Urban Transformations

https://doi.org/10.1186/s42854-026-00092-2

Article in Press

Cities as laboratories for the energy transition

Received: 9 March 2025

Accepted: 20 January 2026

Published online: 05 February 2026

Cite this article as: Laborgne P. Cities as laboratories for the energy transition. *Urban Transform* (2026). https://doi.org/10.1186/s42854-026-00092-2

Pia Laborgne

Cities as laboratories for the energy transition

Keywords: energy transition, cities, scope of action, MLP, sociotechnical niches.

Abstract

Cities are at the forefront of the energy transition, playing a pivotal role in shaping the way we generate, consume, and manage energy. At the urban level, frictions in the energy regime and specific local constellations can open space for experimentation with energy system innovations with the potential to transform the energy regime beyond the local context. This paper proposes that urban stakeholders not only adopt novel strategies and technologies, positioning cities as testing grounds and pivotal sites for implementing change but also innovate and explore new methods to improve energy efficiency, alter energy consumption patterns, and innovate energy production.

Focusing on the local scope of action and the urban level as a level for experimentation, this paper applies the multilevel perspective (Geels 2002), which analyzes transformations as an interplay of three different levels: landscape, regime, and niches. The results are based on case studies in two metropolitan areas in Germany, Frankfurt/Main and Berlin. Starting with a literature review on the role and scope of actions for cities, it presents and discusses findings from qualitative guideline-based actor and expert interviews, providing insight into the assessment, experiences and perceptions of key actors of the local energy systems of these two urban areas.

The results highlight the scope and fields of action of cities and highlight the high potential for local experimentation as well as existing challenges and barriers.

Science highlights

- Energy system transformation is a complex socio-technical process and collective effort, with cities as key arena.
- Local actors differ significantly in how they perceive cities' ability to shape, frame, and implement the transition.
- Arguing efficiency against local action ignores the value of experimenting and embedding transitions locally.

Policy and practice recommendations

- Cities face limits to experimentation; secure space for local, transdisciplinary action is needed.

- Traditional governance hinders local sustainability experimentation and is a key lever.
- Key success factors in Frankfurt were transversal administration, networking and an intermediary.

1 Introduction

Having started in Germany in the 1980s, gaining pace in the 1990s and then again after the Fukushima events in 2011, the German energy transition is a long-term sociotechnical transformation process and a central societal challenge and task (Kühne and Weber 2018; Laborgne and Radtke 2023). As such, it was defined as a "collective effort" by the German Ethics Commission in 2011 (Ethik-Kommission Sichere Energieversorgung, 2011). Much earlier, the question of energy was already depicted as a "cultural and socioeconomic cardinal issue" by Max Weber, among others (Radtke and Canzler, 2019, p. 2).

The transformation of energy systems requires both technical and social transitions and, in turn, has an impact on both levels. Environmental problems are not seen solely as expressions of inappropriate technologies but as complex sociotechnical systems (Monstadt 2007). Transforming the energy system is a complex system innovation that involves a combination and interplay of technological innovation, social innovation and infrastructures in which they are embedded (Schneidewind and Scheck 2013). A purely technocratic approach will fall short, as choices of technologies and behavior are culturally framed and need an integrative approach (Renn et al. 2020).

The article first highlights key areas of influence of the energy system on urban areas as well as areas of influence at the local level with respect to energy policies and transitions. Then, it will introduce the theoretical lens of the research underlying the article, the Multi-Level-Perspective with a focus on sociotechnical niches, and finally presents the results of case studies in two cities, Berlin and Frankfurt Main regarding the local scope of action of cities.

1.1 Cities and Energy

The design of urban infrastructure is a key element in the development of a city and an important starting point for increasing its sustainability (International Energy Agency IEA 2019; Monstadt, 2004, 2007; Moss et al., 2011). On the one hand, it significantly affects the utilization of resources and thus the extent of resource consumption; on the other hand, it influences the economy and social participation.

The urban energy infrastructure has three key areas of influence (Monstadt 2007):

- It influences and interacts with almost the entire production process, services of a city and areas such as social infrastructure as well as individual social behavior and wellbeing.

- It plays a key role in the local and regional economy: energy suppliers are among the most important local employers and investors. Another important aspect is the burden of rising energy costs, which are becoming a budgetary risk for many municipalities;

- It determines a significant part of urban metabolism

The chances of realizing sustainable spatial development therefore depend largely on the development of supply and disposal systems (Monstadt 2004).

Energy policies increasingly shape local societal conflicts and disparities regarding energy justice (Sovacool 2019), social acceptance (Laborgne and Radte 2023) but can also set frames for community building and empowerment (Bögel et al 2023; IEA 2023; Leonhardt et al 2022). Energy has the potential to create and strengthen communities in various ways, fostering social connections, cooperation, and collective action.

The municipal level plays an important role in achieving the goal of more efficient resource utilization and mitigating climate change (Hoff 2021; Rohracher and Späth 2017), and since the years 2000, the local level, especially cities and regions, has been seen as the central level for implementing energy transitions (Laborgne 2023; Mattes et al. 2015; Rohracher and Späth 2013; Selvakkumaran and Ahlgren 2017). Municipalities are consumers and role models, on the one hand, and planners and regulators, suppliers and providers, on the other hand (Hoff 2021; Kern et al 2005). The Rio Conference of 1992 emphasized the importance of municipalities and called on them to initiate a local Agenda 21 through consultation processes.

Urban centers, in which a growing proportion of the population lives and where the consumption of resources is spatially concentrated, are particularly important for the ecological transformation of societies (UN - HABITAT 2016). Moreover, they are important drivers of sustainable development (Monstadt 2008) and social change. Simmel, for example, describes large cities as economically and productively cultural places that have always provided society with decisive dynamic impulses for further social change (Simmel 1903).

While local communities act in a framework defined by national and European policies, on the other hand, the European Charter of Local Self-Government (1985) and Maastricht Treaty (1992) set cornerstones for “safeguarding and reinforcement of local self-government” (Council of Europe, 2016: 10). In Art. I-11 para. 3 of the Treaty of Maastricht, the principles of proximity to citizens, subsidiarity, and local self-government are laid down (Laborgne 2025). With respect to the affairs of the local community, the German Basic Law guarantees Article 28 (2): GG extensive regulatory freedom to municipalities within the framework of laws and concerning matters that are rooted in the local community or have a specific reference to it (Hoff 2021). A distinction is made between the voluntary and obligatory tasks of the municipality. The latter include

areas such as urban land-use planning, land development, urban development, urban redevelopment, and housing promotion (Ibid.).

Since the 1990s, far-reaching transformations of urban energy infrastructure systems have occurred: changes in the technical structure, service structure and urban governance structure.

At the level of technical structures in particular, an increase in the importance of decentralized systems can be observed. Traditional energy supply structures are heavily based on centralized systems and are now faced with new players, constellations and technical challenges. Decentralized systems provide new impetus to questions of social acceptance; on the one hand, they tend to be closer to the living space of energy consumers and therefore more perceptible; on the other hand, microsystems require active acceptance in the form of investment and use by the consumer (Wüstenhagen et al. 2007; Laborgne 2025). Another area is the increasing demand for more resource-efficient technologies and products.

For a long period of time, the state or state-affiliated provision of all sector-relevant supply and disposal services by regional monopolists was the norm. However, a change in service structures began in the 1990s. Many public companies were privatised, or their supply and disposal tasks were delegated to private actors (Monstadt and Schlippenbach, 2005). Service structures have also changed due to new environmental regulations, resulting in the emergence of new sectors of the environmental economy. An important aspect here is the more active role of consumers, who now have a choice of providers and can get directly involved in the provision of services such as electricity and heat production.

While traditionally, federal states and municipalities have directly controlled the provision of infrastructure services (at least in terms of entitlement) or were directly involved in the production of sector services in the form of public companies, services have been increasingly privatized. Currently, a recommunalisation is taking place (Hoff 2021).

The traditionally decentralized regulation of infrastructure is also being supplemented by national or European regulatory institutions. A significant change in urban governance structures is due primarily to the demand for ecological resource management. In view of the relatively limited regulatory control resources of the federal states and municipalities, governance is strongly characterized by the need for cooperation with different actors.

