



Research Article

Challenges to local innovation and implementation of low-carbon energy-transition measures: A tale of two Austrian regions

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ABSTRACT

This paper contributes to the current debate on implementation gaps in local low-carbon energy transitions. We observe the need for a comprehensive analytical framework to assess the challenges associated with local energy transitions: we thus propose integrating key aspects of Transition Management (TM) and the Multi-Level Perspective (MLP) into the Regional Innovations Systems (RIS) framework. The resulting blended framework enables policy learning through discourse and interaction between governance and implementation levels, a key prerequisite towards creating the necessary framework conditions for local innovation and transformation. The application of this novel blended framework to the case of two municipalities in Austria, one urban and one rural, shows local measures, building on local knowledge, having great potential to foster local low-carbon energy transitions: this is seen in strong social networks and in dedicated local transition change makers, creatively circumventing issues such as the lack of financial resources. Yet, existing regulatory and institutional conditions at the national and state levels often hinder the local implementation. We argue that the limited power of agency of regional policymaking are a major stumbling block to local energy transitions, thus increasing the need for vertical policy integration and learning.

1. Introduction

The rapid decarbonization of the energy sector needed in the foreseeable future requires a purposeful and fundamental shift in the patterns of energy production and consumption (Foxon, 2011; Solomon and Krishna, 2011; Roberts and Geels, 2019). The speed of the transition and the magnitude of the challenges it involves are without precedent. Debates are thus rife on how such energy transitions—especially at the local scale—can be fostered and managed proactively (Heiskanen et al., 2010; Solomon and Krishna, 2011; Mattes et al., 2015; Faller, 2016; Andrews-Speed, 2016; Frantzeskaki and Loorbach, 2010). It is particularly important for energy transitions to be steered and managed locally in view of their bottom-up and participatory nature (e.g. van der Schoor and van Lente, 2016). Existing analytical framings focus largely on the technological aspects of low-carbon transitions. These framings, however, are increasingly being seen as inadequate, given the social complexities involved in transitions, including the actor landscapes, institutional and regulatory environments, governance challenges, and geographical preconditions associated with a multi-level transition (e.g. Jessop et al., 2008; Coenen, 2018; Ehnert et al., 2017). Critical

conceptual reflection and empirical studies are thus needed to tease out the major societal factors affecting the success or failure of low-carbon transition.

To provide both conceptual and empirical insights, this study first builds a blended analytical framework based on the Regional Innovations Systems (RIS) literature, complemented by Transition Management (TM) and the Multi-Level Perspective (MLP). It then applies this framework to gain an understanding of the to, and enablers of, local low-carbon transitions. An analysis of our case studies is then provided. The case studies were conducted in urban and rural municipalities participating in the climate and energy model regions (*Klima und Energiemodellregionen*, KEM) program in Austria. The KEM program was chosen as a focus of our empirical investigation, as it embraces a multi-level governance concept in which private and public entities at the national, federal state (hereafter referred to as state), and local levels collaborate with one another. At the same time, the KEM program also builds on the concept of ‘networked’ resources and continuous learning – in which numerous program activities foster these aspects such as exchange of information (fostered through formal and informal channels among designated energy managers) and quality management activities

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that are which is overseen and supervised at the federal and state levels (Klima Energie Fonds, 2019).

The remainder of the paper is organised as follows. Section 2 reviews the existing analytical approaches taken to multi-level energy transition, identifies key strengths and limitations, and presents our newly enhanced framework based on the RIS. Section 3 proposes our case study areas of the KEM program.

2. Background—Analytical approaches to assessing multi-level to community-level energy transitions

2.1. Regional innovation systems for understanding local-level transformation

Communities offer substantial potential to address persistent transition problems, including societal dilemmas and shared infrastructure (Heisenkanen et al., 2010; Mattes et al., 2015). Community-level energy transitions provide initial seedbeds for transition. This is partly because renewable energy production initiatives are increasingly decentralised and municipalities often serve as instigators of the systemic transformation needed for energy transition (Geels, 2011; Mattes et al., 2015; Koehrsen, 2017). This can be linked to the understanding of Avelino et al. (2019) of “transformative” social innovation that alters and/or replaces existing institutions, thereby empowering “niches” to replace incumbent regimes and landscapes.

To this end, RISs are proposed as systems in which firms and organisations are “systematically engaged in interactive learning through an institutional milieu characterised by embeddedness” and in socio-technical and social innovation on a regional scale (Cooke et al., 1998, p. 1581). Within this approach, three institutional forms have been identified that facilitate systemic innovation at the regional level, namely, financial, learning, and cultural. In addition, in their analyses of various European regions, including case studies in Austria, Cooke et al. (1997) found that RISs have two main perspectives related to regional autonomy. The first is to develop policies and manage finances and investments towards innovation; the second relates to the cultural basis for systemic potential.

Mattes et al. (2015) also proposed the RIS approach and expanded it to account for the actors and subsystems that play a role in a community-level energy transition, something which forms an important conceptual starting point for our research. Mattes et al. (2015) specifically seek to bridge the gap between existing transition frameworks and complex processes of local and institutional change that are rarely analysed. More recent research on regional innovation systems has underlined the capacity of the RIS concept to understand patterns and organisational structures required for regional innovation and implementation (e.g., Gracia et al., 2014; Jolly, 2017; Oliveria et al., 2017). Yet, as will be argued below, this RIS approach can be significantly improved by incorporating additional aspects of multi-scale policy-learning and, institutional and governance landscapes.

2.2. Transformative change through multi-scale policy and societal learning

Currently, a significant portion of local energy transition literature utilises innovation studies frameworks, most notably the MLP (Argyriou, 2018; Kivimaa et al., 2019). The MLP concept was originally intended to be used to study the process of technological innovation and adoption. It theorises that innovation is first conceived on the niche level and then upscaled. As such, MLP mainly aims to understand the interactions between these levels (Rotmans et al., 2001). The use of this concept in the context of local energy transitions has often been criticised for its strong focus on technological innovation instead of societal structures (e.g. Smith et al., 2005; Mattes et al., 2015; Fallner, 2016, p. 85). Yet the MLP approach makes strong arguments for the importance of learning across scales (Araujo, 2014; Geels and Schot, 2007), while the RIS concept

argues for transformative technological learning within the spatial scale of the transition (Cooke et al., 1997; Mattes et al., 2015). We thus strengthen the RIS framework by incorporating into it the MLP feedback loops between “niche” and “landscape,” which are highly relevant in the context of local low-carbon transitions.

