As a reaction to the found barriers, a decision-support methodology is introduced that should help the municipalities in the pre-project phase to:

**Step 1:** Identify possible community energy technology strategies and assess their suitability
**Step 2:** Connect technical strategies with qualitative information on the community, allowing the choice of adequate planning procedures to implement the suggested energy strategies

The basic function of the methodology can be described as a rough energy strategy feasibility analysis, with an addition of soft factors to find the technology bundle that is most likely to be implemented and advice about possible planning strategies to achieve this. In ***Step 1*** the energy demand and energy potential for the community is estimated via building archetypes, followed by the finding of adequate technology bundles to match energy demand and supply. In ***Step 2*** an analysis of soft factors that are characteristic for the community is conducted. Different energy related dimensions relevant for communities – such as stakeholders, materiality, budget, technology, environment or legal framework – get summarized in community energy profiles (CEP) that identify tasks and barriers for the implementation of the specific community. A CEP can be related to a library of CEPs from successful community energy developments. Thus, suggestions for successful energy planning methodologies can be transferred from communities that faced similar challenges in the past. The advantage with CEPs lies in the comparison of patterns instead of a comparison of unique local settings. Hence, the meta information of case studies gets accessible.

The application of the decision-support methodology in the case study lead to feasible options, systematic data on energy demand and knowledge about planning procedures, which resulted in the establishment of a successful self-sustaining community energy planning process. Thus, CEPs can in this case contribute to a better implementation of energy strategies. Still, the CEP methodology needs to be improved into a semi-automatic community energy planning tool.

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## Summary

Energy-efficiency and CO2 neutral energy provision will be a central task for urban development in the coming decades. Despite promising efforts to approach this at community scale, the implementation of renewable energies is still too slow to meet global GHG reduction goals. The paper evaluates the current status of community energy planning via a review of literature and practice. Main findings of the paper are that current community energy planning lacks a systematic approach, suffers from insufficient information, tools and resources. Thus, municipalities are often unable to take on a steering role in community energy planning. To overcome these barriers and guide municipalities in the pre-project phase a decision-support methodology, based on community energy profiles, is presented. The first application of the methodology enabled the municipality Elmshorn to build-up a cost-efficient and carbon neutral district heating grid. The case of Elmshorn shows the capacity as well as the potential for optimization of the methodology, which makes further development of the methodology into a semi-automatic tool necessary. The introduced tool could enable municipalities to take a more active role in community energy planning.

**Keywords:** Community energy planning, infrastructure and energy concepts, implementation of renewable energies, community energy profiles

## 1. Introduction

One of the biggest challenges in the coming decades for our society will be to transform cities into sustainable and resource-efficient spatial structures. About 40% of final energy consumption happens in buildings and up to 80% of this takes place in urban agglomerations [1]. Construction technologies enable the development of low-energy buildings. But the sole consideration of new buildings isn't sufficient. The integration of old and new buildings into interconnected systems, supplied by renewable energies, becomes a key task. This task has to be approached at community scale – rather than at the building or the city scale – which has advantages, and seems almost like a necessity. It is at the community scale that many technical synergies can be realized, promising scale effects be reached, and decision makers be mobilized to act in their common interest [2]. The implementation of energy strategies should be a task for municipalities and urban planning [3]. But implementation rates of renewable energy systems are currently unsufficient to meet global energy strategy goals [4]. Frontrunner projects rarely get multiplied [5]. The reasons are barriers among the knowledge on technologies and the urban planning practice [2]. Energy strategies at municipal level are too general and technocratic to be implemented on a community scale and qualitative factors are not sufficiently considered [6]. Community energy planning, driven by municipalities, can be divided into four phases: Preparation and orientation; model design and analysis; prioritization of measures and decision; and at last implementation and monitoring of the specific measures [7]. While there is many of tools for the technical last three phases, there are just a few tools for the first phase [8], which is about identification of tasks, preparation and settings goals for CECs; it is crucial for the whole process, because it defines the procedure and technological path [9]. Municipalities are able to reach national energy policy goals, scaled to a local level, if they have sufficient planning tools, guidance, and a systematic approach [5][10].