Focusing on the example of Germany, this paper analyses the scope of action of cities in the field of energy and how cities act as laboratories for the energy transition, developing and implementing it in different ways. Transitions are defined here as "long-term structural transitions from an existing to a new - or to a more sustainable sociotechnical regime" (Konrad et al. 2004: 9). Cities are a key level for the fulfillment of central societal functions such as the provision

of energy and heat (Schneidewind and Scheck 2013) and for the interaction of the corresponding sociotechnical systems (Rohracher and Späth 2017; Schneidewind and Scheck 2013).

The hypothesis is that there are very different development paths depending on the local context, opening room for negotiation, experimentation and the embedding of transitions. Cities can be seen as “heterogeneous arenas for sustainability transitions” (Rohracher and Späth 2017: 287). National goals and strategies are not simply adopted but renegotiated, transformed and adapted in the local context (Sturm and Mattissek 2017).

The analysis is framed by the multi-level perspective (MLP) according to Geels (2002), which explains change in sociotechnical systems through the interplay of three levels: the superordinate landscape, the regime as the level of dominant structures and the niches as the level of experimentation and change (Geels 2002; Geels 2004; Geels 2005, Geels 2007). The presented case studies focus on such local niches.

Capturing the multidimensionality of change, the multiplicity of actors and their embeddedness in social contexts with different technical and social elements are the main advantages of MLP. (Rohracher and Späth 2009; Laborgne 2023).

1.2 Theoretical background

There are basic principles from historical technology research and approaches from social science innovation research, which, on the one hand, analytically describe the object of investigation, energy infrastructure, as a social system and its characteristics, such as path dependencies and inertia (theories of large technical infrastructures, e.g., Hughes 1993), and, on the other hand, analyze how a transformation of these systems takes place. The present work draws on the multi-level perspective of Geels (2002), which explains change in sociotechnical systems through the interplay of three levels: the overarching landscape, the regime as the level of dominant structures, and niches as the level of experimentation and change (Geels 2002; Geels 2004; Geels 2005, Geels 2007). These levels constitute a nested hierarchy, with regimes situated within the landscape and niches embedded within the regimes. According to the MLP perspective, the occurrence of change is the result of dynamics on the three levels coming together and reinforcing each other (Geels 2004; Verbong and Geels 2007). Transition is defined as a change from one regime to another (Geels 2007) or as "long-term structural transitions from an existing to a new - or to a more sustainable sociotechnical regime" (Konrad et al. 2004: 9). The work presented here focuses on the niche level as well as the bridge between the niche and regime. A specific aspect of this paper is the agency at the local level, i.e., the capacity to act (Duygan et al 2019; Giddens and Sutton 2014).

The MLP combines different theoretical approaches that complement each other (Geels and Schot 2010). Originating from STS and evolutionary

economics, it also refers in particular to Giddens' theory of structuration, in which actors take up space as in STS but whose actions are analyzed more strongly as being shaped by rules and social structures. The actions of actors are embedded in rules (norms, cognitive rules) and resources (control over things and people). However, both exist only through their reproduction in social practice, so although they structure action, they are themselves structured by it (Giddens 1984). Actors actively utilize rules and resources, and their actions are guided but not determined by them; there remains room for maneuvering, which leaves room for change and variation and therefore local experimentation.

Evolutionary economics contributes, in particular, to the perspective of long-term developments and dynamics at the macro level as well as the idea of niches, which has its origins in biology (Geels and Schot 2010).

Geels and Schot (2010: 52) summarize the contributions of the three perspectives: *"STS focuses on relations between actors and sociotechnical systems/configurations. Structuration theory and neo-institutional theory articulate relationships between actors and structures (regimes). And evolutionary interpretations make a particular cross-section of socio-technical configurations, focusing on interactions between variation and selection environments within".*

The MLP is defined as a process theory (Geels and Schot 2010).

The analytical levels of the MLP – landscape, regime and niche – do not correspond to geographical levels. Cities are sites for the interaction of these levels in concrete implementation contexts with specific constellations (see also Rohracher and Späth 2017) and high social density and spatial proximity as well as closeness to the users of energy. This makes them a privileged level for embedding transitions (Ibid.) and for experimentation and learning.

1.2.1 Sociotechnical niches

This article particularly refers to the concept of niches. The term originates in biology (ecological niche) and is related to factors of development and survival (living conditions, the role of a species, and the relationships of a species with its environment). It was introduced into the economic sciences as a market niche by Schumpeter (1912).

Currently, the concept is widely used in the transition literature and is related to a protected space for the development and testing of new things, learning processes, and network formation research due to concepts such as niche management and the MLP.

In the MLP, niches are regarded as the level of radical changes that deviate from the prevailing regime structures (Laborgne 2023; Konrad et al. 2004). They represent "local development and application contexts for special forms of technology" (Konrad et a. 2004: 12, translated by Laborgne 2023). This is

where “innovations can develop, learning processes can take place and new social structures can emerge” (Laborgne 2023: 281). Smith and Raven (2012) identify three key properties regarding the protection of niches: shielding, nurturing and empowerment. In the analysis of the transition approach, technological transitions (TTs) are based on them (Geels 2002, Konrad 2004; Smith 2007), although they require appropriate conditions at the landscape level and openings at the regime level.

Different types of niches are described in the literature, which differ in terms of their nature and the conditions under which they arise/contextualize. On the one hand, there are technical and institutional niches (Hoogma et al. 2002; Konrad et a. 2004) and "natural" and "artificial" niches (Konrad 2004). Späth/Rohracher also describe discursive niches, e.g., regional energy visions (Rohracher and Späth 2009). Niches not only nurture technical innovations but also change social practices, e.g., “new organizational approaches to fulfilling functions” (Laborgne 2023: 281; Hoogma et al. 2002).

This study specifically uses the term "sociotechnical niche" (Konrad et al 2004: 63). This expands the concept of technical niches. On the one hand, the focus is not specifically on technical innovations but also on organizational and institutional innovations. Technology is only seen as a possible "means of functional fulfillment" (Konrad et al. 2004: 16). This can even remain the same, while a transformation takes place at the organizational level (ibid.). On the other hand, on the basis of the concept of Konrad et al. (2004), attention is given to different structural dimensions that characterize the niches under consideration and distinguish them from the regime. In this concept, it is not a single innovation that is tested but the entire sociotechnical configuration (Konrad et al. 2004: 64)

On the basis of these extensions, the concept of the sociotechnical niche is defined for the study as a "specific local combination of structural elements" (Konrad et al. 2004: 64), in which new approaches to the fulfillment of functions, in this case, the supply and use of energy, are developed and tested (Laborgne 2025). The concrete local setting can thereby act as a “boundary object” (Schneidewind and Scheck 2013), with specific local goal setting and local constellations creating frames for real-life experiments (ibid.). In the work presented here, these are framed as sociotechnical niches. Technical as well as organizational/institutional and discursive niches are considered. They can be competitive with the regime, symbiotic or enhancing, protected or market niches, i.e., niches based on local conditions (Konrad et al. 2004).

2 Methods and case studies

The research project relies on case studies in Frankfurt/Main and Berlin, alongside a literature review and document analysis. Key data are gathered through qualitative interviews with local actors and experts, offering insights into their perspectives on energy policies beyond official documents.

The interviews were transcribed verbatim and analyzed with MAXQDA, following Gläser and Laudel's qualitative content analysis method (2010). This systematic approach extracts information via thematic categories, allowing for structured data reduction. Categories are initially developed on the basis of questions, assumptions, and theory and evolve throughout coding. New categories supplement rather than replace existing categories, ensuring openness in analysis. A second coding process was conducted.

The case studies focus on the timeframe spanning from the early 1990s to 2012, characterized by increasing awareness and engagement concerning urban energy issues (e.g., Capello et al., 1999). The Fukushima events in 2011 served as catalysts, further intensifying these efforts. Several interviewees regarded these events as a wake-up call, emphasizing the urgency for action. They leveraged these events and the ensuing discussions to strengthen their advocacy and secure essential resources for implementing their plans. Consequently, these incidents can be viewed as a "window of opportunity" for facilitating energy transitions (Laborgne 2023).

The two cities represent quite different contexts and strategies, as will be shown in the following case study introductions.

2.1 Case study Berlin

The study involved 16 interviews in Berlin, each lasting between one and 2.5 hours. The analysis included newspaper articles, Senate minutes, energy concepts, legal texts, and communications from various stakeholders. The interviewees represented state-level local politics (2), senate administration (3), major energy suppliers (Gasag and Vattenfall, 1 each), the Berlin Energy Agency (2), district administration (1 energy officer), environmental and energy associations (1 each), science/consultancy (2), the Federal Environmental Agency (1), the Berlin Climate Protection Council (2), and the Association of Municipal Companies (1).

