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A multi-stakeholder decision support system for local neighbourhood energy planning

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ABSTRACT

Implementation of clean energy initiatives at the neighbourhood level by local stakeholders is necessary to reach internationally agreed climate goals. The present paper aims to design a novel decision support system in order to facilitate clean neighbourhood energy planning with the involvement of multiple stakeholders, initiated by a local authority. In our study the cornerstones of a multi-stakeholder decision support system, containing data, models, tools, and a design process are presented so as to assist local authorities in preparing an energy plan for reaching pre-set climate goals. The decision support system was tested in a pilot case in the city of The Hague, The Netherlands. This new policy instrument is helpful for effective energy planning by introducing stakeholders and sharing and learning from different perspectives. The explicit recognition of boundary conditions specified by stakeholders turns out to enrich a purely 'technical' energy optimisation plan and to generate a much broader support for new energy initiatives. By making a location-specific plan stakeholders are able to come up with useful information and recommendations. Furthermore, a facilitator present during the design process was necessary to guide the discussion and provide explanations about the data.

1. Introduction

Over the last few decades, it has become increasingly urgent to make the transition to clean energy (Araújo, 2014; Fouquet, 2010; Hildingsson and Johansson, 2016). Starting with the Kyoto Protocol, and now with the most recent climate agreement in Paris confirmed in Marrakech and Bonn, most of the world leaders have come to recognise the importance of the clean energy transition in order to stop climate change (United Nations, 2012, 2015, 2016). In addition, the European Union is updating its clean energy directive which is geared to realising the transition to clean energy in its Member States (EU, 2016). Local authorities have become more important for reaching clean energy and climate goals set by the EU for the Member States, as they are more effective in finding solutions that fit the local context by launching local energy planning initiatives (Kelly and Pollitt, 2011; Bale et al., 2012; Evola et al., 2016; Pablo-Romero et al., 2016).

The Netherlands, as a Member State of the EU, has accepted the goal of reaching 14% clean energy in its energy mix by the year 2020, and at present new goals for this are being discussed (EU, 2009, 2016). However, the Netherlands has to design more ambitious plans to reach the accepted goal, as currently clean energy only accounts for 4% of Dutch energy production (Vasileiadou et al., 2016; Boon and Dieperink, 2014). Therefore, the Dutch government has decided in a national agreement that Dutch local authorities should reduce energy consumption and encourage clean energy production in order to reach the national goals (SER, 2013). As the built environment is responsible for over 40% of European energy consumption, the introduction of clean energy technologies in buildings is a promising initiative for local authorities to focus on (Ministerie van EZ, 2011; IEA, 2016; Van der Heijden, 2016; Visscher et al., 2016). To decide which locations are most suitable for specific technologies, an evidence-based decision support system (DSS) is needed. The goal of this study is to develop a DSS that aids local authorities in making neighbourhood energy plans, which are broadly supported by the local stakeholders, taking into account the local context. These plans are made to meet both local and national energy and climate goals. This system contains data, models, tools, and a design process (Fruijtier et al., 2014).

In this paper, Section 2 reviews the literature that provides cornerstones for the design of our DSS. The components that make up the DSS are described in Section 3. Section 4 introduces the pilot study undertaken in this research. The results of this pilot study are presented in Section 5 and discussed in Section 6. Finally, Section 7 concludes

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that, on the basis of our results, this DSS can assist in a multi-stakeholder energy planning process at the neighbourhood scale, while Section 8 offers the policy implications.

2. Literature review

In this section the scientific context of this study is outlined. This study focuses on local clean energy planning, where the goal is to make an initial clean energy plan on a neighbourhood scale for buildings. The planning process is based on Geodesign, a multi-stakeholder approach, to ensure broad support for the local clean energy plan. The advanced use of geospatial data at different scale levels, including the building level, and spatial models to inform stakeholders of the current state of their neighbourhood and of new possibilities for change and the implications of this change, forms the main contribution of this paper. We will first sketch the context of our study.

Both Kelly and Pollitt (2011) and Evola et al. (2016) describe the importance of local clean energy planning, as the local context and geography play a large role in a decentralised production of clean energy (for instance, amount of solar irradiation or turbulence of the wind). Furthermore, the local context is more known to local planners and policymakers than to those at higher levels of government. And, as buildings in the European Union are responsible for 40% of the energy consumption, in this study the focus is on local clean energy production in buildings (IEA, 2016).

For the initial planning of clean energy initiatives, a neighbourhood approach is often advocated (Delmastro et al., 2016). This means not generating specific solutions for individual buildings, but focussing on the neighbourhood scale, where general solutions are devised for locations within the neighbourhood. Furthermore, as a range of clean energy sources (e.g. geothermal or residual heat) is only viable on the meso-scale.