Likewise, in transition literature, the concept of social and policy learning stresses mechanisms of reflexive monitoring, and dialogues among subsystems are seen to be a basic requirement for complex and uncertain transition challenges (Szarka, 2006; Gracia et al., 2014; Boon et al., 2016; Karpouzoglu et al., 2016). The TM approach aims to steer long-term transition in the light of uncertainty and also to apply multiple rationales via the inclusion of a variety of actors (Smith and Stirling, 2005; Smith et al., 2010; Meadowcroft, 2011; Smith and Seyfang, 2013; Malekpour et al., 2020), experimentation, evaluation, and learning, to achieve a gradual improvement of existing development pathways (Rotmans et al., 2001; Meadowcroft, 2009; Loorbach and Rotmas, 2010; Pisano et al., 2014; Voß and Bornemann, 2011).

2.3. Focus on institutions and governance levels

The consideration of institutional settings, which Nelson (2005) calls social technologies, is commonly proposed for energy transition studies (Nelson, 2005; Weber and Hemmelskamp, 2005; Fünfschilling and Truffer, 2014). The importance of institutional aspects has been demonstrated by Stirling (2014), who found that the obstacles to transformative change are due to epistemic and normative, or institutional and cultural reasons, rather than to technical ones. Andrews-Speed (2016) argued that the acceptance of technological change requires substantial institutional change. Hildingsson and Johansson (2016) also pointed out that environmental concerns must be mainstreamed within institutional frameworks to prompt energy transitions.

Both the absence and overlap of institutions affect the effectiveness of low-carbon transitions. Institutional voids, defined by Hajer (2003, p.75) as a lack of “generally accepted rules, procedural norms” are highly context-dependent. Späth and Rohrer (2012) argue that in energy transition, the existence of an institutional void can be beneficial in that it can create an environment where responsibilities and powers are not clearly defined, enabling “supportive conditions for the development of new discursive arenas for alternative political agendas and providing opportunities for the emergence of new institutions” (p. 471). At the same time, given that policy and regulation concerning low-carbon transitions are rarely developed in a complete institutional void, the existing institutional landscape of related sectors such as sectoral development policies in agriculture, energy, and transport as well as resources management policies (such as land and forest management policies) all affect which low-carbon investment actions are possible and desirable.

Earlier studies that focus on local transitions emphasise the importance of the spatial scale at which institutions operate (Coenen et al., 2012). Mattes et al. (2015), in their application of the RIS framework to community-level energy transitions, incorporated aspects of local civil society, such as NGOs; and they mobilised society, along with subsystems of local political parties and public administration that can initiate and suppress local change within a regional system. The RIS approach, however, neglects two significant aspects. First, the agency of actors, that is, the ability of an actor to provoke or resist change within the innovation system. This aspect is stressed in transition studies literature, for example, the role of social entrepreneurs as emphasised by TM (see Gui and MacGill, 2018). Second, the consideration of interaction beyond the RIS boundary through learning and the creation of the necessary framework conditions, as emphasised by MLP. We have hence strengthened the RIS approach by incorporating these two aspects.

3. Climate and energy model regions in Austria

The Austrian KEM program was established in 2009 to facilitate the

implementation of measures to foster low-carbon energy production and regional energy independence (Klima- und Energie Fonds, 2019). Foci of the KEM program include renewable energy, low-carbon mobility, energy efficiency, and sustainable building, with an emphasis on energy independence and regional development. The overall budget for 2017 was €8.75 million, of which €1.28 m was reserved for the Austrian Rural Development Program 2014–2020, and €0.5 m for the model refurbishment of public buildings. Currently, 811 municipalities in 91 KEM regions are receiving funding and support from the Austrian Climate and Energy Fund (*Klima-und Energiefonds/KLIEN*), within the KEM program (Klimaundenergiemodellregionen.at, 2017a).

The KEM structure is embedded within several legal and institutional frameworks at the national and state level (Fig. 1). The KEM program is managed and supported by KLIEN. The KLIEN itself is overseen by the Ministry of Sustainability and Tourism¹ and the Ministry for Transport, Innovation and Technology. Funding as set out in the climate- and energy-fund law (*Klima-und Energiefondsgesetz*) (BGBl. Nr, 2012). This legal framework lays the foundation for obtaining supplies of sustainable energy, mitigating greenhouse gas emissions, and formulating an appropriate climate strategy to support these aims. At the same time, the Austrian climate protection law (*Klimaschutzgesetz*) sets emissions ceilings for six sectors and regulates the development and implementation of the climate protection action for the energy and industry sectors that fall outside the EU Emissions Trading Scheme. Studies on KEM have highlighted its uniqueness (Späth and Rohrer, 2010; Truger, 2017; Komendantova et al., 2018).²

At the national level, KEMs are supported by federal organisations in terms of project conception and development and the KEM quality management requirements. The main purpose of KEM is to foster a nationwide energy transition, beginning at the community level, and to encourage renewable energy development, low-carbon mobility, and sustainable building. The implementation of these initiatives in the KEMs focuses on awareness-raising, funding procurement, and implementation of community projects.

At the same time, KEMs are encouraged to embrace heterogeneity and engage with various local actors and interest groups to implement projects in support of the energy transition. Previous analyses of KEMs have found significant differences in potential energy demand and energy production. Suburban KEMs tend to have a high energy demand, but their potential to cover their demand is quite low; semi-rural and rural KEMs, on the other hand, have significantly lower population densities and thus lower overall energy demand. As their potential for renewable energy production is relatively high, these areas have the potential to become electricity exporters (Schinko et al., 2020).

4. Methods

In this study, we propose an analytical framework (Fig. 2) building on RIS and expanded by aspects of TM and MLP, to identify the enablers of, and barriers to, low-carbon energy transitions within local innovation systems. We argue that the transformative capacities of local-level innovation systems, identified through a RIS lens, needs to be assessed by reviewing the framework conditions beyond the regional scale as well as within it. Specific attention should be paid to the institutional and policy conditions determined at higher governance levels which affect regional capacities for transformation. Based on the literature presented in Section 2, we shall further assess the existing mechanisms of policy learning and the creation of enablers for regional innovation and transformation. This is achieved through discourse and interaction from the implementation to the policy level. The ability of then implement

¹ The former Federal Ministry of Agriculture, Forestry, Environment and Water Management.