Berlin, which functions as both a city and a state, holds substantial energy policy competencies. Governance involves the House of Representatives, the Senate, and district administrations, reflecting Berlin's unique municipal, associational, and state characteristics. The city's 12 districts serve as the implementation level for energy policy. Berlin's monocentral metropolis status, characterized by historically low regional exchange, notably impacts its energy supply sector. Despite joint energy strategies with Brandenburg, interviews underscored the differing interests of the two entities, with the metropolitan region perceived as having minimal relevance to Berlin's energy system.

With a population density second only to that of Munich, Berlin had nearly 3.5 million inhabitants residing in 892 km² in 2012. The city's high tenant population (approximately 85%) and below-average disposable income have earned it the moniker "tenant city Berlin." This characteristic poses significant

obstacles to climate protection efforts, as highlighted by interviewees and echoed in media discourse. Housing associations, accounting for 35% of apartments (2012), play a crucial role in shaping Berlin's energy policy landscape.

Berlin has pursued an explicit energy and climate policy since 1990 (SenGUV 2011). The basis at the time was the Energy Conservation Act passed in 1990, which was fleshed out in 1994 with the first energy concept. Although the process of institutionalizing energy policy planning had already begun in the early 1980s, it only gained significant momentum with the growing pressure to act on climate policy at the end of the 1980s and finally with the change of government to red–green (Monstadt 2004).

Berlin traditionally based a large part of its climate and energy policy on voluntary agreements. In the studied period, a key strategy of Berlin's energy policy was to "win over Berlin's business community as an active climate protection partner" (SenGUV 2011: 24), i.e., a cooperative form of governance. Examples of the implementation of this strategy include the Berlin Climate Alliance, which brings together Berlin's largest CO2 emitters. The members sign a voluntary commitment to contribute to CO2 reduction through specific projects. Companies (the energy suppliers Vattenfall and Gasag) are also involved in the Berlin Energy Agency. In addition, there are climate protection agreements with major energy suppliers and public companies. These agreements set out mutual obligations between the state and individual companies and associations and agree that specific activities contribute to CO2 reduction (Berliner Energieagentur 2011a). According to the Energy Concept of 2020, the instrument of climate protection agreements has established itself as an integral part of climate protection policy in Berlin (Berliner Energieagentur 2011b). In her evaluation of the Berlin approach of "climate protection partners", Ulrike Schlippenbach (2009) summarized the advantages and disadvantages of such a voluntary approach. On the political and administrative sides, for example, delays caused by lengthy legislative procedures are avoided, and there is greater acceptance of the measure and a corresponding willingness to follow up. The disadvantages include the risk of "free riders", a potential delay in any necessary regulations, possible compromise-related dilution and the uncertainty of predicting the results (Schlippenbach 2009: 54).

2.2 Case study Frankfurt/Main

In Frankfurt, 10 interviewees represent various entities, including the city administration (Energy Department and Energy Management), Mainova (the local public energy company), ABGnova (an intermediary institution created by the energy company Mainova and the public housing company ABG), the Chamber of Industry and Commerce (IHK), the Regional Association Frankfurt RheinMain, the Regional Council Darmstadt, and the State of Hesse (Ministry of Environment, Energy, Agriculture, and Consumer Protection). Official

documents such as city council resolutions, guidelines, and energy management data, along with information brochures and studies, form the basis of information.

With approximately 693,000 inhabitants across 248.3 km² as of the studied period, Frankfurt experienced population growth driven by migration and birth surplus. Known as a financial center since the Middle Ages, the city's economy, dominated by the service sector, employs 14% of its workforce. The security of supply for data centers is a top priority in Frankfurt's energy policy, particularly emphasized by respondents from the Chamber of Industry and Commerce and Mainova.

Networking among various actors, including administration, politics, science, business, and civil society, is crucial in shaping Frankfurt's energy policy. Efforts to foster cooperation within and outside administrative levels have been deliberate.

The precursor of Frankfurt's current energy policy was the establishment of an energy office in the 1980s (Laborgne 2025). Contextual factors approximately 1990, including municipal commitment and European-level discourses around climate protection, led to further institutionalization, notably with the founding of the "Climate Alliance of European Cities" in 1990. At the time, the creation of an energy office was not self-evident and sometimes controversial. *"Before that, if any energy process, any energy request came into the city administration, into the magistrate's, it immediately went into the municipal utilities file. And then, of course, the establishment of an energy department that was independent of energy sales, which is taken for granted today, was a minor revolution back then. The fact that people said, "No, we have our own people, they won't take any orders". At the time, we first took on the municipal utilities, also with the support of politicians"* (City administration F22).

A notable contrast to Berlin during the period in question was the presence of a publicly owned energy utility in Frankfurt, Mainova, resulting from the merger of Stadtwerke Frankfurt am Main GmbH and Maingas in 1998. Mainova had since expanded its sales territory, particularly in gas sales, and functions not only as a supplier but also as a producer.

Mainova's role is characterized in the interviews as one that executes targets, providing necessary instruments. Targets originate from various levels of governance, from politics to the city, while the company innovates and implements strategies to meet these objectives. While the city sets clear targets, Mainova, despite being primarily a private-sector entity, operates with a strong alignment with the city's goals, given the city's significant ownership stake of 75% (during the studied period). An interviewee noted, *"We are the executive body here in the sense of an extended arm. That's why I said earlier that we are actually a bit of an employee of the city - I also said " executing agent" to us earlier. In this respect, they* [the city] *have targets that they have*

to implement from above and can then apply them to us. If you don't have a municipal utility, it's kind of difficult".

A parallel with Berlin at that time was the shared ambition to regionalize energy policy. Despite this, the regionalization of energy policy in the Frankfurt Rhine-Main region was still in its early stages, as noted by the IFEU (2008) and Monstadt, Schmidt, Wilts (2012). Despite Mainova's municipal ties, its infrastructure is regionally positioned, especially concerning the gas network. The high volume of commuters and dense settlement in the Rhine-Main area underscore the interconnectedness of the Frankfurt with its region. Additionally, the city's reliance on the countryside for renewable energy sources highlights the symbiotic relationship between urban and rural areas.

The focal point of this article is the results regarding the perception of the scope of action for cities regarding the energy transition, with the objective of understanding how local stakeholders conceive, adopt and shape the role of the local level.

3 Results

3.1 Perception of roles and scope of action

The interviewees agreed that there is scope for local action in the area of energy policy. Municipalities are places to try out innovations in energy and climate protection policy, and *"if successful, can be disseminated relatively quickly via municipal networks*" (Energy Agency, Berlin). However, they assess and value this and the role of cities differently. On the one hand, there is a clear "think global, act local" (Local Politics, Berlin); Other interviewees see the local level as complementary to the federal and EU levels. However, one interviewee believes that there is some scope for action at the local level, but that the aforementioned higher levels are decisive and it is not reasonable to take action at the local level. In his opinion, only action in the local or state-building sector is feasible.

"*My thesis is that the local authority can no longer do much and probably does not need to do much because you have solved everything at the federal level.*" (Energy Company, Berlin)

The other interviewees also see the scope for legal action at a local level in regard to the federal and EU levels as clearly limited. Even the possibilities at the state level are viewed rather critically, at least as far as legal regulations are concerned. For example, the federal level is often simply faster, which can be attributed to greater competence resources, among other things.

"*In my opinion, this is always difficult when it comes to laws, and that has been my experience over the last ten years. I hardly know of any federal state that has really succeeded in passing a law here. Because the federal laws are already there. And, at the time when the individual municipalities are struggling with such laws, the federal government usually has similar laws on the way at more or less the same time*" (Energy Company, Berlin). In his view, it is therefore better to bundle the competence at this level and to avoid diverging regulations and standards, where ultimately, no one can see through.

The possibility that a municipality or federal state can act as a pioneer, as Baden-Württemberg has done with the Renewable Heat Act BW (EWärmeG), is not considered here.