The aim of the study is to contribute to a systematic approach for energy planning at community scale with the introduction of a decision-support tool for the first planning phase. The results are both theoretical and applied in practice. To achieve this, the current status of community energy planning in north-western Europe was assessed, via a literature study and the review of Community Energy Concepts (CEC) to apprehend the common practice. Based on the found deficits in literature and practice – lack of systematic approach, insufficient information and resources in municipalities and unsuitable energy planning tools – a decision support methodology was developed. The basic approach is to add qualitative information to quantitative energy simulations: To account the fact, that every community has different local settings, Community Energy Profiles (CEP) were developed that express qualitative factors that have to be considered in relation to energy planning in this area. CEPs can map the different challenges for energy planning, such as stakeholder interests or buildings with heritage value and in this way supply the municipality with additional qualitative information on energy strategies. This enables municipalities, in combination with quantitative energy simulation tools, to develop tailor-made energy strategies, which have a higher chance of implementation.

The decision-support methodology got applied on a case study to test the CEP, which confirmed main findings from the literature review and assessment of CECs. Further, the CEPs helped the municipality to find a feasible energy strategy and initiate a comprehensive energy planning process. The methodology needs to be extended with an attached semi-automatic energy simulation tool. The first application of the methodology indicates the high significance of the study, because the municipality tried for several years to initiate an energy planning process for the community development project, but simply lacked an overview of the local energy potential, energy demand and knowledge on adequate planning strategies. Further, the addition of qualitative data via CEPs to quantitative and theoretical energy simulation is a new approach and might help to bridge the gap between energy strategies and the actual energy strategy implementation rate.

The remainder of this paper is structured as follows: After the methodology section, the paper is divided in two parts: Chapter 3 summarizes theoretical results, containing the analysis of literature, practice of CECs and a barrier analysis for successful community energy planning. Conclusive, the decision-support methodology based on CEPs is introduced in 3.4. The methodology got applied in practice, in a case study, which is described in chapter 4. Finally, the results and impacts of the application of the methodology are discussed in Chapter 5., which is supplemented with suggestions for future research on CEP, to develop the CEP-methodology into a planning tool.

## 2. Methodology

The study started in 2013 as master thesis project and continued after submission until 2015. The research process is divided into two phases: theoretical research based on grounded theory and application of the developed methodology in a case study, after the concept of action research. In **the first phase,** a review of community energy planning literature (3.1) and several CECs in north-western Europe were conducted (3.2). The publications were classified by spatial level, author and relevance for municipalities. This paper only contains a summary of main findings and most relevant publications – a detailed analysis can be found in [2]. The purpose of analyzing CECs was to assess common practice of community energy planning to contrast theoretical literature. The findings are the basis of a barrier analysis of successful community energy planning.

To avoid bias in the sample of CECs, well-known and random projects were selected to depict a wide spectrum of cases. Tasks, planning procedures and driving stakeholders were analyzed, to enable the development of narratives for each case as well as a a cross-case comparison [11]. The cases were assessed using a combination of qualitative research methods; mainly document study, but also interviews and observations. Publicly available strategic documents were gathered and recorded in a database for each project. The data was supplemented with further documents from non-municipal institutions, interviews and observations. The constant comparison between the cases, based on grounded theory proceeding [12], allowed the identification of patterns, which were assigned to categories that are related to technical, economic and organizational aspects of community energy planning. For each case weaknesses, strengths, barriers and opportunities to bypass these were tagged and summerized in memos, containing the case key information. The concluding barrier analysis of the current state of the art of community energy planning in theory and practice (see 3.3), set the frame for the outlined decision-support methodology that should facilitate to a more successful community energy planning by municipalities (see 3.4).

**The second phase** is founded on the previously conducted theoretical research. In an action research phase [13], the outlined decision-support methodology was tested on a brownfield development project. The author suggested a planning methodology, based on the outlined decision-support methodology, to the municipality and developed a CEC to supply the community solely with renewable energies. As external consultant, the author accompanied the process from generation of the technical energy concept until the decision about the implementation of the energy strategy from spring 2014 until autumn 2015. Data was collected with the method of active participant observation [14], which enabled the researcher to gain an in-depth understanding of the barriers within the case study, about stakeholder behavior, and the planning process until the final decision about the technical concept. At the same time, the municipality had access to expert knowledge and new planning methods that they were not aware of previously. Ultimatley, the assessment of the case study allowed the evaluation of the first time use of the decision-support methodology to identify need for optimization and further research.

