Strategies for a sustainable energy transition: the case of the housing sector in Graz, Austria

Hohmann B
University of Graz, Institute of Geography and Regional Science, Heinrichstrae 36, 8010 Graz
bernhard.hohmann@uni-graz.at

Abstract. To facilitate a sustainable energy transition, the housing sector needs to be considered as a whole. Consequently, buildings as well as spatial structures have to be sustainable. Buildings, new and existing, need to be energy efficient, low carbon, considering diverse demands, while also providing a healthy indoor environment and a high quality of life. Spatial structures have to be efficient through compact development, supporting the transition to a post fossil society and mobility regime, that also provide high quality public spaces. In a transdisciplinary approach, strategies and policies, relevant for the case of Graz, Austria, were analyzed. Challenges and potential solution approaches were identified in a theory discussion, considering spatial development and construction aspects. A resulting set of measures to support the necessary sustainability transition is evaluated and iteratively enhanced by qualitative expert interviews with relevant stakeholders, i.e., researchers, practitioners and the administration. The aim of this research is to come up with a set of policy recommendations for decision makers. First results of this work in progress are already available and presented in this paper.

1. Introduction
In order to avert drastic consequences of climate change, the 2°C target, also embraced by the Paris Agreement [1], needs to be met. This is only possible if GHG emissions are significantly reduced to achieve the energy transition to 100% renewables. Participating countries have set themselves individual goals, which will be hard to attain, but still even need to become more ambitious. Furthermore, climate change is not the only challenge that needs to be tackled. Brand argues, that the situation can be rather described as a multiple crisis, which requires a profound social change [2]. The Sustainable Development Goals (SDGs) [3] are a key global governance approach, that tries to tackle this complex situation comprehensively, covering not only climate action, but all kinds of social aspects as well. The SDG 11 Sustainable Cities and Communities is of special importance, as buildings are a major contributor of GHG emissions due to their high energy consumption.

According to the Energy Efficiency Plan of the EU [4], buildings account for 40% of the total final energy consumption in the EU. More than 80% of this energy demand is caused by heating and domestic hot water. In addition, construction and renovation processes also contribute to energy demand. Moreover, the location of a building indirectly also influences the amount of emissions, as it impacts mobility patterns of occupants and infrastructure extent.

As a result, buildings in loosely populated suburbia are generally responsible for a significantly higher energy consumption, due to less efficient mobility patterns than homes in urban areas. Furthermore, considerably more resources have to be spent (energy and money) on the construction and maintenance
of the necessary infrastructure in dispersed areas. Therefore, it is crucial to consider the spatial dimension of the housing sector, to decrease its impact on energy consumption. Consequently, it is favorable to promote measures that lead to denser structures, which can also be socially beneficial and integrative.

Individual buildings, on the other hand, raise questions, such as, how they should be built, heated, cooled or ventilated, in order to facilitate a switch to renewable energy supply, to increase their energy efficiency and to decrease energy and resource consumption. Moreover, a distinction is necessary between new constructions, with significantly more degrees of freedom, and existing buildings that need to be refurbished, insulated or adapted. All these discussions must not neglect the social dimension of sustainability and thus, consider the needs of and impacts on the residents, providing a high quality of life.

Graz, as a medium sized European city, serves as a case study for this research. Until 2030, the city is expected to grow dynamically within the city limits by 18% (based on 2014), i.e., approximately 48,000 additional inhabitants with an according need for new housing [5]. Furthermore, the historic center of Graz is an UNESCO World Heritage site, which limits growth and redensification options in the downtown area, as well as energy efficiency measures.

The aim of this research is to generate a set of strategic principles and specific measures that can guide the housing sector in Graz on a path of a sustainable energy transition. The suggestions consist of top down measures (i.e., legislation, tax or subsidies), but also consider bottom-up approaches, such as the strategic enforcement of increased participation. The generation process of this set of recommendations, as well as the whole research design and methodology is outlined in Section 2. A system model describing the relations of stakeholders and the connection to the research process is presented in Section 3. The preliminary set of recommendations is discussed in Section 4, while the current state of this research in progress, next steps and future work, will conclude this paper in Section 5.

2. Research Design

The underlying hypothesis of this research is that: strategies, regulations and incentives, concerning the housing sector in Graz, have to be significantly improved to promote a sustainable energy transition. This leads to the research question: how to adapt strategies, regulations and incentives (subsidies and tax), to enforce the right measures to promote a sustainable energy transition? To answer this question, a transdisciplinary approach was chosen, as discussed in Section 2.1. The applied mixed methods multi actor process is presented in Section 2.2.