Other interviewees see Berlin as a federal state with the ability to make legal regulations but not municipalities. Approaches such as the solar statute in Marburg are viewed skeptically in terms of their enforceability. However, competencies for such regulations are not consistently denied; for example, one interviewee sees local building law as an important lever, and the lack of binding building standards (going beyond the Energy Saving Ordinance EneV) is regretted several times. The scope for Berlin as a state was particularly apparent in the building stock, which is not regulated nationwide.

In the interviews, it is noticeable that in regard to the question of the scope of action at the city level, this question of legislative options is clearly in the foreground and appears to be the most controversial (even at the state level). However, other areas are also assessed differently. At the municipal level, the area of public real estate is mentioned as an important scope for action. This is also seen by the skeptical actor as a sensible local option for action. The area of renewable energy is generally mentioned, but the opportunities in Berlin are described as very limited.

One stakeholder is even critical of local projects in this area and believes that they should be coordinated nationally so that investments are made where the yield is highest. He fears a general lack of efficiency in municipal projects in the energy sector in terms of financial investment and the CO2 savings achieved. As a result, municipalities are not building sensible things but rather "nice" things:

"*There is a great danger that municipalities will do nice projects that are particularly pretty. Solar scooters, passive houses, making a school there. Building an energy mountain there. In other words, money is being invested that is far from optimal. From a purely economic point of view, I would always say that local thinking is reducing CO2 emissions savings... So the more you actually tend to do it regionally, as long as you don't focus on it properly, but run the risk of going for image projects, the more you run away from the overall optimum*." (Energy Company, Berlin)

The interviewee now suggested creating a nationwide fund with the resources that would otherwise be invested locally. This fund would then be used to support locally meaningful projects.

A critical question here would be whether the individual municipalities would pay financial resources that they invest locally in projects or funding programs into a nationwide fund. In addition, research on social acceptance in particular has shown that local embedding is an important factor for the success of strategies to increase the use of renewable energies (Jobert et al. 2007). While efficiency gains may indeed be conceivable with organization and distribution at the national level, implementation at the local level offers advantages in terms of adaptation and a greater diversity of directly involved actors and thus resources, particularly locally available experience and knowledge of the local context. However, this gives rise to interesting approaches to the sensible and desired degree of autonomy for municipalities.

In summary, how is the role of municipalities perceived?

While most interviewees see local authorities, and cities in particular, as having a responsibility to take the initiative and actively use existing scope for action, one stakeholder is also very skeptical about a pioneering role. You have to be careful, and it is difficult "*Because if you are the pioneer in something, everyone always accuses you of going overboard. And you have to be relatively strong in order to do something, especially if you do something different from the others, you can of course also be wrong*." (Energy Company, Berlin).

Others see large cities in particular as having a special responsibility:

"*So basically, cities are, in our opinion anyway, the most important players. In climate protection or energy efficiency. The figures are like this; they say that large cities consume 80 percent of the energy and also have CO2 emissions of 80 percent, so of course large cities are very important.*" (Energy Agency, Berlin)

There are many opportunities at the local level to save energy, for example. What is important here is "*the more concrete, the better*" (Energy Agency, Berlin). Cities can create pilot and demonstration projects on the ground that *“show people that something like this works, that it does not only have negative effects, but that there are also positive developments”* (City administration, Frankfurt).

Table 1 summarizes the key aspects and perceptions regarding the local scope of action.

Table 1 Key aspects and perceptions regarding the local scope of action

Key Aspects	**Description**

General perception of role and scope of action	Municipalities perceived by all interviewees as relevant arenas for experimenting with energy and climate innovations that can spread through local networks; Especially large cities are seen as relevant arenas for effective climate and energy policies. Understanding of the role and responsibility of cities varies widely among actors.
Relation to higher governance levels	Local action often considered complementary to federal and EU efforts. Some interviewees see limited necessity for local measures due to overarching federal solutions; others emphasize local autonomy and the importance of the “think global, act local” principle.
Legal scope	The most controversial dimension and biggest difference between Frankfurt and Berlin. Municipal capacity is limited, especially compared to state or federal levels. However, setting local building standards (e.g., beyond EnEV) are seen by some as key leverage points. Skepticism persists about enforceability of local statutes like Marburg’s solar ordinance.
Public sector as role model	Municipalities considered able to act as role models e.g. through their public buildings and real estate management. Even critics regard this as sensible local action potential.
Renewable Energies Implementation	Opportunities for local renewable energy projects acknowledged but are often perceived as limited (especially in Berlin). One interviewee calls for national coordination to avoid inefficient “showcase” local projects and to maximize CO_2 savings through optimal national allocation.
Efficiency vs. local embedding	Debate between efficiency (through national coordination) and local embedding e.g. important for social acceptance. Critics argue that local “image projects” may misuse funds relative to CO_2 reduction potential; Proposal of one interviewee for a centralized national fund to distribute resources efficiently across regions. Local implementation on the other hand enables citizen involvement, contextual adaptation, and trust-building, balancing economic optimization with local agency and legitimacy.
Pioneering role	Some actors warn against being “too pioneering” due to political risks or potential criticism; others highlight the responsibility of large cities to lead by example in decarbonization, given their energy consumption and

	emissions, as well as the potential to develop and test new solutions locally.
Experimentation, pilots and demonstration	Local experimentation, demonstration and pilot projects are cited as vital instruments to make transitions tangible, learn, build confidence, and provide positive examples (“show how it works”).

3.2 Key factors influencing the scope of action in the perceptions of the interviewees

The interviews and contrast between the two case study areas make it clear that the scope of action varies strongly with respect to the local context conditions. These framework conditions and transition processes are characterized by specific inherent logics and spatial characteristics, e.g., financial situation, the local economy, infrastructure, ownership structures and the urban fabric, as well as local society, energy governance and energy history.

Cities find themselves in a tight corset of framework conditions that differ, e.g., regarding “prosperous” growing cities such as the Frankfurt or shrinking or financially restricted ones. The financial scope, the existence of municipal utilities and a municipal housing association as well as the population structure were named important local factors for the respective scope of action of cities, the latter in particular with regard to the frequently occurring description of Berlin as a "tenant city" and the associated restrictions and problems.

The aspect of the "tenant city of Berlin" as a limitation of the local scope for action crops up repeatedly in the interviews. The argument of a possible burden on tenants is not only seen as a legitimate concern but also partly as a pretext against stricter local standards. In contrast, the large housing stock of the local housing associations is seen as an advantage with respect to the scope of action in Berlin.

Berlin's financial situation is repeatedly cited as a major limiting factor. This applies not only to the possibilities of local funding programs but also to the implementation of local building standards in the public sector. The same applies to the lack of municipal utilities at the time of the study and the privatization of the energy supply. This and the limitation of local scope for action by federal legislation (in this case, in particular, the Federal Emission Control Act) becomes clear, for example, in the case of a planned new construction of the Klingenberg power plant, which was cited as an example by several interviewees. Although this was ultimately prevented, it was only possible through public political pressure. However, who or what exactly prevented the power plant and how this occurred are described differently in the interviews.

The situation is similar in the area of combined heat and power (CHP): *"We wanted to pass a climate protection law and we always had it in there, as an example, just to make it clear, we want heating plants, pure heating plants that have more than two MB* [megabite] *of output, thermal output, to be converted to CHP... It is simply not possible, even if it is nonsense to plan like that, because these are plants approved under the Bimsch Act and it would be unconstitutional to demand something like that. This is the problem. All you can do is make appeals and support programs and who knows what else. That will not work. So we would be entering a terrain that would be extremely dubious from a legal point of view and would then only be contested."* (Federal Administration, Berlin)

The area of CHP is, on the other hand, cited as an example where Berlin, as a state, has successfully exerted influence at the federal level. However, this is not possible for a municipality, at least not as directly via Federal Council initiatives. The municipal level has the opportunity to exert influence via pilot projects but also influences legislative processes via municipal associations.

Despite having less legislative scope of action, Frankfurt has developed a strong CHP strategy and implementation. The density of Frankfurt and having power plants in the city are cited as decisive factors that facilitate the implementation of CHP. On the other hand, the issue of security of supply is put forward as playing a major role in Frankfurt. *"There's the fact that they have to guarantee banking locations, data security, everything. This means that Frankfurt's energy policy must always prioritize the issue of security of supply,* i.e.*, safety"* (energy supplyer).