## 3. Part I: Theory based results

### 3.1 Literature findings

The scientific discussion and energy planning practice has changed from pure building assessment and modelling to a wider scale, looking at communities and the interaction between city, building, energy systems and users. Still, community energy planning is a rather new approach [14]. Hence, little literature for municipalities got published. Available publications focus mainly on techno-economic concepts and only to a lesser extent on planning procedures. The same applies for energy planning tools, ranging from Excel spread sheets developed and used by municipal staff or private sector practitioners to complex urban energy system models developed and used by academic institutions. There are a lot of tools available for the more technical and detailed later phases in energy planning, but only a few for the initial phase of preparation of decisions [16]. Municipalities compiling CECs have to hire consultants or collect information from various sources.

There are 3 main studies summing up information on community energy planning, targeting at the development of tools for municipalities to link urban and energy planning to proactively plan energy-efficient communities. Case studies and other examples from the En:EffStadt program are published in [2] and give a overview about methods for community energy planning. With material from the IEA EBC Annex 51, a multi-lingual manual on energy planning got introduced, which is going further into detail and contains an energy concept advisor based on case studies [17]. The UrbanReNet project has a rather technical approach, by combining energy demand and potential of communities into community archetypes [18]; besides examples of application of the archetypes, the development of a planning tool was announced.

The 3 approaches are based on morphologic energy modelling [19], thus, they only serve as orientation for municipalities and can't replace detailed calculations with actual building data.But they are currently the only ones combining technical, legal, administrative and procedural aspects of community energy planning. Still, these guidelines are too complicated for municipalities; they only adress on how to develop a CEC, but not the implementation, which leaves them incomplete.

### 3.2. Findings from the community energy planning practice

The different methodological approaches of the 10 CECs can be divided into two categories (see Table 1 for an overview – full descriptions in [2]): Calculation of energy demand and potential in a community based on building aggregation (bottom-up) or community typologies (top-down). While the top-down approach is more userfriendly and faster (e.g D,H,I), the bottom-up approach allows the integration of actual measurements and is more detailed (e.g. A,B,E,F). Few concepts use measured data; most are based on assumptions, which can be critical for financing renovation projects if the actual energy consumption is overestimated because of prebound effects [19]. Content-related differences between energy concepts occur from the type: For new communities', municipalities generally have a direct influence on energy use via building regulations or land-use planning, which allow particular statements on building sizes, uses, the energy demand and timeframe for implementation. These concepts are rather simple, because of the generally low energy demand that only needs to be matched with a cost-efficient energy supply system. Still, a lot of the possibilities stay unutilized, thus suboptimal solutions with a lower share of renewable energies than achievable were suggested for implementation. Reasons are a lack of technical knowledge in municipalities, opposition from developers and the tendency to see energy planning as an add-on, which is done by utilities or has a lower priority and targets can in a later stage be loosened (e.g. C,F) . If the focus was on energy, it seems that other areas like urban design or user needs got neglected (e.g. D,G).

Table 1: Overview of analyzed Community Energy Concepts

| # | Municipality | Community project | Type of community | Number of apartments | Year |
|---|---|---|---|---|---|
| A | Malmö / SWE | Ekostaden Augustenborg | Renovation | 1.800 | 1998 – 2007 |
| B | Egedal / DK | Stenløse-Syd | New | 800 | 2004 – 2009 |
| C | København / DK | Nordhavn | New | 3.000 | 2011 – 2025 |
| D | Meppel / NL | Nieuwveense Landen | New | 2.100 | 2010 – 2035 |
| E | Hamburg / GER | Bergedorf-Süd | Renovation | 380 | 2013 – 2050 |
| F | Hamburg / GER | Wilhelmsburg-Mitte | New | 150 | 2007 – 2013 |
| G | Heidelberg / GER | Bahnstadt | New | 2.500 | 2008 – 2022 |
| H | Belm / GER | EGQ Belm | Renovation | 140 | 2011 – 2030 |
| I | Marburg / GER | Biegenviertel / Nordstadt | Renovation | 750 | 2011 – 2030 |
| J | Karlsruhe / GER | Karlsruhe-Rintheim | Renovation | 700 | 2008 – 2014 |

