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Modular participatory backcasting: A unifying framework for strategic planning in the heating sector

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ABSTRACT

This study proposes a novel framework, modular participatory backcasting (mPB), for long-term planning in the heating sector. The mPB framework is based on participatory backcasting (PB) and integrates principles of modularity, participatory modelling, and transdisciplinarity. We discerned for mPB 13 modules that can be arranged according to the purpose and specifics of each planning process. The design of the mPB framework and its implementation are presented for the cases of participatory strategic planning processes to achieve sustainable heat provision by 2050 in a Ukrainian city (Bila Tserkva) and a Serbian city (Niš). The results show that mPB allows adaptability to local contexts and limitations through exclusion, augmentation, substitution, splitting and inverting properties of modularity; decreases the learning time for applying the framework in a novel context; increases the reproducibility and transparency of long-term energy planning processes; enables efficient integration of quantitative methods into the participatory process; and advances collaboration between academia and society. The proposed framework is beneficial for advancement of local planning and policy-making practices by creating strategies with a wider support of stakeholders. It could also be useful for further research through cross-case analysis.

1. Introduction

The heating sector is an important part of the energy system and accounts for a considerable share of urban energy use in many countries (IEA, 2013). Sustainability transitions in the sector are a high priority for the EU and other countries worldwide and are seen as a key contributor to decarbonisation, increasing energy security, energy efficiency and the quality and affordability of heating services (EU Commission, 2013). The potential for change towards sustainability in the heating sector is substantial (Lund, 2018). However, numerous barriers of different types need to be overcome in order to enable desired transitions. These barriers include path dependencies related to technical infrastructure, supply chains and networks of actors; high sunk costs; and short-sightedness in current political and economic decision making.

To overcome these barriers and deliver robust strategies for socio-technical changes in the sector, a shift towards participatory governance and reflexive planning approaches is urgently needed (Frantzeskaki and Loorbach, 2010; Truffer et al., 2010). It is also important to create collective ownership and build consensus among different societal actors, integrate vertical and horizontal planning and adopt a long-term perspective in planning (Fuso Nerini et al., 2018). However, the prevailing mode of planning in the heating sector is characterised by the emphasis on system optimisation, consideration of a narrow range of alternative solutions, the dominance of socio-economic criteria and a vertical, single-sector perspective.

The need in alternative planning frameworks in infrastructure sectors was addressed in the recent research through development and implementation of various participatory planning approaches, e.g. regional infrastructure foresight (Truffer et al., 2010); participatory exploratory modelling (Moallemi and Malekpour, 2018); participatory scenario analysis for integrated regional modelling (Walz et al., 2007); and participatory modelling processes in water resources management (Halbe et al., 2018). However, most of these approaches have only been implemented in a single case (or similar cases), while their applicability under different conditions, their scalability, and their adaptability are rarely addressed in the literature.

Adaptability of frameworks for long-term planning is especially important for the heating sector, which is characterised by a great diversity of existing socio-technical configurations and numerous potential solutions to enable sustainability transitions. Thus, it is important for the frameworks to be adaptable to different *planning levels* (e.g. urban, regional, national), *socio-cultural contexts* (e.g. planning horizon, participatory culture, ongoing discourse regarding sustainability), and

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project limitations (e.g. budget, time, skills available).

This study addresses this research gap by identifying overarching *design principles* to be used for long-term planning approaches in the heating and other similar sectors. The work draws on lessons from *modularity* (Baldwin and Clark, 2000)*, participatory modelling* (Dreyer and Renn, 2011; Voinov et al., 2016), and *transdisciplinarity* (Lang et al., 2012) applying them to modify the participatory backcasting (PB) framework (Quist, 2007). Participatory backcasting was selected as a suitable approach to address long-term sustainability challenges in the energy field, since it can enable consideration of a broader space of possible solutions that are not based on existing trends and currently dominating technologies, inclusion of environmental and social criteria and enhancement of participation by a broader range of stakeholders (Robinson, 1982; Dreborg, 2004; Quist, 2007). As a result, *modular participatory backcasting (mPB)* is suggested as a framework for long-term planning in the heating sector. In the present study, the implementation of mPB is demonstrated for the cases of the Ukrainian city Bila Tserkva and the Serbian city Niš. The potential adaptability and scalability of mPB to a particular socio-cultural context and project limitations are examined, as is the importance of considering diverse planning levels by explicit consideration of system boundaries in planning.

The paper is organised as follows: Section 2 outlines the specifics of the heating sector and strategic planning in the sector; Section 3 describes the design principles to be incorporated in a suitable framework for strategic planning; Section 4 presents the mPB framework, designed according to the suggested principles; Section 5 describes implementation of the mPB framework and the main results and benefits of its implementation in two empirical cases; Section 6 discusses mPB and suggests several directions for further research; and Section 7 presents conclusions and suggests a number of policy implications.

2. Strategic planning in the heating sector

The heating sector is an important infrastructure sector in many countries and possesses a number of specific characteristics. In order to enable sustainability transitions in the heating sector through suitable strategic planning approaches, these characteristics have to be recognised and considered.