A key factor for local action is the actor constellation and the existence of local "promoters of change" and their cooperation. In Berlin, an interviewee from the administration stated, *"One central point is of course money, finances. But the second is just as crucial, I think, that in many cases it depends on actors and ultimately individuals who make something like this, yes, their own cause. If you don't have these pushers, then not much will happen"* (National Environmental Administration). Another interviewee of the administration in Berlin stated: *"We can decide a lot, but what is then actually implemented on the ground is always a question of people coming together and really getting things moving and not just talking about an issue"* (Administration of a City District, Berlin). Additionally, an interviewee from the administration in Frankfurt stressed this as a key point for success: *"It needs promoters in politics, it needs promoters in the administration, that is a very difficult thing, because they do not always develop something like that on their own, and it needs promoters, so to speak, in the area that you can call, yes, a bit diffusely, planning and urban development"*. This corresponds to findings in the literature on local climate action that highlight the role of key local actors and their interplay (Hörter et al. 2018). On the one hand, there is a need for changes in governance structures, adequate personal resources and strong support from the head of administration. This is expressed in a statement from a stakeholder in the administration in Berlin: "*My impression is also that the administrations are not,*

I would say, adequately staffed in terms of numbers and content. They're all trying very hard, but I think that is a huge problem if you look at the long term, what's needed there, that can no longer be done with traditional governance structures. So, I would also be very much in favor of having a combined Senate department that focuses on energy and environmental issues or energy, environmental and climate issues in Berlin And it should also be given a high level of authority to assert itself and, if you like, be supported by the Governing Mayor" (Energy Expert, Berlin). On the other hand, there is a need for a culture of cooperation, close cooperation with and between initiators and accelerators, a well-organized local network and a process that is constantly finding and integrating new points of contact and relevant actors (Ibid.). Frankfurt seems to be a good example for building on network creation and local cooperation. As highlighted by numerous interviewees, effective networking played a crucial role in shaping Frankfurt's energy policy. For example, an administrative interviewee noted that *"our strength truly lies in this [networking] now in recent years, - as in soccer sometimes - in the interaction" (Energy Management, City administration of Frankfurt).* Both within and beyond administrative spheres, deliberate efforts have been made to promote networking and collaboration among various stakeholders. An interviewee active in the local sustainability council described the constructive atmosphere as a decisive factor. *"I can truly say that from this sustainability advisory board that I sit on. It is incredibly constructive, there's very little - well, I do not notice any typical political trench warfare, I hardly ever experience that here, it is truly extremely unusual and it is actually incredibly creative in terms of finding solutions. I'm not just saying that to praise anyone, but I find it truly striking. Completely amazing. And that's actually - the arguments are always factual, the content is always very self-critical, incredibly self-critical, even in the city council, so when you see, simply the people who act there, first of all, I have to say, they are really really good, incredibly reflective and absolutely relevant. I do not know why there is so little cult of personality in Frankfurt. There is - so it is unbelievable in the matter and incredibly little according to the motto: because it is me. Therefore, it is really just great, you have to say" (Intermediary in housing-energy-habitation, Frankfurt).* He also noted that *"Frankfurt stands out from other cities because of a certain level of agreement, people are basically very united on many issues, which I actually find very unusual, I do not know that from the Federal Republic,* i.e.*, from other parts of Germany"*.

The perception from administration is slightly less uncontroversial regarding energy policy in Frankfurt but also describes good cooperation as the main factor for success: *"I believe that the success factor is definitely good cooperation between the political level and the administrative level. Communication and the fact that even when things get a little tougher and sometimes unqualified arguments come from outside, e.g., against passive house construction or against efficiency standards, that you do not fall over straight away, but instead stand up, have a bit of backbone and say: "We're going to stand by this and see it through" and have staying power. That is certainly a success factor,* i.e.*, good cooperation between the political and*

administrative levels and having staying power" (Energy Management, City administration of Frankfurt).

In Berlin, the Berlin Energy Saving Act provides for energy officers in the districts (BenSpG §20); these have been networked for several years in the working group of energy officers, which representatives of the administration and the districts rate very positively. "*In the past, there was hardly any communication, no contact whatsoever and nothing is worse than having to reinvent the wheels for certain projects, which is absurd. Now there is a lively exchange" (Senate Administration).*

Both cities have installed central intermediary institutions, the Berlin Energy Agency and ABGnova, a subsidiary of the local energy utility Mainova AG and one of the largest housing companies in Germany, the ABG Frankfurt Holding, which focuses on energy efficiency in housing and mobility. These systemic intermediaries (Van Lente et al. 2011; Hannon et al. 2014), thus an institution operating at interfaces and at the system level, coordinating multiple actors, represent a central instrument for the alignment of actors and possibilities and local learning processes (Laborgne 2023; Van Lente et al. 2011).

The agreement in Frankfurt also relates to another cited success factor, the main argumentation line for convincing a broad range of actors that might otherwise remain skeptical or even block. The strategy is to set a strong focus on economic efficiency, as explained by an interviewee from the city administration: *"Because that is what actually convinces everyone in the end. In the end, you always have to get past the city parliament somewhere and you have to get past the treasurer and you have to get past the audit office and there is guaranteed to be the next round of cuts at some point and so at the end of the day, you have to be able to show that the whole thing is economical over the life cycle and if you only ever look at the investment costs, then the better efficiency standard always falls down and that is why it is important to look at the total costs rather than the investment costs. So if you can manage to move away from investment costs to total costs, which is actually sensible and necessary according to Hessian municipal regulations anyway - but nobody does it - then you're already more than halfway there. That is the key success factor."*

This aspect also underlines the need for the negotiation and local adaptation of narratives, common orientation and visions. The identified key factors influencing the local scope of action are summarized in the following table (Table 2: Key Factors Influencing the Local Scope of Action).

Table 2 Key Factors Influencing the Local Scope of Action

Factor	**Synthesis of Findings (Berlin and Frankfurt)**

Financial Situation	The financial capacity of a city shapes its ability to design and implement energy measures as well as the specific strategies (e.g. focus on Public- Private-Partnerships). Budget constraints limit local funding and project realization, while financially stronger cities can more easily pursue proactive strategies.
Municipal utilities and housing associations	Importance of public ownership, e.g. the strong role of Mainova AG and ABG Frankfurt Holding. The existence of municipal utilities and housing associations provides crucial leverage for local energy transitions, enabling integrated strategies. Where these are lacking or privatized, local autonomy and implementation capacity are reduced. In Berlin, municipal housing stock seen as advantage but also constrained by tenant concerns.
Local economy	Economic structure influences energy priorities (e.g. security vs. affordability). In Frankfurt, banking and data security industries shape a high emphasis on supply reliability.
Energy history	Local energy history strongly shapes local options and strategies, e.g. privatization and “island situation” (Monstadt 2008) in Berlin.
Spatial configuration and Infrastructure	Spatial configuration and local infrastructures determine local pathways and technical solutions. E.g. in Frankfurt, density and existing power plants support a combined heat and power (CHP) strategy. In Berlin, the historical island situation strongly shaped local energy infrastructure.
Legal scope	European, national and state legislation set key boundaries for municipal action. Cities operate within a tight regulatory corset, often relying on soft measures, appeals, and pilot projects to influence change within legal constraints. City states (as Berlin) have more leverage but do not necessarily use it.
Actor constellation and leadership	The presence of dedicated local promoters—administrative, political, or societal—is decisive for initiating and sustaining change. Leadership continuity and individual commitment are major enabling conditions. Shortage of staff and fragmented governance structure limit capacity.
Governance	Effective local governance depends on integrated administrative structures, sufficient staff capacities, and strong political backing. Fragmented responsibilities and understaffed administrations reduce the ability to act strategically. Frankfurt’s transversal energy governance demonstrates how coherence enhances implementation strength. At the time of the study, in Berlin fragmented responsibilities prevailed and the need for an integrated Senate department on energy and environment was strongly expressed by several interviewees.

Cooperation and networks	A cooperative culture and well-functioning local networks between administration, politics, business, and civil society are essential for implementing energy transitions and maintaining long-term engagement. Berlin e.g. developed cooperation through a working group of district energy officers. Frankfurt figures a strong sustainability council.
Intermediary Institutions	Intermediary organizations play a vital systemic role in aligning actors and facilitating experimentation and learning. They serve as bridges across sectors and levels, supporting systemic innovation in local energy policy. In Berlin, the Energy Agency acts as central coordination and learning platform. In Frankfurt, ABGnova and ABG Frankfurt Holding function as key intermediaries between the energy, housing and mobility sectors.
Narratives	Narratives align actors and frame legitimacy and acceptance for local measures. Conflicting narratives, e.g. around tenant protection, can constrain action (Berlin). In Frankfurt, a strong alignment around an economic efficiency narrative was systematically used.