² Using the MLP framing, the KEMs have thus been described as examples of discursive niches by Späth and Rohrer (2010).

changes in framework and policy to facilitate transitions at the implementation level, we argue, requires adaptive capacities on all governance levels.

Based on this analytical framework, we constructed an empirical comparative case study analysis of two Austrian KEMs. We chose one suburban and one rural KEM to test the applicability of the expanded analytical framework across different socioeconomic and geographical contexts. After consulting with several KEM managers, two highly successful KEMs were identified based on the following criteria: receipt of an award from the federal government for their successful implementation progress, and five years of implementation experience.

Once the target KEM regions were selected, stakeholder mappings were conducted and initial insights into key policy issues were identified. This was conducted via desktop research of published documents such as KEM reports and proposals, and preliminary informant interviews with the management of each KEM. These provided a basic understanding of important stakeholders and actor networks in each KEM as well as of the linkage to the governance landscape at the national and state levels.

Based on the stakeholder maps constructed, we conducted 19 in-depth interviews with relevant actors and stakeholders at the national, state, and regional levels. The interviews covered representatives from all stakeholder groups identified in the stakeholder mappings. The semi-structured interviews (face to face or over the phone and between 50 min and 2 h in length) were conducted in German between April 2017 and January 2018, exploring the three main subject areas of (i) stakeholder views on the Austrian energy transition, (ii) the role of the KEMs in fostering decarbonization of the local and national energy system, (iii) challenges and barriers leading to an implementation gap, and (iv) direction of, and governance within, KEM processes.

The interviews were recorded and transcribed verbatim and analysed applying a Grounded Theory approach (Glaser and Strauss, 1967; Charmaz, 2006). In the first cycle, an initial coding was applied in which common themes were identified and added to the coding catalogue. The interviews were coded several times to account for new observations that emerged throughout the process, resulting in a focused, iterative, and evaluative coding approach. Based on the foci identified in the analytical framework, we conducted a theoretical sampling of the coded data organising the interviews and codes based on the concepts relating to implementation challenges, statements on policy and implementation instruments, statements on the KEM program, including the role of the KEM manager, and statements on the motivations for taking measures to encourage energy transition.

5. Results

5.1. The institutional and stakeholder landscape in the two case study regions

Stakeholder maps for selected KEMs—Freistadt (rural) and Baden (suburban)—are shown in Figs. 3 and 4. KEM Freistadt is located in Upper Austria, and has an area of 993.9 km² comprising mainly agricultural land. Freistadt has been a KEM region since 2009 (KEM, 2020b) and as of 2018, its membership includes 27 municipalities with a total population of 56,874. The Freistadt KEM region aims to achieve low-carbon transition by 2030 through the promotion of improved building insulation and heating appliances, energy-efficient electrical appliances, and a shift to e-mobility and biogas vehicles in the transport sector.

KEM Baden is a suburban KEM that has been operating since 2010. It is located in the town of Baden in the state of Lower Austria. It is one of the smallest KEMs in Austria with a total area of 26.89 km² (KEM, 2020a). In 2011 KEM Baden set itself the goal of reducing energy demand to 440 GWh per year and increasing regional renewable energy production to 411 GWh per year by 2020 (KEM Baden, 2011). KEM Baden's low-carbon transition strategy focuses on reducing energy

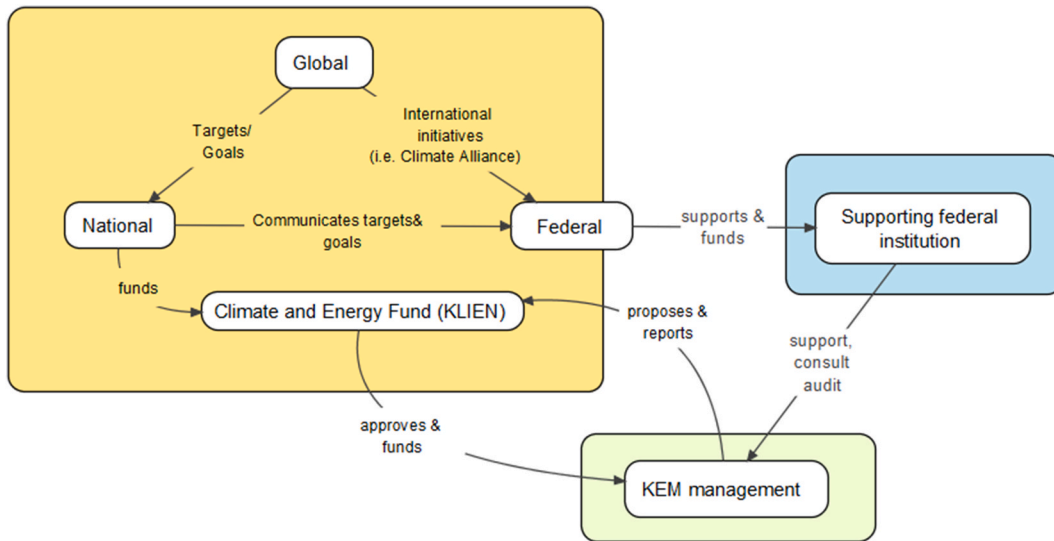


Fig. 1. Global, national, state and KEM management actors and stakeholders in relation to the KEM program.