2.1. Transdisciplinary Approach

As stated by Stiess et. al. [6], few fields of action are as complex as the area of housing and construction. Ecologic, economic, social and institutional dynamics are interconnected in numerous ways, causing interacting and overlapping effects. Therefore, an adaption of the building stock requires the consideration of a multitude of actors of different fields and contexts. In addition, various professional perspectives and conflicting goals need to be incorporated. According to Stiess et. al. this integration effort can only be tackled by applying a transdisciplinary approach. First, disciplinary knowledge of fields, such as construction, architecture or urban planning need to be analyzed and combined to a coherent concept. Second also the relevant actors for an according implementation of the proposed measures need to be included in the research process [6].

Consequently, a transdisciplinary approach is chosen to answer the present research question. Moreover, this work has the aspiration to not only analyze this complex field, but also to trigger change to make the current situation more sustainable. It is hence based in the field of critical geography, which traces back to Max Horkheimer’s critical theory and assumes, that everything that influences human life is man-made and thus changeable [7]. This connects to the realm of the transformative paradigm, as outlined by Creswell [8]. It is based on the critical theory and underlines the self-conception of researchers who feel to have a responsibility to dedicate their work to serve aims of social justice and sustainability. Within this worldview, research is commonly collaborative, based in political domains
and power and justice-oriented. Most importantly, however, it is change-oriented which implies a transdisciplinary approach, including multiple actors from politics and society into the research process.

As discussed by Jahn and Keil [9], the transdisciplinary research process is not a clearly defined procedure. Within the field, different discourses focus on more science or more practice focused branches. In general, transdisciplinary research aims on generating scientific solutions for societal issues. This can appear in the form of an intervention in public discourses or an increased expert knowledge. On the other hand, also scientific results are created, e.g., new transdisciplinary models or detailed problem descriptions. The transdisciplinary integration describes the process from the constituted societal problem to an elaborate societal solution. For the necessary sustainable solutions, segmented disciplinary and common knowledge are not sufficient. Therefore, a reflected synthesis of the different solution approaches is necessary and leads to a systemic problem solution of the societal problem. In addition, this synthesis of different knowledge creates a new comprehensive theoretical structure [9]. A general model of a transdisciplinary research process, differentiates three stages [9].

(i) A common object of research has to be constituted by combining different disciplinary knowledge with practical issues, commonly involving the relevant actors. This leads to the research questions.

(ii) Relevant disciplinary knowledge is generated and integrated.

(iii) In the transdisciplinary integration, practical solutions are generated and a new transdisciplinary knowledge base is created. This stage summarizes the results of the previous stage and verifies the validity and relevance of the proposed solution approaches, by, e.g., conducting expert interviews with the relevant stakeholders. This creates strongly integrated objects, e.g., strategies or specific measures. Thus, added value is generated for each involved actor and beyond by creating a base for potential future cooperation and research.

In this research disciplinary knowledge from the fields of architecture, construction engineering, geography and spatial planning are integrated to take a broad perspective on the role of the housing sector in Graz, in a sustainable energy transition. This scientific knowledge is combined with the practical experience of relevant stakeholders (i.e., experts) to generate a new transdisciplinary knowledge base and come up with a set of possible measures to transform the status quo sustainably. The process of this multi-actor mixed methods approach is discussed in Section 2.2.

2.2. Methodology

In accordance with the transdisciplinary research approach discussed in Section 2.1, the methodology follows a three stage process.

1.) First, an analysis of global challenges and possible solution approaches was conducted in which the goal of a sustainable energy transition was focused on the housing sector. In combination with feedback from exploratory interviews with researchers of the respective disciplines and practitioners, this lead to the research question.

2.) Against the backdrop of the theory discussion, a qualitative analysis of strategies and policies, concerning the national, the provincial and the local level of administration, relating to the housing sector in general or concerning the spatial development dimension, was conducted. The documents were processed and coded using MAXQDA [10] to systematically identify relevant text passages, by using different sets of search strings. Out of these relevant text passages, challenges and possible solution approaches were extracted. This process lead to a first set of specific measures, as well as, more general strategic recommendations. Scientific experts of the fields of architecture, civil engineering and spatial planning were asked for their opinion on these proposals. In these semi-structured qualitative expert interviews, the suggestions were discussed and graded to identify the most relevant measures.