4 Discussion and Conclusions

Cities are arenas where energy and climate protection innovations are developed, tested and implemented. Enhanced by spatial proximity and within a manageable frame of reference, locally individual projects, instruments and governance approaches can (and are) being tried out at municipal level, which, if successful, can be disseminated relatively quickly via municipal networks (Matthes and Müschen 2001).

As Rohracher and Späth (2017) point out and as analyzed by the author on the example of case studies on social innovations in Frankfurt/Main (Laborgne 2023), the role of cities goes beyond the mere level of niche experimentation toward having a key function in regard to linking niches and regimes and interrelating niches, regimes and landscape levels, e.g., through the implementation of innovations in local infrastructures. Local niches like ABGnova in Frankfurt provide space for shielding, nurturing and empowering innovations. The direct link to local infrastructure providers opens the opportunity to test and embed these into infrastructures, thus creating the bridge from niche to regime level. This role of the local level going beyond mere implementation and niche experimentation is also illustrated by the perception of the scope of action in the case studies presented in this article but to different degrees. The results of the interviews show that the scope for action of cities is perceived very differently and that the role of cities in providing a framework and actively shaping the transition, beyond implementing it, is seen controversially by local actors. In addition to limits set

by national and EU regulations, efficiency arguments are put forward. However, this perspective overlooks two crucial aspects. First, it fails to acknowledge the significance and potential of experimenting with transitions in a tangible environment. Second, it neglects the crucial need to test and embed these transitions within concrete constellations and social practices.

An experimental shift has emerged since the 2000s in sustainability sciences, where experimentalism is widely recognized as essential for translating knowledge into action (Karvonen and Bylund, 2023; Parodi et al., 2023a). In the interviews, cities are consensually perceived as an arena for testing and demonstrating innovations and for negotiating goals and measures within a concrete framework. They can, e.g., “show how it works”, which is important for learning and building trust in sociotechnical innovations. The further scope of action is less consensual and is perceived differently, with financial constraints, conflicts and social acceptance cited as key barriers. Urban areas are subject to a constellation of structural constraints that vary, for instance, between "prosperous" cities such as Frankfurt, which are undergoing expansion, and those experiencing decline or financial constraints. The financial resources available, the presence of municipal utilities and a municipal housing association, and the demographic composition of the population have been identified as pivotal local factors that influence the scope of action available to cities. This is particularly salient in the context of Berlin's frequently cited characterization as a "tenant city", which is associated with restrictions and challenges. Legal constraints and uncertainties are also frequently cited, with these barriers perceived to limit the scope of action by setting risks, for example, regarding investments or the possibilities of local rule setting (for legal frames and uncertainties, see Hoff 2021). Two expressed needs here concern, on the one hand, long-term strategies and reliable policies as well as financial resources and, on the other hand, a basis for experimentation, which could be provided by a real-world lab law (currently in preparation for Germany; Parodi et al. 2023b), which is intended to create a more innovation-friendly framework. Well done, this might further strengthen cities as transition arenas responding to the climate and energy crisis and actively contributing to sustainability transitions by providing a secure basis and scope for experimentation, especially for city administrations.

Relating back to the MLP, a dominance of reorientation and reconfiguration pathways (Geels et a. 2016) including incumbent actors and the importance of new alliances can be stated. This can be observed in both case studies with a strong emphasis on an interrelation of organizational and technological change. Reconfiguration pathways are characterized by combining niche-innovations and existing regime transforming the system’s architecture (Geels et a. 2016).

Finally, a consensus emerged from the interviews concerning the importance of engaged stakeholders in this process. This supports the assumption by Geels et al (2016) that trajectories are always enacted and require continuous effort by actors. The existence of local "promoters of change" and "pushers" and their cooperation and network building were identified as key factors. This refers

back to the energy transition as a "collective effort" (Ethik-Kommission Sichere Energieversorgung, 2011). Cities play a pivotal role in this regard and constitute a central arena for societal negotiation of these efforts and their implications as places where different visions and expectations are directly and practically confronted with each other and as experimental grounds. However, just as effective cooperation among local actors and interactions across the niche, regime, and landscape levels are central factors, the same applies to multilevel governance, which establishes important framework conditions (e.g., legal constraints and bureaucracies but also funding and long-term policies) and framing discourses. Further research should especially explore how to strengthen local innovation ecosystems and cooperation as well as capacities and capabilities to create socio-technical niches as space for experimentation by shielding, nurturing and empowerment practices and for supporting the transfer from niche to regime. Here, much can be learned from numerous examples also in a European/international perspective.

5 References

Berliner Energieagentur (2011a). Übersicht der Energiesparpartnerschaften in Berlin. http://www.berliner-e-agentur.

Berliner Energieagentur (2011b). Energiekonzept 2020. http://www.berliner-e-agentur.

Bögel, P. M., Trenks, H., Upham, P., Sauter, H., Albiez, M., Stelzer, V., & Laborgne, P. (2023). Diversifying power in action: A socio-psychological approach to inclusive energy transition experiments. Energy Research & Social Science, 100, 103070.

Capello, R., Nijkam, P., Pepping, G., Bithas, K. (1999), Sustainable Cities and Energy Policies, Berlin, Heidelberg, Spinger.

Duscha, M., Dünnebeil, F., Dünnhoff, E., Gugel, B., Hertle, H., Kuhn, C., Traub, S. (2008). Energie- und Klimaschutzkonzept für die Stadt Frankfurt am Main. ed. Institut für Energie- und Umweltforschung Heidelberg GmbH. https://www.ifeu.de/fileadmin/uploads/IFEU_KSK_Frankfurt_Endbericht_Aug09_final.pdf [Accessed May 16, 2024]

Duygan, M., Stauffacher, M., Meylan, G. (2019). A heuristic for conceptualizing and uncovering the determinants of agency in socio-technical transitions. Environmental Innovation and Societal Transitions. 33, 13-29.

Ethik-Kommission Sichere Energieversorgung. 2011. Deutschlands Energiewende – Ein Gemeinschaftswerk für die Zukunft. Berlin, 30.05.2011. https://www.nachhaltigkeitsrat.de/wp-content/.

uploads/migration/documents/2011-05-30-abschlussbericht-ethikkommission_property_publi

cationFile.pdf

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study, Research Policy 31: 1257–1274.

Geels, F. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Research Policy 33:897-920.

Geels, F. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. Technological Forecasting & Social Change 72: 681-696.

Geels, F., Schot, J. (2007). Typology of sociotechnical transition pathway. Research Policy 36 (2007) 399–417.

Geels, F., Schot, J. (2010). The Dynamics of Transitions: A Socio-Technical Perspective. In: Change Grin, J., Rotmans, J., Schot, J. Transitions to Sustainable Development. New Directions in the Study of Long-Term Transformative Change. Routledge. New York 2010.

Geels, F., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M., Wassermann, S. (2016). The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). Research Policy 45 (4) 896-913.

Giddens, A. (1984). The Constitution of Society: Outline of the Theory of Structuration. University of Caifornia Press. Berkeley and Los Angeles.

Gläser, J. and Laudel, G. (2010). Experteninterviews und qualitative Inhaltsanalyse als Instrument rekonstruierender Untersuchungen. Wiesbaden: VS Verlag für Sozialwissenschaften.

Hannon, M. J., Rhodes, A., Skea, J. (2014). Facilitating and coordinating UK energy innovation through systemic innovation intermediaries. [Conference: International Sustainability Transitions, Utrecht] https://www.researchgate.net/publication/305327324_Facilitating_and_coordinating_UK_energy_innovation_through_systemic_innovation_intermediaries [Accessed May 16, 2024].