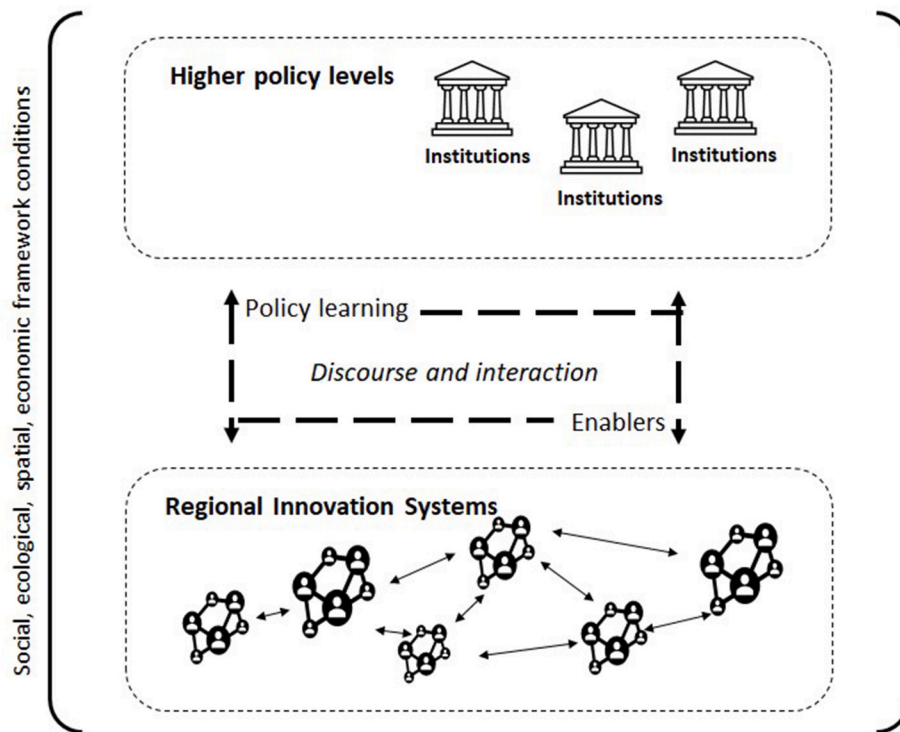


Fig. 2. Analytical framework for assessing barriers and enablers for transition.

demand in public and private buildings through refurbishment and optimisation, and by strengthening decentralised renewable energy options.

5.2. Challenges and enabling factors for community-level low-carbon transition

Local low-carbon transitions are significantly curtailed by multi-level institutional, policy, and regulatory barriers determined at the national and state levels. At the same time, successful stakeholder engagement, facilitated by an experienced energy manager, is seen as crucial to the success of Austria’s KEM program. The interactions between the factors making up the multi-level governance landscape are

recognised by all levels of respondents, as shown in Figs. 5–7.

Overall, the institutional, policy, and regulatory framework conditions (i.e., conditions outside the control of KEM regions) were identified as the most frequently cited challenges by national- and state-level respondents and by KEM Freistadt, and as the second most-cited challenge by KEM Baden. The importance of KEM managers was the second most frequently cited enabler by national- and state-level respondents and KEM Freistadt, while the interference of local vested interest was the most frequently cited barrier by KEM Baden. By all levels of respondents, aspects pertaining to the adoption of technical innovation such as Solar PV, Hydro and Biogas, were among the least frequently mentioned challenges facing KEM programs—underscoring the importance of the social and governance aspects of local low-carbon transition. We

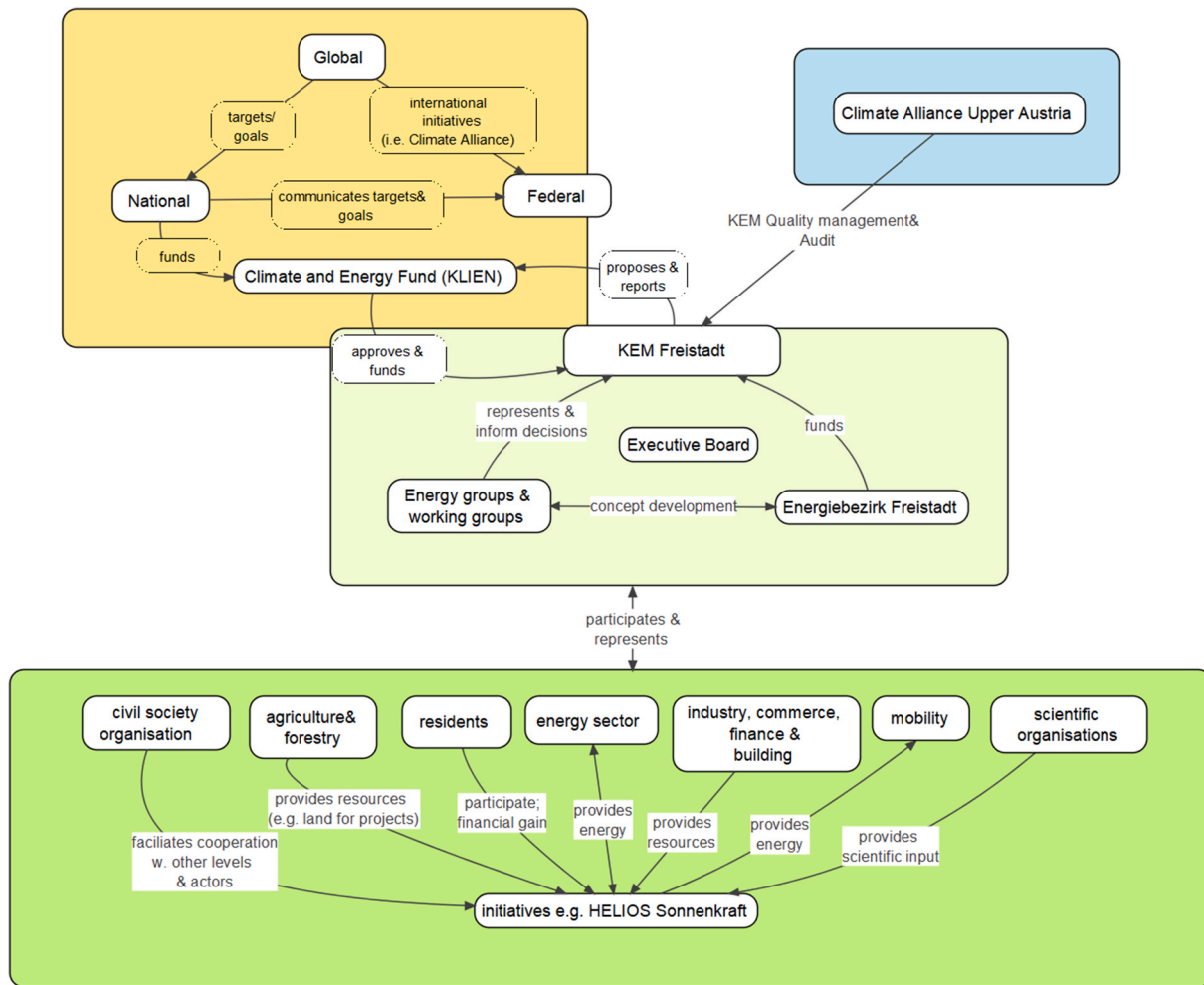


Fig. 3. Stakeholder mapping for the KEM Freistadt.

describe below details of frequently mentioned challenges and enablers relating to (i) multi-level institutional, policy and regulatory aspects and (ii) actor agency and the importance of social entrepreneurs.