The analyzed CECs for existing communities were more complex: The determination of the energy demand was, except for the Scandinavian case, a major task and dealing with the replacement of existing infrastructure was for all concepts an economical challenge. The main issues remain stakeholders, which have to be convinced to adapt their individual actions towards a cooperative community target. The implementation of the energy strategies for existing communities is pending on stakeholder involvement, which is in all analyzed CECs a weak spot: The strategies stay vague, fragmented and short-sighted. Frequently, CECs stay techno-economic (e.g. E,H) and contain only drafted implementation strategies, which makes a realization questionable.

### 3.3. Barriers for a successful municipality driven community energy planning

Literature on community energy planning can be divided into two types: technically scientific publications, focused on specific problems in modelling or energy simulation and guidebooks or manuals that are based on experiences from practice. While the former are more theoretical and require a technical in-depth knowledge, the latter sum up and generalize energy technologies for supply and demand in relation to energy-efficient communities, enriched with results from previous CECs.

Despite finding similar patterns in the structure of all analysed CECs, the actual proceeding, suggested technologies and implementation strategies – if existing – seemed randomly chosen. The selection of technologies and planning methodology in the concepts is unsystematic, which can partly be explained by the missing literature. Further, all concepts were created by external consultants, leaving the crucial role of the facilitator to coordinate stakeholders and steer the extensive process to the municipality. Limited knowledge on energy at the planning entities often resulted in lower energy efficiency achievements, than technically possible and an overall decreased implementation rate; no concept got fully realized. Thus, two major mismatches were identified:

- CECs and the available literature are too technical and rarely consider qualitative factors that are crucial for implementation of energy strategies. Thus, there is a gap between literature, CECs and actual implementation
- Municipalities lack knowledge on energy planning and ensuing a guideline on choosing adequate planning procedures to implement technical concepts

### 3.4. Decision-support methodology with "Community Energy Profiles"

As a reaction to the found barriers, a decision-support methodology is introduced in order to help the municipalities in the pre-project phase to:

**Step1:** Identify possible community energy technology strategies and assess their impact on the energy performance of the community

**Step 2:** Connect the technical strategies with qualitative information of the community, allowing the choice of adequate planning procedures to implement suggested energy strategies.

If municipalities have a perception of which energy solutions are feasible in an early stage of a project, they are able to act pro-active and make decisions about a general planning proceeding. This has advantages, such as a more target-orientated way of working, exploration of all potentials in an early project stage leading to lower costs, robust solutions and the attainment of co-benefits, which is advantageous for contacting local stakeholders. This is in particular for community renovation projects of high value if municipalities can offer fitting standard energy solutions in the beginning of the dialogue with house owners. The function of the methodology can be described as a rough energy

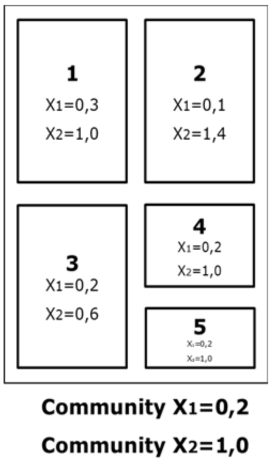


Fig. 1: Step1: Community built by 5 units with current energy production ($x_1$) and energy potential ($x_2$)

strategy feasibility analysis with an addition of soft factors to find the technology bundle that is most likely to be implemented and advice about possible planning strategies to achieve this.