Hoff, M. (2021). "Rahmenbedingungen zur Umsetzung: Handlungsspielräume kommunaler Selbstverwaltung für Energieeffizienz im Quartier“, in Handbuch Energieeffizienz im Quartier, eds. C. Reicher and A. Schmidt (Wiesbaden: Springer Vieweg), 221-234. https://doi.org/10.1007/978-3-658-21873-7_22

Hoogma, R., Kemp, R., Johan, S., Truffer, B. (2002). Experimenting for Sustainable Transport. The Approach of Strategic Niche Management. London: Routledge. https://doi.org/10.4324/9780203994061

Hörter, A., Schirrmacher, J., Beer, M., Sommer, B. (2018). Schlüsselakteure bewegen kommunalen Klimaschutz. Erfolgreicher kommunaler Klimaschutz dank Schlüsselakteuren. Projektergebnisse und Handlungsempfehlungen für lokale Klimaschutzakteure. ed. Europa-Universität Flensburg. http://schluesselakteure.de/wp-

content/uploads/2018/05/Leitfaden_Erfolgreicher-kommunaler-Klimaschutz-dank-Schl%C3%BCsselakteuren.pdf [Accessed May 16, 2024]

Hughes, T. (1993). The Evolution of Large Technological Systems. In: BiJker, W., Hughes, T., Pinch, T. (Eds) The Social Construction of Technological Systems New Directions in the Sociology and History of Technology. MIT Cambridge.

IFEU (2008), Energie- und Klimaschutzkonzept für die Stadt Frankfurt am Main 2008, available at: https://www.ifeu.de/fileadmin/uploads/IFEU_KSK_Frankfurt_Endbericht_Aug09_final.pdf.

International Energy Agency (2019). World Energy Outlook 2019. Paris. https://www.iea.org/reports/world-energy-outlook-2019 [Accessed May 16, 2024]

Jobert, A., Laborgne, P., Mimler, S. (2007). Local acceptance of wind energy: Factors of success identified in French and German case studies. Energy Policy. 35:5, 2751-2760. https://doi.org/10.1016/j.enpol.2006.12.005

Karvonen, A. and Bylund, J. (2023). “Small measures, large change: the promise and peril of incremental urbanization”, in Haste: The slow politics of climate urgency, eds. H. Haarstad, J. Grandin, K. Kjærås, E. Johnson (London: UCL Press), 153-161.

Kern, K., Niederhafner, S., Rechlin, S., Wagner, J. (2005) Kommunaler Klimaschutz in Deutschland - Handlungsoptionen, Entwicklung und Perspektiven. Berlin: Wissenschaftszentrum Berlin für Sozialforschung gGmbH. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-196722 [Accessed May 16, 2024]

Konrad, K., Voß, J.-P., Truffer, B., Bauknecht, D. (2004). Transformationsprozesse in netzgebundenen Versorgungssystemen. Ein integratives Analysekonzept auf Basis der Theorie technologischer Transitionen. [Forschungsbericht zum Projekt "Integrierte Mikrosysteme der Versorgung"]. https://www.researchgate.net/publication/242733207_Integrierte_Mikrosysteme_der_Versorgung_Dynamik_Nachhaltigkeit_und_Gestaltung_von_Transformationsprozessen_in_der_netzgebundenen_Versorgung

Kühne, O. and Weber, F. (2018). "Bausteine der Energiewende – Einführung, Übersicht und Ausblick“, in Bausteine der Energiewende. RaumFragen: Stadt – Region – Landschaft. eds. O. Kühne and F. Weber, (Wiesbaden: Springer VS), 3-19. https://doi.org/10.1007/978-3-658-19509-0_1

Laborgne, P., Radtke, J. (2023). "Akzeptanz und Partizipation in der Energiewende“, in Handbuch Umweltsoziologie, eds. M. Sonnberger, A. Bleicher, M. Groß (Wiesbaden: Springer VS), 1-15. https://doi.org/10.1007/978-3-658-37222-4_54-1

Laborgne, P. (2023). Local intermediaries in energy transitions: bridging the gap from niche level to changing the regime. Z Politikwiss 33, 277–296.

Laborgne, P. (2025). Local Energy Transitions: The Role of Socio-Technical Niches. In: Hamman, P., Roudil, N. (Ed.) The Future of Cities and Energies in

Western Europe: Scales, Actors and Social Experiments. Berlin, Boston: De Gruyter, 2025, pp. 207-226. https://doi.org/10.1515/9783111378992-012.

Leonhardt, R., Noble, B., Poelzer, G., Fitzpatrick, P., Belcher, K., Holdmann, G. (2022). Advancing local energy transitions: A global review of government instruments supporting community energy. Energy Research and Social Science. 83, https://doi.org/10.1016/j.erss.2021.102350

Matthes, F. and Müschen, K. (2001). “Bilanz und Perspektiven kommunaler Energiepolitik“, in Berliner Energieinnovationen, ed. J. Pöschk (Berlin: Verlag und Medienservice Energie).

Mattes, J., Huber, A., Koehrsen, J. (2015). Energy transitions in small-scale regions — What we can learn from a regional innovation systems perspective. Energy Policy. 78, 255–264.

Monstadt, J. (2004). Die Modernisierung der Stromversorgung. Regionale Energie- und Klimapolitik im Liberalisierungsprozess. Wiesbaden: Springer VS.

Monstadt, J. and Naumann, M. (2004). Neue Räume technischer Infrastruktursysteme. Forschungsstand und -perspektiven zu räumlichen Aspekten des Wandels der Strom- und Wasserversorgung in Deutschland. Berlin: Deutsches Institut für Urbanistik.

Monstadt, J., Schlippenbach v., U. (2005). Privatisierung und Kommerzialisierung als Herausforderung regionaler Infrastrukturpolitik. Forschungsverbund netWORKS, (netWORKS-Paper, Nr. 20).

Monstadt, J. (2008). Urban Governance and the Transition of Energy Systems: Institutional Change and Shifting Energy and Climate Policies in Berlin. International Journal of Urban and Regional Research. 31:2, 326-43.

Monstadt, J., Schmidt, M., Wilts, H. (2012). "Regionale Zusammenarbeit in der Ver- und Entsorgung des Rhein-Main-Gebiets“, in Die diskutierte Region: Probleme und Planungsansätze der Metropolregion Rhein-Main, eds. J. Monstadt, K. Zimmermann, T. Robischon, B. Schönig (Frankfurt am Main: Campus Verlag), 185–211.

Moss, T., Guy, S., Marvin, S., Medd, W. (2011), “Intermediaries and the Reconfiguration of Urban Infrastructures: An Introduction”, in Shaping Urban Infrastructures. Intermediaries and the Governance of Sociotechnical Networks, eds. S. Guy, S. Marvin, W. Medd, T. Moss (London, Washington DC: Earthscan), 1–13.

Parodi, O., Steglich, A., Bylund, J. (2023a). "Real-World Lab”, in Handbook Transdisciplinary Learning. Ed. T. Philipp (Bielefeld: transcript Verlag), 287-296.

Parodi, O., Schwichtenberg, R., Stelzer, F., Rhodius, R., Schreider, C., von Wirth, T., Lang, D. J., Marg, O., Wagner, F., Egermann, M., Bauknecht, D., Wanner, M., (2023b). Stellungnahme des Netzwerks Reallabore der Nachhaltigkeit zur Reallabore-Gesetz-Initiative. GAIA - Ecological Perspectives for Science and Society. 32:4, 399-401.

Radtke, J. and Canzler, W. (2019). “Lehrbuch Energiewende – Eine Einleitung“, in Energiewende: Eine sozialwissenschaftliche Einführung, eds. J. Radtke, W. Canzler (Wiesbaden: Springer Fachmedien), 1–28. https://doi.org/10.1007/978-3-658-26327-0_10

Renn, O., Ulmer, F., Deckert, A. (2020). The Role of Public Participation in Energy Transitions. London: Elsevier Science.

Rohracher, H., Späth, P. (2009). The Fragile Dynamics of Urban Energy Transitions: The Eco-Cities of Graz and Freiburg in Retrospect. [Paper presented at the International roundtable conference Cities and energy transitions: past, present, future].

Rohracher, H., Späth, P. (2013). The Interplay of Urban Energy Policy and Socio-technical Transitions: The Eco-cities of Graz and Freiburg in Retrospect. Urban Studies, 51(7), 1415-1431. rohracher

Rohracher, H., Späth, P. (2017). "Cities as arenas of low-carbon transitions. Friction zones in the negotiation of low-carbon futures”, in Urban Sustainability Transitions, eds. N. Frantzeskaki, V.C. Broto, L. Coenen, D. Loorbach (New York: Routledge), 287-299.