While heating is important for many countries around the world, there is no single socio-technical configuration for heat provision. On the contrary, many different configurations have been developed under different socio-cultural and physical conditions. For example, in many cities in Scandinavia and Eastern Europe, centralised district heating (DH) systems are common (Magnusson, 2012; Knutsson et al., 2006; Werner, 2017). In the UK, a common solution is individual boilers connected to a natural gas supply network (Bolton and Foxon, 2015; Hanmer and Abram, 2017). In many cities in southern Europe that do not require constant heat provision during much of the year, electrical heaters are common (Connolly et al., 2013), while in rural areas and single-family houses in many countries, traditional wood-burning stoves are still the common solution. Different technical solutions for heating are connected to different networks of actors involved in the heating sector. These networks typically include such actors as city councils, public utilities, producers of heating equipment, environmental and other kinds of non-government organisations (NGOs), individual and organisational heat consumers, construction companies, industries owning waste heat, and actors from related sectors (e.g. electricity, water, waste). The diversity of socio-technical configurations in the heating sector unavoidably results in a diversity of conditions and limitations under which management and planning in the sector are undertaken. Moreover, planning approaches in the heating sector differ in terms of planning levels (e.g. urban, regional, national). Planning on the urban level is the most common situation, partly due to the physical limitations on heat transfer over long distances. For decentralised heating solutions such as heat pumps, a local community or even a single consumer can be the only decision maker. Management of resource supply networks (such as natural gas) can be performed on regional, national or even international level. While it is important to consider the diversity of planning levels, reconsideration of *system boundaries* in terms of sectors (e.g. Lund, 2018; Persson et al., 2014; Connolly et al., 2014) and in terms of geographical boundaries (Hodson et al., 2017; Purcell, 2006) is often needed to enable sustainability transitions. The diversity in socio-technical configurations, planning levels, and socio-cultural contexts requires adaptability of long-term planning approaches to ensure their applicability under different conditions.

According to a recent analysis of the UN's sustainable development goals (SDGs), especially SDG7: “ensure access to affordable, reliable, sustainable and modern energy for all”, *transdisciplinary collaborations* are essential in achieving these goals (Fuso Nerini et al., 2018). For this, the value and need for integration of knowledge accumulated within different research disciplines and the local knowledge of various societal actors must be recognised. Access to data and knowledge, mutual learning and sharing experiences are thus crucial for reaching the goals. Another reason for the development of participatory frameworks is the currently changing role of traditional heating sector actors (e.g. ‘prosumers’ instead of consumers or local authorities acting as an enabler of collaborations) and the emergence of new relevant actors (e.g. from the other sectors or planning levels). Implementation of *participatory frameworks* would increase the sense of ownership and legitimacy of decisions taken and support implementation of new strategies (Vergragt and Quist, 2011). Therefore, there is a need to ensure participation of different societal actors in long-term planning processes and transdisciplinary collaborations between researchers and societal actors when implementing long-term planning frameworks.

To enable sustainability transitions in the energy sector, many novel solutions for heat provision are available. They include advanced centralised solutions such as Smart Energy System and Smart Grid (Lund, 2018), decentralised solutions such as heat pumps and solar-to-heat technologies (Buonomano et al., 2013) and energy storage technology (Romanchenko et al., 2018). In addition to small-scale heat pumps commonly installed in single-family houses, large-scale heat pumps can be used in a DH system (Averfalk et al., 2017; Bach et al., 2016). Moreover, the current temperature of heat transported in pipes can be lowered using low-temperature grid technologies (Østergaard and Lund, 2011). Alternatively, the need for heat provision can be decreased by changes in connected sectors, e.g. increasing the energy efficiency of buildings through retrofitting strategies and setting high standards for new buildings (up to passive house level), improving the efficiency of heat usage by implementation of data analysis techniques and feedback-response mechanisms, effecting changes in consumption patterns among individual and public consumers etc (Pasichnyi et al., 2017). The suitability of different solutions is highly dependent on local socio-cultural and physical conditions. Some solutions can be combined within a single strategy, whereas others are conflicting options, e.g. setting high energy efficiency standards for buildings and development of heating infrastructure (Gabillet, 2015; Späth and Rohracher, 2014). This diversity of possible technologies implies that *scenario exploration* methods need to be included in strategic planning frameworks.

Scenario exploration and development of robust strategies to achieve sustainability in the heating sector can be supported by formal and conceptual *modelling*. Analytical methods and tools can permit exploration of the effects of various alternative technologies and their impact on climate, environmental and social issues. Quantitative modelling, which is rather well developed in the energy field (Herbst et al., 2012; Keirstead et al., 2012; Urban et al., 2007), can be of help in this task. However, conventional use of modelling needs to be revisited by addressing such challenges as the influence of hidden assumptions, the risk of simplifications, challenges in uncertainty analysis, ambiguities in model interpretations etc. (McDowall and Geels, 2017). Therefore, a suitable framework for long-term planning needs to