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Strategic planning for sustainable heating in cities: A morphological method for scenario development and selection

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HIGHLIGHTS

- A method for scenario development and selection has been developed.
- The method is based on the morphological approach and scenario criteria.
- The method is applied to participatory strategic planning for sustainable heating.
- The method is tested in participatory backcasting projects in Ukraine and Serbia.
- Consensus-based scenarios are constructed for more sustainable heating systems.

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ABSTRACT

The transition to more sustainable heating systems requires socio-technical approaches to strategic planning. Scenario development plays a key role in strategic planning, as the process supports the development of future visions and actions required for their realisation. However, new approaches to scenario development are required to address the limitations of conventional scenario development methods, such as the cognitive barriers of 'groupthink', reluctance to consider 'outside-the-box' options, handling of complexity, and ad hoc scenario selection and general non-transparency of scenario development processes. This paper describes the development and implementation of a novel method for scenario development and selection in the context of participatory strategic planning for sustainable heating in cities. The method is based on the morphological approach and a number of scenario criteria including *transparency*, *reliability*, *coverage*, *completeness*, *relevance/density*, *creativity*, *interpretability*, *consistency*, *differentiation* and *plausibility*. It integrates creativity workshops and interdisciplinary stakeholder participation to enhance the ownership and legitimacy of the scenarios. The approach entails the generation of a complete space of scenarios for heating systems and reduction of this space using cross-consistency analysis and project-specific requirements. Iterative development and implementation of the method is illustrated using two participatory backcasting projects focused on strategic planning for providing a comfortable indoor climate for Bila Tserkva, Ukraine, and Niš, Serbia by the year 2030. The results demonstrate that the method helps overcome the limitations of conventional approaches to scenario development and supports rigorous and transparent selection of a scenario set for participatory analysis. The method fostered the elicitation of consensus-based scenarios for more sustainable heating systems in both cities with regard to the quality of indoor comfort, environmental impact, resource efficiency and energy security.

1. Introduction

Cities are engines of innovation and growth, responsible for approximately two-thirds of total global energy consumption and carbon dioxide (CO_2) emissions from final energy use (AR 5, [1]). Energy for heating is a significant proportion of urban energy use and is predominantly met using fossil fuels, such as natural gas and solid fuels [2]. Decarbonisation of the heating sector, improvement of energy efficiency, ensuring energy security and affordability are currently among the top priorities for the EU and many countries world-wide [3].

Transitions to sustainability require a shift to a new trajectory involving changes in socio-technical systems, social groups and

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institutions [4]. Heating systems suffer from problems inherent to infrastructure sectors, which are often locked into unsustainable trajectories because of path dependencies and selection environments that favour incremental change as opposed to radical system reconfiguration [5,6]. To help guide the transition of socio-technical systems towards sustainability, strategic governance activities (together with tactical, operational and reflexive activities) have been highlighted as key to long-term goal formulation and developing transition agendas [7]. Furthermore, Loorbach [7] argues a need for new modes of governance that are able to expand the effects of the prevailing planning forms in the long-term context, whilst Partidario and Vergragt [8] highlight a need for strategic planning for sustainability transformations. Truffer et al. [6] suggest a number of characteristics that strategic planning should possess in order to be effective in guiding socio-technical change in infrastructure sectors, including: a participatory mode of planning; incorporating stakeholder values; reflecting on contextual factors; and openness to creative exploration and innovative options. These insights are particularly important for heating systems considering their complexity, interconnection with other city infrastructure, system lock-ins, significant sunk costs and numerous stakeholders with various interests.