5.2.1. Multi-level institutional, policy, and regulatory barriers and enablers

Contrary to the notion of institutional void, the current institutional, policy and regulatory environments surrounding low carbon transition in Austria is a complex web of multi-level requirements that often work to decelerate the local momentum for change. Institutional voids, if they exist, are generally confined to the local level, and these may or may not be exploited, depending on the available resources at the local subsystem levels. Examples of challenges to the implementation of KEM programs faced as a result of national-level institutional, policy, and regulatory barriers are many and include aspects such as:

- **Principal-agent problem arising from tenant protection regulation**—landlords cannot pass on the cost of refurbishment to their tenants, whereas tenants benefit from the reduced costs of energy consumption. Landlords are therefore more reluctant to implement building refurbishments.
- **Regulatory requirements for the conservation of culturally significant buildings**—this was frequently cited as a reason for not refurbishing (as external insulation is not allowed, and interior insulation is also rarely considered). This was mentioned numerous times by stakeholders in Baden. The city of Baden, especially the old town area, is of significant historical value, and most of the old buildings are owned by the city. The difficulty of implementing

insulation and other low-carbon energy measures due to historical conservation regulations makes the reduction of energy demand in public buildings challenging.

- **High transaction costs relative to benefits**—the administrative requirements for publicly subsidised refurbishments were also described as “cumbersome and exorbitant” thus discouraging stakeholders from making use of this policy option. This is particularly so for larger-scale enterprises, for which the available subsidies are deemed too small relative to the administrative requirements involved. Respondents also noted that low energy prices disincentivise the adoption of low-carbon investment options.
- **Adverse tax incentives**—the *Pendlerpauschal* (commuter allowance), for example, gives citizens tax relief on the costs of commuting from home to their workplace, thus “encouraging” them to live further away from their workplace instead of limiting their mobility. The current property tax system was also deemed inadequate by stakeholders. Property taxes in Austria are paid when a property is purchased, not as an ongoing yearly tax, and this also disincentivising citizens from moving closer to their place of employment.
- **Policy uncertainty regarding the continuity of nationally extended subsidies (e.g., biomass)**—uncertainty regarding the economic feasibility of biomass was the most frequently mentioned barrier in KEM Freistadt: biomass subsidies are scheduled to expire after seven years, after which the production of biogas will no longer be economically feasible. Local respondents called for an overhaul of funding instruments, such as an extension of subsidy schemes or

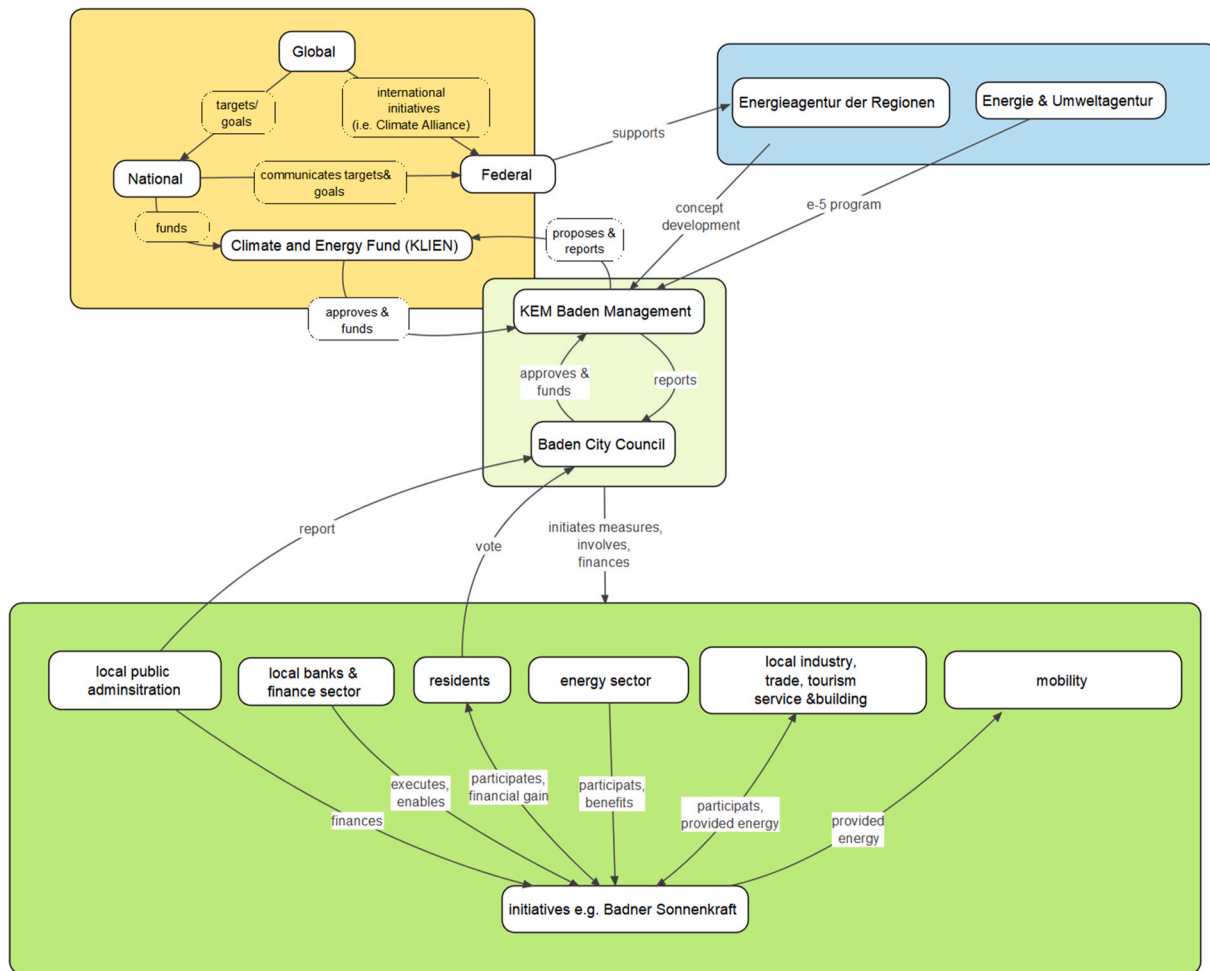


Fig. 4. Stakeholder mapping for KEM Baden.

implementation of other schemes to make renewable energy more competitive with fossil fuels, as well as integration of biogas into the gas network.