3.) This reduced set is currently being evaluated in interviews with practical experts, i.e., developers, cooperative housing associations, architects or civil engineers. In the next step, feedback from administration officials is obtained. Finally, the resulting set of recommended strategic principles and specific measures is presented to political decision makers.
3. System Model

To visualize the relations of the relevant stakeholders and instruments to influence the transition, a system model was iteratively developed and validated in cooperation with scientific experts. The system model depicted in Figure 1 also connects this research with the multi level perspective (MLP), introduced by Geels [11]. The MLP, is a model to describe socio-technical transitions which differentiates three levels. In this broad framework, a so called patchwork of socio-technical regimes is influenced by niche innovations and an exogenous landscape. Socio-technical regimes propose, that process technologies, practices and scientific knowledge are socially embedded in a network of actors, institutional structures and infrastructures. Niches are sources of radical change, located at the micro-level, that can lead to incremental or substantial regime change. The exogenous landscape represents external factors which cannot be controlled by individual actors, but influence the regime level. Pressure from the landscape can open a window of opportunity in the patchwork of regimes, in which niche innovations have the potential to establish themselves as alternative paths within the system. In contrast, the current regime will try to resist fundamental changes [12]. Therefore, attention has to be focused on how to destabilize current regimes, as the system needs to be transformed towards sustainability.

In the present case the exogenous landscape is, on the one hand, represented by global influences that cannot be altered by the patchwork of regimes, i.e., climate change, the economic system, demography, urbanization or migration. On the other hand, the landscape can be interpreted as to additionally include...
regulations, incentives and education. These instruments, which can be influenced and altered by key stakeholders, can put pressure on the regimes of the housing sector or urban development. This way, sustainable practices, which represent the niches in the MLP, can potentially establish themselves in a window of opportunity in the current patchwork of regimes. These sustainable practices can be participatory processes that respect actual needs of occupants, or bottom up initiatives that try to trigger change to establish sustainable practices. In part these sustainable practices already materialized as best practice examples, which are part of the current patchwork of regimes, but still represent niches.

The system model includes the relevant stakeholders identified in this research process. The instruments, which can be utilized to put pressure on the system to initiate a sustainable transition, are determined by politicians and administration officials who decide and prepare new legislation. These decision makers can be influenced by scientific expert opinions of researchers. Both stakeholder groups influence strategies, which serve as principal guidelines of how the instruments should gradually develop. Moreover, researchers have a direct influence on education, but only indirectly on regulations or incentives. The instruments, are interpreted as part of the landscape environment for the housing sector and urban development, that influences the behavior of the key stakeholders within these regimes, i.e., homeowners, tenants, investors or practitioners, such as architects, construction companies, building service technicians or developers.

Consequently, this system model also refers to the research design and the three stage methodology, as described in Section 2. 1.) Global challenges and influences are analyzed, which represent the exogenous landscape. 2.) The instruments are analyzed to identify challenges and potential improvements, to put pressure on the system to trigger the opportunity for a change towards sustainability. The identified ameliorations (i.e., strategic principles and specific measures) are evaluated and enhanced by the relevant scientific experts. 3.) Next, practitioners commit their perspective on the reduced set of suggestions. In the final step, the resulting set of measures is presented and discussed with administration officials and political decision makers to initiate this process of a sustainable transition.

4. Strategies and Policies for a Sustainable Energy Transition

As discussed before in Sections 2 and 3, the research process generates a set of recommended strategic principles and specific measures. In this section preliminary results are presented. The qualitative analysis of strategy and policy documents (39 relating to the housing sector in general and 24 concerning spatial development), resulted in a first set of 96 recommendations and additional general challenges. These were discussed and iteratively improved in qualitative interviews with scientific experts, who also graded the specific measures and strategic principles. This way the vast amount of suggestions was reduced to a set of 50 most important recommendations (stage 2). Currently, this set is evaluated by practical experts, i.e., developers, cooperative housing associations, architects or civil engineers and in a next step, feedback from administration officials and political decision makers will be obtained (stage 3). The preliminary recommendations are summarized and structured in regulations, incentives, measures concerning education and strategic principles (in correspondence with the system model in Figure 1).