**'Step 1'** of the methodology is to identify the current and future energy demand and energy potential from local renewable energy sources and find possible scenarios on how to match these. Every spatial unit within a community has three defining values: the energy demand; energy potential accessible via different technologies; and current use of the existing energy potential to meet the demand. If these three values interrelate into one value, the energy performance of a community gets measureable and comparable. The value is relative, because it originates from the current local situation and the local potential. Thus, if a municipality is assessing a community, it can measure to which extent the community or single units within the community can be supplied with renewable energy and how far the development is enroute to the target. Because of the lack of data in the pre-project phase, it is necessary to work with assumptions. For the energy demand, the use of building archetypes [22],[23] or urban block archetypes [18],[24] are necessary. The chosen approach is depending on the community size. For the energy potential it is possible to make assumptions for each energy technology based on values in relation to the area taken from various literature sources or from archetypes [18]. The most user-friendly way would be to use archetypes as a preset, which gets applied on each community energy demand and energy potential. The aim of 'Step 1' is to balance energy demand and supply from local, renewable sources and develop energy technology scenarios on how the community can be supplied with energy. A suggestion of three techno-economic most feasible solutions can be computed with the tool to show the municipality which basic options are available.

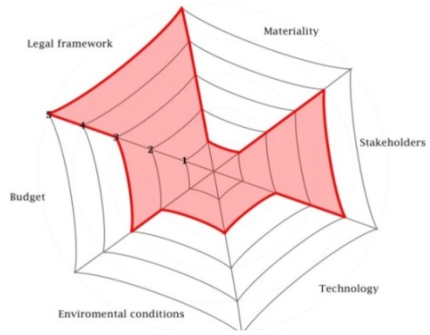

Fig. 2: CEP with challenges in legal framework and stakeholder involvment

**'Step 2'** of the methodology adds qualitative data to the quantitative energy technology scenarios. Community Energy Profiles should describe the complexity of different dimensions for each community. Through the division of community in different energy related dimensions – e.g. issues in the field of legal framework, technology, materiality, budget, stakeholders and environmental conditions – the complexity of communities can be broken down into different challenges (see figure 3). Through ascription of numeric values, detected for each dimension by 5 questions to be answered by the planner, districts get comparable via their challenges. This allows a comparison with earlier CECs. Hence, the meta information of case studies, the CEP that dictated the chosen planning strategy can be linked to the actual community. Thus, suggestions for successful energy planning methodologies can be transferred from communities that faced similar challenges in the past. The advantage with CEPs lies in the comparison of patterns instead of a comparison of unique local settings.

In this way municipalities get supplied with additional information, which enriches the energy technology scenarios and allows finding the main implementation barriers for each scenario. In case the energy scenarios from 'Step 1" are technically similar, the addition of a CEP shows which of these scenarios have a higher feasibility of implementation, determinated by the local setting in the community. With a library of CEPs from

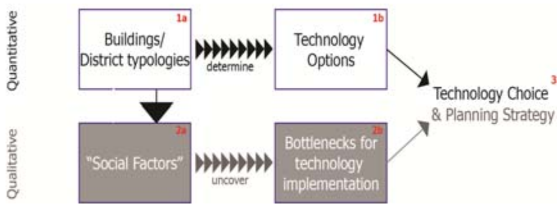

Fig. 3: Function of decision-support methodology

case studies, it is possible to suggest planning procedures to the municipality that have been successful in communities with similar CEPs, thus, with similar challenges and tasks. The knowledge about feasible technology strategies for their communities, the main barriers for implementation and an advice about possible planning methodologies can make the decision-support methodology into a valuable communication tool for municipalities to initiate community energy planning. The advantage of the methodology is that 'Step 2', the CEPs can stand alone and the energy strategy feasibility analysis can be performed by more advanced energy modelling tools, thus CEPs can still be used in a later project stage. Also it is possible to rescale municipal energy strategies with 'Step 1' to community level, which enables a continuos assessment of policy implementation.

# 4. Part II: Application results of methodology use in a case study

The in 3.4 introduced decision support methodology got applied in the municipality of Elmshorn for the first time. A more detailed description of the technical concept, cost-efficiency and feasibility can be found in [21].