- **Federal supporting agencies**— in the state of Lower Austria, the federal energy and environment agency (*Energie-und Umweltagentur*, ENU) offered significant support to the KEM regions undergoing the KEM quality management and, within this process, consulted with and supported the KEM management. The cooperation and consultation with the federal energy and environment agency was mentioned by the region’s policymakers as one of the contributors to KEM Baden’s success. A state-level stakeholder in Upper Austria also emphasised the usefulness of the KEM audit as a tool for consultation and discourse during which KEMs can discuss and find solutions to difficult problems.

Respondents also noted KEM program-specific barriers, including:

- **Short funding cycles (three years)** which prevent KEM managers from submitting proposals for lengthier but more far-reaching projects. While originally the scheme was funded in two-year cycles (to which the three-year funding cycle is regarded an “improvement”), the cycles are still perceived as being too short. Several stakeholders further mentioned that such short funding cycles, including the funding of a part-time position for the KEM manager, either (i) create “insecure employment outlooks” for the KEM manager and are thus unattractive for established professionals, or (ii) limits municipalities to their availability of established organisational structures. The

KEM manager in Baden, for example, is also employed by the City of Baden as an energy and climate officer.

- **Requirements for co-funding means that municipalities are required to contribute 1 Euro per capita to the KEM region’s funding.** Public-private partnerships paying membership fees, were once encouraged within the KEM scheme, but have now been disallowed. In Upper Austria, KEMs are classified as a club or an association under the municipal public spending guidelines. This puts funding of KEM membership in direct competition with other socially and culturally valued activities.

In addition, several respondents cited state-level barriers and enablers including:

- **The lack of a federal-level supporting agency in Upper Austria,** was mentioned as an additional challenge. Having no direct connection to decision-makers at the national level creates additional conflicts as the *Energiesparverband*, or energy saving association, competes for funding with the KEM region.

Overall, the majority of respondents considered that regulatory measures should be established at the national and state levels to facilitate the promotion and integration of local goals. Respondents frequently noted the need for clear and binding climate mitigation strategies at the federal or state levels and the willingness of the relevant authorities to enforce mitigation measures in high-emitting sectors as a prerequisite for a local energy transition.

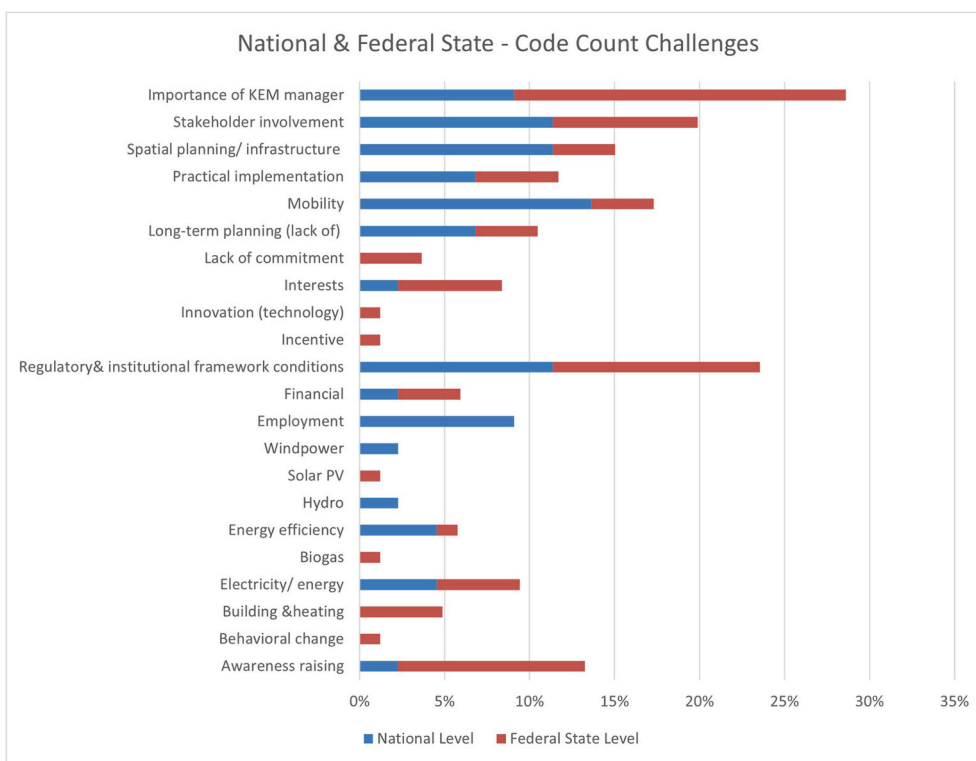


Fig. 5. Challenges according to mentions within the key stakeholder interviews at the national and state level. Percentages are indicated in relation to total number of codes.

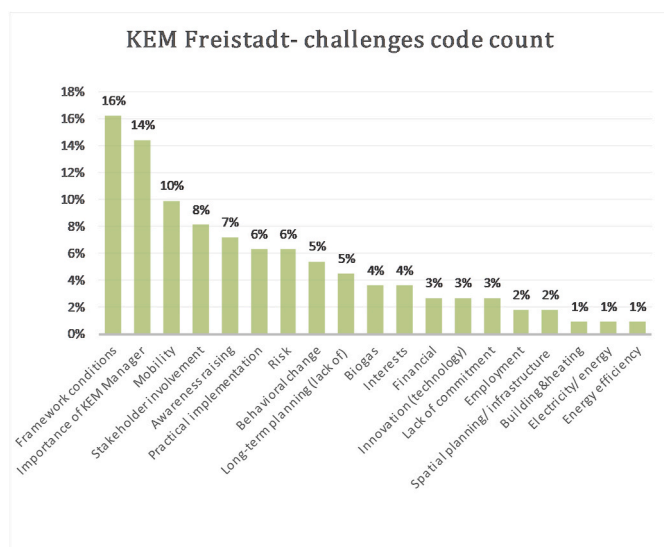


Fig. 6. Challenges according to mentions in the key stakeholder interviews in the KEM Freistadt.