4.1. Regulations

Regulations are a key instrument to secure sustainable development in a top-down manner. For a long term sustainable development, the mandatory use of LCAs in the construction of buildings, is a key requirement. Furthermore, immediate bans on fossil energy sources for the supply of new buildings, obligations to implement passive cooling (shading) on all new buildings or an immediate total ban on split system air conditioning devices in new constructions are important measures to avoid long-term lock-in effects. Another relevant measure would be the mandatory implementation of low-temperature radiant heating and cooling with thermal component activation in new constructions. To ensure a healthy indoor environment and to prevent rebound effects the introduction of mandatory training offers (e.g., the correct use of heating or ventilation systems) by developers for occupants in new highly energy efficient buildings could be a beneficial measure. In addition, mandatory post occupancy evaluations in
new apartment buildings and evaluation of the results by the facility management could also improve the actual performance of buildings.

Another key topic to increase sustainability is the promotion of reuse instead of demolition and replacement. This could be supported, if in case of a replacement, the gray energy of the demolished building would be added to the LCA or the energy performance certificate (EPC) of the succeeding building. In case of historically important buildings, reuse also implies the preservation of building culture. In case of willful neglect of such buildings, it could be beneficial to introduce a confiscation option for the community (with compensation). The densification of urban spaces to promote compact development could be fostered by allowing developers to exceed the maximum density in refurbishments as well as new constructions, if a green building certificate is obtained to prove compliance with sustainability criteria.

In order to foster inclusive and collaborative planning, it is suggested to specifically dedicating a certain share of building land in new developments (e.g., in land-use plans), for co-housing initiatives, as it is practiced for instance in Vienna. Moreover, obligatory additional community areas in new housing projects could help to support social integration. The rate of sustainable refurbishments could be increased by the introduction of mandatory higher rates for the creation of reserves (in condominiums), dedicated to the sustainable implementation of a refurbishment, respecting construction methods, materials or a well-considered decision process (proved by a LCA). Furthermore, it would be helpful to adapt the apartment property law (Wohnungseigentumsgesetz) in a way to prevent that one owner can block the implementation of a refurbishment. A reform of the tenancy law to create equal conditions for all tenants, or an adaption of rents in social housing, depending on income with periodic updates, to avoid that wealthy tenants occupy needed social housing, could lead to a more just space and cost distribution in the housing sector.

For a sustainable spatial development, a mobility transition to a post-fossil society is necessary. Thus, restrictions for motorized individual transport are necessary, i.e., no subsidies for still individual car based e-mobility, reduction of the number of public car parking spaces and of public investments in road infrastructure. In addition, a reduction of mandatory minimum numbers for the construction of car parking spaces for new buildings, and introduction of upper limits would be beneficial. At the same time, the mandatory minimum number of bicycle parking spaces for new constructions, with a focus on roofed parking, also considering bicycle trailers and cargo bicycles, need to be increased. The introduction of a separate location factor for buildings or an extension of the EPC by spatial factors (e.g., proximity of public transport or local suppliers) could raise awareness about the benefits of centrality. A stricter enforcement of the demand of the construction law, that the design of a building has to fit the present street-, town- and landscape, could help to make the urban environment also visually more attractive. Moreover, sprawl could be reduced by mandatory mixed-use multi-story developments on supermarkets and the introduction of tight maximum absolute limits of the plot size for new single family homes, corresponding to the local settlement structure.

4.2. Incentives
In contrast to regulations, incentives (which can be alternative or complementary measures) can help to softly promote a sustainable transition. New incentives, promoting innovative participatory housing approaches, e.g., co-housing, could be introduced as a part of the housing subsidies of the province. The subsidies for reuse and refurbishments could be extended to also cover community areas. In turn, the support for new detached single family homes in urban areas could be scrapped to reduce space consumption. Furthermore, a mandatory consideration of the embedding in the neighborhood and the surrounding public space should be tied to the granting of subsidies.

In order to increase the number of sustainable refurbishments, further investment incentives for owners (subsidies or tax reliefs) to refurbish sustainably (proved by a LCA) should be created. The introduction of specific subsidies for an accompanying process in refurbishments of condominiums, could increase participation and raise awareness, facilitating a more sustainable implementation.
Another suggestion is the coupling of interest rates of building savings contracts (Bausparvertrag) and correspondent loans to the gained CO₂ emission savings of a refurbishment. Generally it is suggested to establish more incentives on all levels of administration to facilitate reuse rather than demolition and replacement, as well as the introduction of distinct incentives to promote densification in the process of a refurbishment. Incentives for extensive greening of roofs, on the other hand, could alleviate some of the negative effects of higher densities.