### 4.1 Investigated area

The community "Krückau-Vormstegen", an 18.5 ha redevelopment area in the inner city of Elmshorn, is distinguished by a mix of abandoned industrial buildings, brownfields and occasional residential buildings. The municipality decided to redevelop Krückau-Vormstegen into a mixed use community as an extension of the inner-city. While some of the old industrial buildings with heritage value and the existing residential buildings, with approximately 210 apartments, should be kept; an additional 550 new apartments and around 60.000 sq. m. commercial and public buildings are expected to be realized until 2030. The typology is ranging from semi-detached houses up to huge warehouses. Neighboring, partly divided by streets, are several multi-story apartment buildings and two industrial sites. Further surroundings are small to medium sized commercial establishments and a train station.

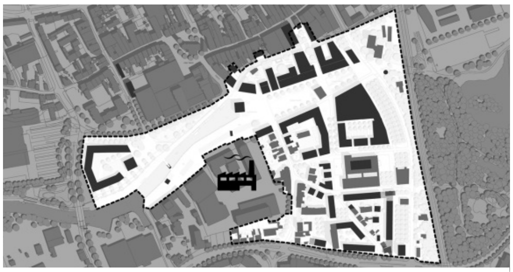

Fig. 4: Investigated area (light coloured) with old building stock (grey), new developments (black) and waste heat sources (icon).

### 4.2 'Step 1': Technical consideration of energy demand, potential and energy strategies

Due to the new buildings and the bad condition of the old building stock, the future heating energy demand will change distinctly. After estimating the demand of the old building stock, energy renovation assumptions for all 35 old buildings were made, resulting in a heating energy saving potential of 51%; resulting in a total heating energy demand for the renovated buildings of 3.2 GWh/a. For the new buildings the heating energy demand ranges between 1.02 GWh/a (passive house standard) and 2.49 GWh/a (according to estimated building regulation energy standard). Together with the renovated building stock the communities overall heating energy demand ranges between 4.29 - 5.75 GWh/a. The overall electricity (EL) demand is estimated with 3.98 GWh/a.

The lack of reliable general key figures for local renewable energy potentials in relation to urban design made an individual consideration of all energy technologies for the local setting necessary. This was done by assessing the suitability of each technology in a process of elimination. If the local setting (climate, geology, hydrology, urban design and typology) doesn't allow a technology, it wasn't further considered. If a technology is suitable, its current technical efficiency was set in relation to available production capacity or available area to calculate the maximum technological energy potential for the whole community. The energy potentials can be found in table 2. It was found, that there is a total heating energy potential of 44.64 GWh/a and an electricity generation potential of 14.21 GWh/a theoretically accessible within the community. This surpasses the energy demand by far (see Table 2). In a second step a techno-economic feasibility analysis of seven energy supply variants was performed. Identified as most feasible energy scenarios were the use of a production waste from an industrial site next to the community that can be equated with biomass (A), a mix of solar thermal energy and heat pumps (B) or mix of industrial waste heat, heat pumps and roof integrated PV (C). All scenarios are based on the establishment of district heating. Scenario A, the use of local production waste, is distinguished by high cost-effectiveness.

Table 2: Suitability and technical potential of renewable energy technologies in the community

| Energy source | End energy | Suitability | Energy Potential [GWh/a] |
|---|---|---|---|
| Industrial waste heat | Heat | Partly | 1.73 – 3.46 |
| Waste combustion | Heat/ EL | None | - |
| Drain water heat recovery | Heat | Little | - |
| CHP (oat peel waste, “biomass”) | Heat/<br>EL | Good | 33.18<br>7.96 - 12.61 |
| Geothermics , near-surface | Heat | Good | 1 – 3.1 |
| Geothermics, deep | Heat/EL | None | - |
| Photovoltaics | EL | Good | 1.6 |
| Solar thermal energy | Heat | Good | 4.9 |
| Hydropower | EL | None | - |
| Wind power | EL | Little | - |

### 4.3 ‘Step 2’: CEP for Krückau-Vormstegen and the suggested planning methodologies

Based on interviews with local authorities, the utility works, business associations and landlords, the templates to develop a CEP for Krückau-Vormstegen were filled out by the author. Because of the parallelism of building renovation and new developments, the CEP for the community shows many barriers and tasks in all dimensions of energy planning. In particular the dialogue with stakeholders is crucial, first to access the waste heat and waste potential and second to reach the building owners and tenants for connection to district heating and building renovation. Further crucial points are the renovation of buildings with memorial status and the legal framework to supply the building stock with district heating. The technological barriers for implementation are rather small, because the suggested technical solutions are mainly standard. Specific barriers for the suggested energy scenarios were the different required temperature levels of the building heating systems (B,C), finding reliable stirling-engines in an adequate size (A) and to handle the varying waste heat accrual (C).