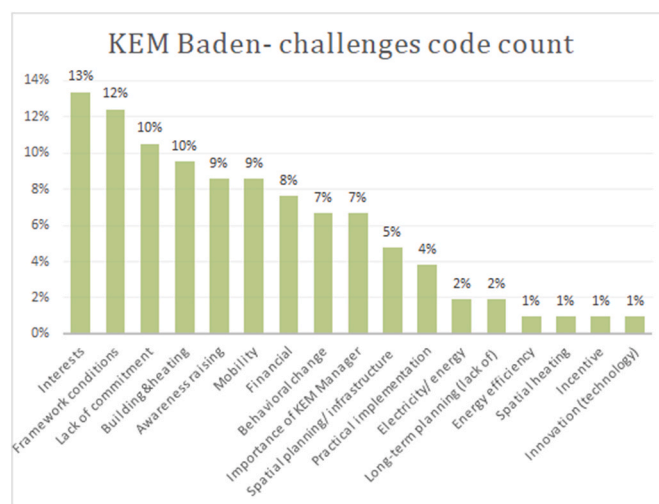


Fig. 7. Challenges according to mentions in the key stakeholder interviews in KEM Baden.

5.2.2. Regional innovation and actor engagement as barriers and enablers

The involvement of local politics and awareness raising were both reported to be a strength of the KEM program. However, interventions by local vested interests are seen as barriers in some cases. Both KEM Baden and Freistadt have undertaken successful awareness-raising campaigns across their regions at community venues such as schools and kindergartens, and have put on film festivals focused on climate issues. Both KEMs have facilitated low-carbon activities beyond simple awareness raising, through extensive networking/lobbying that facilitates the social entrepreneurship of citizens and local businesses. These

were further supported by actors within a narrow institutional void.

Key findings of enablers and barriers relating to regional innovation and actor engagement are as follows:

- **Engagement of political actors**—the involvement of local political actors in the KEM implementation processes was seen to be especially important, as local policymakers have the capacity to pass on lessons learned to higher political levels through their party and other political affiliations. At the same time, local political actors were seen as hesitant to act on contested, but sometimes necessary, legislative or policy measures and to support investment options that extend beyond a legislative session.

- **Innovative financing options**—The HELIOS GmbH citizen-participation model for investment in PV installations in KEM Freistadt was developed out of a need for funding. A crowdfunding law was later passed (2015) (Bundesrecht, 2015) at the national level to address the lack of financing instruments to support these social entrepreneurships.
- **Well-connectedness of KEM managers**—trust in KEM managers is frequently cited as being a major enabler of the KEM program. For example, due to the effective communication and networking facilitated by the KEM manager in Freistadt, all the municipalities agreed to provide public e-mobility parking, which enabled the regional energy provider to install charging stations. Another example regarding the importance of networks is the case of the crowdfunded solar panel scheme organised in the KEM Baden.
- **Local entrepreneurship** was also observed in the case of KEM Baden which a similar challenge, with the implementation of a crowdfunded solar PV project. KEM Baden originally planned to finance the installation of solar PV panels for local, mostly public, buildings, with residents being able to contribute to one or more solar panels, starting with small investments of €500. This project was in the final planning stages when it was denied by the Financial Market Authority (*Finanzmarktaufsicht*), because KEM had no banking license. Through the close connection of the KEM manager to regional stakeholders, including the local bank, the KEM developed a program of crowdfunding of individual PV panels that could be funded by opening a savings account. This was possible because of the semi-independence of local banks regarding small projects and the trusted network of local social entrepreneurs who were able to creatively circumvent the regulatory barriers.

At the same time, local vested interests are seen as significant barriers including:

- In KEM Baden, measures that limit individual transport within the city are often met with opposition, as businesses fear this will lower sales.
- Larger private corporations are reluctant to invest in longer-term low carbon investment, while public enterprises, such as public car-sharing services, or public building management companies, are better able to develop strategies and act on long-term plans.

6. Discussion

Our analysis of barriers and enablers in regional innovation systems indicates that existing institutional policy and regulatory framework conditions at the national and state levels significantly influence the transformative capacities of the KEMs. At the same time, our conceptual framing suggests that local agencies are key to overcoming the many challenges encountered. We also found evidence that as all these factors interact to foster low-carbon transition, an integrated framework of multi-scale actors, landscape, and institutional dynamics provides a promising analytical framing.

Both KEMs faced significant implementation challenges connected to inefficient, uncoordinated, and sometimes contradictory legal, policy, and institutional framework conditions at the federal and national scales. A major reason for this is the relative lack of autonomy that regional governments have in setting their own policy and governing their own resources. Yet this level is regarded as an essential seedbed for regional innovation and transformation. Challenges to mitigation and adaptation measures were also mentioned regarding the absence of policy integration both horizontally and also from national to the state level. This is similar to observations made in numerous other studies (Schaffrin et al., 2014; Clar, 2019; Steen et al., 2019; Steurer et al., 2019).

The importance of cross-scale interaction and vertical policy integration, and institutional collaboration, in defining different transition

pathways is well established in the transition management literature (Foxon et al., 2010). Our analysis strongly indicates that collaboration and support at the state level are essential facilitators of local-level implementation and vertical policy learning. This is observed in the difference between KEM Baden, where project planning, monitoring, and implementation are supported by state energy and environmental agencies, and KEM Freistadt which faced coordination issues because it lacked support at the state level.

Counteractive regulatory settings further underline the need for policy integration. As seen in the so-called *Pendlerpauschale*, or commuter's allowance, taxpayers are granted tax relief based on the distance between their home and their workplace. The argument that poor policy integration hinders (local) implementation of energy-transition measures is not new (Cooke et al., 1997; Späth and Rohrer, 2015; Faller, 2016; Hildingsson and Johansson, 2016). Our study also pointed out the importance of local innovation (fostered by a narrow institutional void) to circumvent the challenges posed by higher levels of government. The semi-autonomy of local banks (i.e., local bank directors have a degree of independent decision-making authority), allowed KEM Baden to devise an innovative PV funding scheme that circumvented federal state and national regulations relating to risk.