To enable a co-creation approach to strategic planning, different methodologies have been developed, including participatory backcasting. Backcasting is a useful framework for strategic planning [9] that allows a desirable future vision to be constructed and corresponding pathways to be established to link this vision to the present [10], especially when performed in the participatory manner [11]. Visions are often fleshed out using scenarios, for example, what a sustainable heating system might comprise in the future. Two types of scenarios can be distinguished in the literature: *external scenarios,* which refer to the possible futures formed by external factors that are outside the direct control of actors; and *internal scenarios* (also called *internal strategy scenarios*, *strategic system configurations* or *strategic choices*), which refer to the possible configurations of the system in the future that are, to some extent, under the control of actors [12,13]. By pitting various internal scenarios against external scenarios, the strategic planning process has the potential to deliver more adaptive and robust strategies across a broad spectrum of future states [13,14]. However, the well-established intuitive-logics approach[1] to scenario planning has significant limitations [16] that are partly explained by the cognitive barrier of "groupthink" while working with complex systems under the uncertainty inherent to scenario development processes [17]. The literature from the cognitive psychology field provides evidence of how cognitive phenomena influence "what information is searched for and what data are accepted or rejected" [17] and explains the challenges to widening mental constructs and enabling 'outside-the-box' thinking through neural network mechanisms. In line with the findings of cognitive psychologists, the limitations observed by scenario planners include the reluctance of stakeholders to consider options that "deviate too far from those anchored in observations from the past" [14], which leads to the exclusion of surprising developments and innovative configurations. Furthermore, the stakeholders become disorientated by complexity and overwhelmed by the large number of possible system configurations and futures, which leads to a need to pre-select a limited number of scenarios, usually three to six, for in-depth analysis [18]. When this pre-selection is carried out in an ad hoc manner, there is a high risk of the choice of scenarios becoming non-transparent and strongly influenced by the individual interests of those selecting them. Moreover, a non-systematic approach to scenario development and selection may result in loss of interesting configurations of socio-technical systems, which diminishes the advantages of the multiple-scenario method [19]. Finally, the ambiguity in scenario interpretation by different stakeholders is recognised as a major limitation of the intuitive-logics approach to scenarios [14].

Stemming from the aforementioned limitations, a number of criteria for scenarios have been identified by various authors, e.g. *transparency*, *completeness*, *relevance*, *creativity*, *consistency*, *differentiation* and *plausibility* [18]. However, Bradfield et al. [17] suggests that most scenario procedures are still "only loosely defined" and that there is a lack of stringent protocols for scenario development and selection. Furthermore, there are few examples of how these criteria can be implemented in strategic planning for infrastructure systems in cities.

To overcome such limitations, this paper aims at: (a) presenting a method for developing and selecting internal scenarios within a process of participatory strategic planning for sustainable heating systems in cities; and (b) describing the implementation of this method through the course of two strategic planning projects, in the cities of Bila Tserkva, Ukraine, and Niš, Serbia.

Section 2 provides a background to heating systems and illustrates their characteristics in terms of socio-technical systems. Section 3 describes the methods used in this study and provides a brief overview of the two case studies that were used for testing the proposed morphological method, which is described in Section 4. Section 5 presents results of implementation of the morphological method within the two case studies. Section 6 discusses lessons learned from implementation of the method, while conclusions are presented in Section 7.

2. A socio-technical approach to heating system transitions

Due to the strong material and institutional interdependencies that develop to ensure the function of infrastructure systems, it is fruitful to view them as socio-technical systems [6]. Infrastructure-based sectors possess a number of specific socio-technical characteristics. For instance, they are essential to everyday life and, hence, classified as public utilities or social goods. Infrastructure systems tend to be natural monopolies and thus have services that are subject to state influence, which may not be traded in markets. Furthermore, due to the size and technical complexity of infrastructure, institutional arrangements are required to achieve interaction between the large number of components [20].

Socio-technical approaches to infrastructure systems emerged in the 1980s in the large technical systems literature (see [21] and, more recently, in the transitions literature (see [22] that attempts to understand mechanisms by which systems change from one socio-technical configuration to another. A common approach in the transitions literature to frame and understand change in socio-technical systems is the multi-level perspective (MLP). The MLP suggests that system innovation can be understood through interactions between *landscape* (exogenous context), *regime* (deep structure of the socio-technical system) and *niche* (innovation and experimentation) levels [23,24].

The socio-technical *landscape* influences niche and regime dynamics and refers to the exogenous context of the regime beyond the direct influence of regime actors. It consists of unchanging or very slowly changing factors (such as spatial structures or the climate), long-term changes (such as macro-level societal and economic trends, societal values or political ideologies) and specific shocks (such as crises of fuel security or political instability) [4]. *Landscape* factors influencing the regime and niche dynamics of heating systems include: an increased focus on environmental sustainability (for instance, ambitious environmental goals, consumer demand for renewable energy); energy security due to resource scarcity and geopolitical instability; privatisation or concession of state infrastructure (for instance, of direct heating

[1] For more details on the intuitive-logics school see Bradfield et al. [15]

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