Kelly and Pollitt (2011) describe the importance of having support from all local stakeholders involved to come to the execution of local energy planning. McElvaney and Foster (2014) describe stakeholders as all people affected by the planning, such as residents, business owners, local government officials, local energy cooperatives, energy companies and clean energy entrepreneurs. To create insight into the stakeholders interests, McElvaney and Foster (2014) describe three levels of stakeholders: the client, the guiding coalition and the community stakeholders. The client is the person that initiates the planning for change, and the guiding coalition comprises representatives from the different coalitions of stakeholders at a location (e.g. inhabitants or shop owners). According to Kelly and Pollitt (2011), it is convenient to have local authorities taking the lead in planning local clean energy initiatives (the client as described by McElvaney and Foster, 2014). By stimulating the implementation of clean energy technology, local authorities can experience clear benefits, such as a decrease in (energy) poverty[1] and an increase in local employment. Furthermore, local authorities are situated closer to the citizens, placing them in a better position than a national or regional government to inform and educate their citizens. Local authorities are also in a position to broker collaborations between citizens, local businesses and NGOs in order to facilitate the transition to clean energy technologies. However, Sperling et al. (2011) show that sometimes local planning can go against national policy, or conflict with local planning in a different municipality. Therefore, they advise national coordination to prevent this from occurring. That is why in this study, we choose to work only with data that is location-specific but available at a wide spatial scale, in order to take into consideration possible interaction with surrounding municipalities.

To ensure that the local authorities can facilitate multi-stakeholder planning, a design process is required. The process used in the present study is inspired by the *Geodesign* process,[2] as defined by Steinitz (2012), Flaxmann (2010), and Goodchild (2010), and has been applied by, for instance, Eikelboom and Janssen (2013) and Wissen Hayek et al. (2016). This process has been chosen, as it has been shown that it is suitable for multi-stakeholder, multi-criteria decision-making processes, and can be applied to decision-making concerning many different spatial and environmental processes. Geodesign was created to assess the performance of a location, and provide solutions to enhance its performance, taking into account different stakeholder views. The performance can be both qualitative and quantitative. It can be measured (e.g. the number of cars that drive on a road each year), modelled (e.g. the potential for solar energy on roofs) or a judgement of the stakeholders (whether a landscape is considered beautiful or not). This process consists of six steps, as shown in Fig. 1. Step 1 is getting to know the local geography, i.e. the current status of the landscape of the location. Step 2 is understanding the processes that operate in that location. Step 3 is collecting ideas for improvement and indicating those objects that are to be unaffected. In step 4, these ideas are combined into a few coherent scenarios, while in step 5, these scenarios are shown to the stakeholders, and impact analyses are carried out. The final step 6 is decision-making, where a final scenario is selected. This description suggests that Geodesign is a linear process; however, as the arrows in Fig. 1 show, it can be iterative. For example, it might happen that during step 3 it becomes apparent that more information about the local geography is necessary. For the purposes of the present study, the Geodesign process had to be amended in order to apply it to the complex planning and data challenges associated with clean energy planning, such as privacy protected data, a wide range of solutions, presence of controversial topics, a large group of stakeholders and difficulties related to funding the initial investment (Trianni and Cagno, 2012). The difference between the planning practice in the present study and Geodesign is related to the decision model. The initial Geodesign process has no fixed decision model; this is discussed with the stakeholders as part of the process. By contrast, in the present study an amendment was made that the decision model is defined in our DSS to be a consensus plan, which leaves no stakeholder disappointed, but maybe does not meet all the requirements that were pre-set by the client or the stakeholders involved in the decision-making process. If, for instance, the stakeholders want both a CO_2 emission reduction and a maximum pay-back period, it might be an unfeasible combination and the stakeholders have to compromise on either one.

Other researchers have already developed operational tools for clean energy planning. For example, Sinha and Chandel (2014), Van der Heijden (2016) and Nigim et al. (2004) give overviews of different energy planning and decision-making tools. Most involve desktop-based or web-based tools that incorporate models for one or several different clean energy technologies, which are operated by manually inserting specific information that calculates relevant performance indicators. Van der Heijden (2016) analyses more generally what type of policy making tools is available for refurbishing low-carbon buildings, while Nigim et al. (2004) specifically analyse tools that enable the comparison of multiple criteria. This is also enabled in the tool designed by Mourmouris and Potolias (2013). This tool also makes use of some basic geospatial data and spatial analysis in the planning process, to make the plans specific for the regional planning level they attain. Further, Di Leo et al. (2015) present a regional energy planning tool, using geospatial

[1] Thus far, the notion of energy poverty has been acknowledged as a problem. But an official definition is only found in the UK, where it is 'a situation in which a household needs to spend more than 10% of its total income (before housing costs) on all fuel used to heat its homes to an acceptable level' (Bouzarovski, 2014). However, Bouzarovski (2014) admits that this definition is flawed, and should be debated scientifically and politically in terms of scope and cause.

[2] Geodesign is a relatively new framework. There is an ongoing debate regarding its definition, but the most common one is by Steinitz (2012): 'Geodesign is changing geography by design'. However, our study uses the more specific definition by Goodchild (2010): 'Geodesign is planning informed by scientific knowledge of how the world works, expressed in GIS-based simulations'.