The suggested planning methodologies were retrieved from the assessed CECs from 3.2, for which CEPs were created. The main suggestions to the municipality were to take the leading role in a cross section working group between utility works, the industrial firm as possible vendor of waste heat and biomass, and the municipality. In a second step local building owners should be included. Further suggested measures are described in [2]. Concerning the reassessment of the energy scenarios the suggestion was made to drop option C and further investigate A and B.

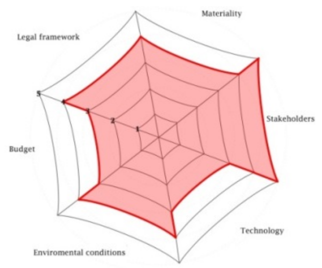


Fig. 5: CEP of Krückau-Vormstegen

### 4.4 Outcomes of using the decision-support methodology

After the use of the methodology and a presentation of the results to the city administration, an energy planning process was initiated. The basic decision to provide the necessary resources was made in February 2014 based on the results of the CEP; a stakeholder dialogue to check the general feasibility was executed, with the agreement on variant A or B as possible and beneficial for all stakeholders. The municipal parliament decided that the community should be supplied with an “innovative district heating grid”. In late 2014 an energy consultancy firm was hired to plan technical details, while the utility contacted landowners and developers in the community to discuss building renovation and district heating. Simultaneously, the municipality worked on a building energy renovation concept based on the suggestions of the CEP, which is still ongoing.

While the main landowners were convinced (owning 400 out of a total 760 apartments) to connect to a district heating, the implementation of variant A or B has not been reached yet: The variant A is endorsed by all stakeholders – because of technical difficulties with the CHP engines, as mentioned in the CEP, a central biogas CHP is the currently favoured variant. If adequate sterling engines are market-ready, the CHP unit and hence the fuel of the district grid could be changed. Status fall 2015, the community will get an open heating grid that can get gradually enlarged.

## 5. Discussion of results and conclusion

The results showed that it is possible to match the energy demand with local renewable energy sources in the community Krückau-Vormstegen. The suggestion of variants in connection to the next planning steps initiated a municipal energy planning process that was required for years. The difference to earlier attempts to bring up energy on the municipalities' agenda, were the availability of concrete and feasible options, systematic data on energy demand, and the knowledge about necesarry next steps. Another driver for the process was the possibility to implement a lighthouse project with the use of local production waste. It put energy on the political agenda and created discussions, which were unexisting before, because of lacking knowledge on energy planning and the expected high costs to buy external knowledge. These findings are correlating to the findings from literature and CEC practice. In the end, the municipality was more confident and target-orientated in acting and communication with local stakeholders, and commissioning energy consultancy. Thus, the use of decision-support methodology can be considered as successful because a self-sustaining community energy process was initiated. It is unlikely that the present most cost-efficient variant for energy supply via locally available biomass in the form of "production waste" can be found in the majority of similar local settings. Still, it shows the need for a detailed qualitative analysis of local renewable energy potentials apart from generic and purely quantitative assumptions. CEPs can only map the current state of a community, hence, they are static. To foster innovations they should become more dynamic. Thus, an integration of a time dimension would be necessary to be able to map technological progress, as seen in the case at hand, to avoid the implementation of solutions that in 5 years are already suboptimal.

The indicated process still is time-consuming and binds too many resources. Thus, automatic procedures and guidelines are needed, to enable municipalities to use the decision-support methodology to assess and optimize possible energy scenarios with CEPs. The next step is to refine the CEP methodology into a community energy planning tool, e.g. a stand-alone web tool that can be used with only minor data input. Concerning the data and models generating the scenarios, it should be considered to split the tool in two parts: One tool for urban and one for rural or suburban settings. Another possibility would be to split CEPs in new developed communities and renovation projects, because the latter are more complex and require more focus on planning procedures.

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