Rozite, V., Prin, M., Laera, S., Oxby, J., Roussel, A. (2023). Empowering people – the role of local energy communities in clean energy transitions. ed. International Energy Agency. https://www.iea.org/commentaries/empowering-people-the-role-of-local-energy-communities-in-clean-energy-transitions [Accessed May 16, 2024]

Schlippenbach, U. (2009). Selbstverpflichtung als Instrument regionaler Energie- und Klimapolitik. Eine Analyse am Beispiel der Berliner KlimaSchutzPartner. [master’s thesis]. [Berlin]: TU Berlin. https://doi.org/10.14279/depositonce-2091

Schneidewind, U., Scheck, H. (2013). "Die Stadt als ‚Reallabor‘ für Systeminnovationen“, in Soziale Innovationen und Nachhaltigkeit, Innovation und Gesellschaft, ed. J. Rückert-John (Wiesbaden: Springer), 229-248.

Schumpeter, J. (1912). Theorie der wirtschaftlichen Entwicklung. Leipzig: Duncker und Humblot.

Selvakkumaran, S. and Ahlgren, E. O. (2017). Understanding the local energy transitions process: A systematic review. International Journal of Sustainable Energy Planning and Management. 14, 57–78. https://doi.org/10.5278/ijsepm.2017.14.5

SENGUV (2011): Klimaschutz in Berlin (http://www.stadtentwicklung.berlin.de/umwelt/klimaschutz/download/SenGUV_KlimaschutzBrosch_2011.pdf) (02.02.2012)

Simmel, G. (1903). Die Großstädte und das Geistesleben. Frankfurt am Main: Suhrkamp.

Smith, A., (2007). Translating sustainabilities between green niches and sociotechnical regimes. Technology Analysis & Strategic Management 19 (4), 427–450

Smith, A., Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. Research Policy 41, 1052-1036.

Sovacool, B. K. (2022). The political economy of energy poverty: A review of key challenges. Energy for Sustainable Development. 199, 1145-52.

Sovacool, B.K., Martiskainen, M., Hook, A. (2019). Decarbonization and its discontents: a critical energy justice perspective on four low-carbon transitions. Climatic Change 155, 581–619 (2019).

Sturm, C., Mattissek, A. (2017). "Energiewende als Herausforderung für die Stadtentwicklungspolitik – eine diskurs- und gouvernementalitätstheoretische Perspektive“, in: Bausteine der Energiewende, eds. O. Kühne, F. Weber (Wiesbaden: Springer VS), 109-128. https://doi.org/10.1007/978-3-658-19509-0_6

UN-Habitat (2016). World Cities Report 2016: Urbanization and Development - Emerging Futures. UN, New York. https://doi.org/10.18356/d201a997-en.

van Lente, H., Hekkert, M. P., Smits, R., van Waveren, B. (2011). "Systemic Intermediaries and Transition Processes”, in Shaping Urban Infrastructures. Intermediaries and the Governance of Socio-Technical Networks, ed. S. Guy, S. Marvin, W. Medd, T. Moss (Washington DC, London: Earthscan), 36–53.

Verbong, G., Geels, F.W. (2007). The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). Energy Policy 35, 1025–103.

Wüstenhagen, R., Wolsink, M., Burer, M. J. (2007). Social Acceptance of Renewable Energy Innovation: An Introduction to the Concept. Energy Policy 35 (5). 2683-2691.

Funding Declaration

I would like to thank the Hans Böckler Foundation for financing the research that is the basis of this article.

Table 1 Key aspects and perceptions regarding the local scope of action

Key Aspects	Description
General perception of role and scope of action	Municipalities perceived by all interviewees as relevant arenas for experimenting with energy and climate innovations that can spread through local networks; Especially large cities are seen as relevant arenas for effective climate and energy policies. Understanding of the role and responsibility of cities varies widely among actors.
Relation to higher governance levels	Local action often considered complementary to federal and EU efforts. Some interviewees see limited necessity for local measures due to overarching federal solutions; others emphasize local autonomy and the importance of the "think global, act local" principle.
Legal scope	The most controversial dimension and biggest difference between Frankfurt and Berlin. Municipal capacity is limited, especially compared to state or federal levels. However, setting local building standards (e.g., beyond EnEV) are seen by some as key leverage points. Skepticism persists about enforceability of local statutes like Marburg's solar ordinance.
Public sector as role model	Municipalities considered able to act as role models e.g. through their public buildings and real estate management. Even critics regard this as sensible local action potential.
Renewable Energies Implementation	Opportunities for local renewable energy projects acknowledged but are often perceived as limited (especially in Berlin). One interviewee calls for national coordination to avoid inefficient "showcase" local projects and to maximize CO_2 savings through optimal national allocation.
Efficiency vs. local embedding	Debate between efficiency (through national coordination) and local embedding e.g. important for social acceptance. Critics argue that local "image projects" may misuse funds relative to CO_2 reduction potential; Proposal of one interviewee for a centralized national fund to distribute resources efficiently across regions. Local implementation on the other hand enables citizen involvement, contextual adaptation, and trust-building, balancing economic optimization with local agency and legitimacy.
Pioneering role	Some actors warn against being "too pioneering" due to political risks or potential criticism; others highlight the responsibility of large cities to lead by example in decarbonization, given their energy consumption and emissions, as well as the potential to develop and test new solutions locally.

Experimentation, pilots and demonstration	Local experimentation, demonstration and pilot projects are cited as vital instruments to make transitions tangible, learn, build confidence, and provide positive examples (“show how it works”).

Table 2 Key Factors Influencing the Local Scope of Action

Factor	Synthesis of Findings (Berlin and Frankfurt)
Financial Situation	The financial capacity of a city shapes its ability to design and implement energy measures as well as the specific strategies (e.g. focus on Public- Private-Partnerships). Budget constraints limit local funding and project realization, while financially stronger cities can more easily pursue proactive strategies.
Municipal utilities and housing associations	Importance of public ownership, e.g. the strong role of Mainova AG and ABG Frankfurt Holding. The existence of municipal utilities and housing associations provides crucial leverage for local energy transitions, enabling integrated strategies. Where these are lacking or privatized, local autonomy and implementation capacity are reduced. In Berlin, municipal housing stock seen as advantage but also constrained by tenant concerns.
Local economy	Economic structure influences energy priorities (e.g. security vs. affordability). In Frankfurt, banking and data security industries shape a high emphasis on supply reliability.
Energy history	Local energy history strongly shapes local options and strategies, e.g. privatization and “island situation” (Monstadt 2008) in Berlin.
Spatial configuration and Infrastructure	Spatial configuration and local infrastructures determine local pathways and technical solutions. E.g. in Frankfurt, density and existing power plants support a combined heat and power (CHP) strategy. In Berlin, the historical island situation strongly shaped local energy infrastructure.
Legal scope	European, national and state legislation set key boundaries for municipal action. Cities operate within a tight regulatory corset, often relying on soft measures, appeals, and pilot projects to influence change within legal constraints. City states (as Berlin) have more leverage but do not necessarily use it.
Actor constellation and leadership	The presence of dedicated local promoters—administrative, political, or societal—is decisive for initiating and sustaining change. Leadership continuity and individual commitment are major enabling conditions. Shortage of staff and fragmented governance structure limit capacity.
Governance	Effective local governance depends on integrated administrative structures, sufficient staff capacities, and strong political backing. Fragmented responsibilities and understaffed administrations reduce the ability to act strategically. Frankfurt’s transversal energy governance demonstrates how coherence enhances implementation strength. At the time of the study, in Berlin fragmented responsibilities prevailed and the need for an integrated Senate department on energy and environment was strongly expressed by several interviewees.
Cooperation and networks	A cooperative culture and well-functioning local networks between administration, politics, business, and civil society are essential for implementing energy transitions and maintaining long-term engagement. Berlin e.g. developed cooperation through a working group of district energy officers. Frankfurt figures a strong sustainability council.
Intermediary Institutions	Intermediary organizations play a vital systemic role in aligning actors and facilitating experimentation and learning. They serve as bridges across sectors and levels, supporting systemic innovation in local energy policy. In Berlin, the Energy Agency acts as central coordination and learning platform. In Frankfurt, ABGnova and ABG Frankfurt Holding function as key intermediaries between the energy, housing and mobility sectors.

Narratives	Narratives align actors and frame legitimacy and acceptance for local measures. Conflicting narratives, e.g. around tenant protection, can constrain action (Berlin). In Frankfurt, a strong alignment around an economic efficiency narrative was systematically used.