The transition to renewable energies could be accelerated by the introduction of a tax on CO₂ emissions in combination with an eco-social tax reform. Specifically targeting heating systems, a tax on these CO₂ emissions, which is progressively increasing over time, could motivate users to switch their heating system. In addition, subsidies for heating systems with thermal component activation that can be used also for cooling (thermo-active ceilings) potentially raise awareness and avert the further increase of the number of inefficient cooling devices.

To make the space and cost distribution more fair, incentives and suitable general conditions could be created to motivate older people to give up unneeded space (e.g., move to a smaller, more convenient flat or share the house). Moreover, a vacancy tax in urban areas could help to activate vacant flats. In order to promote central living and make it more affordable than the suburban, a progressive tax on land, as a function of the utilization ratio of land and the quality of the location (e.g., centrality) could be introduced. Another beneficial measure would be, the introduction of cost transparency in the construction and maintenance of public infrastructure and a splitting of costs according to the principle that the responsible party has to pay.

4.3. Education

Educational measures aim at raising awareness and the dissemination of professional knowledge, in this context. These measures also positively influence the Sustainable Practices addressed in the system model in Section 3. In order to spread knowledge about the latest innovations, best practice and lessons learned on housing among professionals, including relevant research results of other fields (e.g., sociology, psychology, ethnology or geography), it is suggested to establish a suitable medium for that purpose. Additional awareness raising campaigns to promote energy efficient behavior would be beneficial. Likewise the rate of sustainable refurbishments could be increased through, e.g., information about saving potentials in connection with the issuing of energy performance certificates, under the condition that issuers are continuously trained on up-to-date sustainable solutions. An introduction of a summary in construction processes, listing all materials used in a construction process, including their components, properties and impacts on health and the environment, could potentially help to establish awareness about the impact of construction.

4.4. Strategic Principles

In addition to the specific measures that can be attributed to regulations, incentives and educational measures, also more general strategic principles have resulted from the research process. The fostering of the implementation of flexible floor plans of flats in combination with a participatory planning process can help to promote a more just space and cost distribution, as people are more flexible to give up unneeded space, without the need to move. Rebound effects in new highly energy efficient buildings could be averted by a good facility management that monitors energy consumption and contacts occupants in case of irregularities. A general strategic preference of low-tech solutions in construction could significantly help to save resources. For a sustainable spatial development, car free cities with spacious pedestrian zones and high quality public spaces have to be fostered. Furthermore, the increased consideration of local waste heat potentials (e.g., for district heating or local heat supply) needs to receive more attention to promote a sustainable energy transition.
5. Conclusion
So far, the underlying hypothesis, that strategies and policies, concerning the housing sector in Graz have to be significantly improved to promote a sustainable energy transition (cf. Section 2) was acknowledged by all scientific experts. The preliminary results presented in Section 4 are currently under evaluation by practitioners. In the next step they will be discussed with administration officials of the local and provincial government. After this, it will be possible to answer the research question more comprehensively, with the final set of recommendations. Moreover, it will be possible to analyze a second research question, i.e., whether there is a knowledge gap of what is sustainable, among the relevant stakeholders (i.e., architects, developers, construction companies, investors, building service companies, home owners, tenants politicians or administration) and, if yes, how to improve this situation.

The results of this work are specifically concerning the case of the city of Graz. The general approach of the applied research design (cf. Section 2) and the iteratively developed system model (cf. Section 3), could also be transferred to other cases beyond Graz. 1.) The general research question can be directly transferred and possibly adapted to another local context. 2.) A basis for such a transdisciplinary research process can be created by the combination of an analysis of the relevant local policy documents and a state of the art theory discussion. The identified challenges and possible solution approaches are evaluated together with according scientific experts. 3.) Also the expertise of local practitioners and decision makers needs to be included, to produce a set of recommended specific measures tailored to the particular situation. Consequently, this approach can be utilized to support a sustainable transition of the housing sector, also in other local contexts.

Planned future work is to present the final results of this research to local decision makers, to support the targeted transition process. The establishment of an urban lab to acquire deeper insights, to come up with new research results and to foster a dialog among relevant stakeholders, is also planned.

Acknowledgments
Special thanks to Grigor Doytchinov, Thomas Höfllehner and the anonymous reviewers for their valuable feedback as well as to Magdalena Gschaider and Radka Hohmann for proofreading.

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