Both KEMs have succeeded in establishing successful solar PV cooperative initiatives with the active involvement of residents and local businesses. In the two cases, the involvement of local as opposed to federal or national banking actors was key to the initiatives' success. This supports previous findings on the importance of local networks and social entrepreneurship (Jolly, 2017; Gui and MacGill, 2018). The importance of these networks was also seen in Freistadt with the establishment of a district waste association (*Bezirksabfallverband*) (Gui and MacGill, 2018), in which banks also served as entrepreneurs or regional champions, providing legitimacy and security to these schemes. Heiskanen et al. (2010) found that assurance for collective actions, where early actors are assured that other actors will act later, have great potential to minimise social dilemmas. Our findings indicated that the involvement of financial sector actors has served to assure the project and encouragement to action in both KEMs.

The role of an active and engaged KEM manager also emerged as necessary for the involvement of an array of actors and the subsequent success of the KEM. These findings closely correspond with those of Mattes et al. (2015) who found a significant reliance on key established individual actors. The KEM managers were both reported to be knowledgeable and experienced in navigating around and through institutional, policy, and regulatory framework conditions, and were well connected to the community-level stakeholders. The importance of KEM managers, as identified in this study, further underlines the necessity of intermediary subsystems to further regional socio-technical innovation, as observed by Mattes et al. (2015).

In general, we found that despite the current restrictions, the KEM program offer significant benefits to community low-carbon transition in Austria. KEM managers work across regions and are instrumental in connecting actors and attracting funding for large-scale projects. At the same time, KEM managers, while very capable of implementing large energy-transition projects under the right conditions, are significantly limited by national- and state-determined framework conditions. The KEM program aims to enable and empower regions to move toward low-carbon transition and energy independence. It does, however, lack one of the three aspect of empowerment proposed by Avelino et al. (2019): namely, autonomy, competence, and relatedness. Our study indicated that while competence and relatedness are being furthered, the limited capacities of local autonomy represent a major weakness of community-based energy transitions in Austria. This strengthens the argument for vertical policy alignment, while allowing for greater flexibility in local decision-making and implementation.

7. Conclusion and policy implications

In this study, we illustrated that the complexity of societal transformation is mirrored by the complexity of coordination between different policy and implementation levels. We focused on the Austrian multi-level and multi-actor governance structure in the context of the low-carbon energy transition, which requires learning and adaptation on the part of national, state, and regional policy scales, and of several cross-scale institutions and actors. While responsibility for policymaking with a high potential for systematic transformation lies mainly at the national and state levels, policy implementation is largely carried out at the regional and municipal levels. Thus, despite several successful project implementations at the local level, a gap was observed between the implementation level and the policy level.

We studied the emergence of such enablers and barriers in two KEMs, adopting the RIS approach suggested by Mattes et al. (2015), which we extended to include aspects of multi-scale governance and institutional frameworks, together with environmental, social, and geographic dimensions.

Testing this approach, we found the legal, institutional, and regulatory framework conditions, set at the national and state levels, to be the greatest barrier to the implementation of energy-transition measures in the KEMs of Baden and Freistadt. These conditions were either generally incompatible with the efforts made toward energy transition or created barriers that prohibited the KEMs from accessing the funds and support necessary to implement their plans. Furthermore, our analyses indicated that these challenges emerged from a lack of horizontal or vertical policy integration and insufficient policy learning, which led to incompatible policy measures at the national and state levels. Two of the most challenging transition sectors in recent years—mobility and housing—were reported to be related to these restrictive framework conditions. We observed the development of capacities of policy learning and adaptation in regard to financial regulations. However, other policy instruments, connected to established path-dependency, have not been addressed despite consensus on their incompatibility with energy transition goals.

While these framework conditions created a barrier to many implementation measures, we also observed that in both regions, cooperation with financial actors from local banking branches helped to overcome those barriers. This often enabled institutional spaces to be circumvented and operations that took advantage of institutional voids, such as in the case of the KEM Baden solar PV project. In both KEMs, successful citizen cooperatives were created for solar PV installations, which were enabled by partnership with local banks. The local networks of the KEM managers were vital for the involvement of local banks. This underscored the importance of the KEM manager within the regions, as noted repeatedly in most interviews; the KEM manager's role as a social entrepreneur could be seen in the implementation of a range of schemes, including the solar PV cooperatives. It also worth noting that while the literature on regional innovation and transitions focuses on regional financial autonomy and cooperation with industry as an essential part of the implementation of regional innovation and transitional measures, the role of semi-autonomous regional financial institutions in enabling success has received little mention (Cooke et al. (1997); Steen et al. (2019)). This indicates that regional-level implementation schemes, such as the KEM program, do indeed have potential for the implementation of practical energy-transition measures, as long as they are provided with appropriate framework conditions.

Our findings further highlight the importance of understanding regional and local level implementation within the constraints of governance scales, geography, and capacity to implement transformative measures. This study shows that transformation cannot be accomplished by local implementation alone but that local capacities must be enhanced and fostered by national and subnational policy spheres. The KEMs studied presented different socioeconomic, ecological, and spatial characteristics. We found that KEMs were able to utilise

those characteristics for innovation such as the implementation of RE projects. Yet in other cases, such as spatial distribution of infrastructure in rural areas, these characteristics presented challenges for low-carbon transport.

While the RIS approach certainly offers a valuable framework for studying regional innovation and implementation of the energy transition, we found that the consideration of institutional and legal variables at the national and state levels offered crucial insights into the multi-scale complexity of regional innovation systems. We therefore recommend that future research build on this premise and seek ways to expand this framework by including a focus on national and state-level actors and subsystems, in addition to regional level investigations.

In this study, we chose two successful KEMs for our analyses. Their success can be attributed in large measure to the connectedness of their KEM managers, both politically and across sectors, as well as their interest in regional government. While these case studies, due to their equal levels of success, produces valuable insights, we suggest future research should investigate less successful KEMs or similar regionalised implementation programs.

CRedit authorship contribution statement

Jenan Irshaid: Methodology, Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Junko Mochizuki:** Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition. **Thomas Schinko:** Conceptualization, Methodology, Data curation, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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