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Urban Transition of the Heat Sector in Leipzig toward a Post-Fossil City?

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Abstract: The transformation to a post-fossil city is one of the central urban challenges of the 21st century, with heat transition representing an important part of this process. In Germany, a structural change commission has proposed a complete phase-out of coal by 2038. For the city of Leipzig, which is located in a mining region, this opens up the possibility of a post-fossil transformation. Leipzig started an energetic retrofitting process within its housing sector several years ago, and is now planning to phase-out coal-fired district heating as early as 2023. This heat transition could turn Leipzig into one of the pioneering cities of post-fossil transformation. However, such a transition will be accompanied by numerous challenges and problems in the financial, political, technological, and labor sectors. Using the example of Leipzig, we conducted a document analysis and semi-structured interviews to investigate how a transition of the heating sector is conceptualized and planned, which governance structures have emerged, and how they work. In addition, our paper outlines the main interests and goals of the key actors and stakeholders in this transition, as well as their competences and resources. We emphasize that while Leipzig has committed itself to ambitious climate goals, up to now, the city has had no systemic approach for reducing local emissions. Although a window of opportunity has opened for a post-fossil heat transition, this still remains at a niche level due to a lack of interest, path dependencies, and weak governance.

Keywords: post-fossil city; urban transformation; heat transition; local climate policy; urban governance

1. Introduction

Against the background of Article 2 of the 2015 Paris Agreement to limit global warming to below 1.5 °C [1], and the latest findings of the 2018 Intergovernmental Panel on Climate Change (IPCC) Report that global warming of 1.5 °C will already be reached in the period from 2030 to 2052 [2], the implementation of climate protection measures across all levels seems more urgent than ever. The importance of urban transformations has also been increasingly emphasized [3–6]. For a long time, the energy sector was the focus of attention in relation to achieving climate protection goals, yet it is now clear that a transition must also take place in the heating sector. The heating sector is responsible for a significant share of urban emissions, especially in colder regions [7]. In Germany alone, more than half of the final energy consumption can currently be attributed to the heating of buildings, the provision of hot water, and process heat [8]. This makes the heating sector responsible for around 40% of energy-related CO_2 emissions [8]. In Leipzig, our case study, 44% of emissions can be attributed to heat [9]. The transition of the heating sector is thus essential for the success of the energy transition as a whole. The German government committed itself to this in 2016 with the adoption of its Climate Action Plan 2050. Among other things, the plan aims to achieve an almost

climate-neutral building stock by 2050, which would mean a reduction in CO_2 emissions of 80% to 95% compared to 1990 [10]. Achieving a CO_2 reduction of this magnitude will require radical changes in the urban energy systems, as well as a long-term and comprehensive strategy for the energy-efficient retrofitting of existing buildings. However, to date, changes in final energy consumption in Germany are negligible in terms of heat: the building retrofitting rates are not high enough to have an actual effect on CO_2 emissions, and no transformations of heat supply systems have taken place so far, which would lead to an actual reduction in the use of fossil fuels [8].

However, in Germany, a structural change commission negotiated the phase-out of coal and submitted a concept to the government that proposes a complete withdrawal by 2038 [11]. The Leipzig region is affected by this, as it's a region where lignite is mined and converted into electricity and heat energy. The German federal government is providing financial resources to compensate for and accompany structural changes caused by the phase-out of coal. For the city and the region of Leipzig, this opens up an opportunity for a post-fossil transformation. The city of Leipzig, the case study dealt with in this paper, has initiated the transformation and announced the phasing out of coal-fired district heating by 2023. Now, the transformation of the heating supply system must be planned and steered in the direction of renewables. Besides reducing greenhouse gas (GHG) emissions through increasing the share of renewable energies in heat production, improvements in energy efficiency in the building sector could also have a great impact, since it consumes about one-third of the final energy in most countries [12]. Leipzig is no exception: around 26% of the city's CO_2 emissions can be attributed to the supply of electricity and heat to private households [13]. In this article, we examine the difficulties of a transition in the heating sector. Since urban transformation is not only a technical process, but above all an economic, social, and political one [14], we look in particular at the governance structures in our case study. Taking the city of Leipzig as an example, the following questions will be addressed: What does local climate protection policy look like, and what are the existing approaches for transition in the heating sector? Which governance structures have emerged in this field, and how do they work? What are the interests and goals of the key actors and stakeholders in the field of the heat transition? How are the actors provided with competences and resources, and what influence do they have?

2. The Discussion about the Transformation to a Post-Fossil City

For about 10–15 years, there has been an international, essentially academic debate about the post-fossil city, which has been led by planners, architects, and designers, and in part also by social scientists. Other terms are also used, such as a post-oil, post-carbon, low-carbon, CO_2-neutral, or decarbonized city, whose common denominator and definitional core is the complete reduction of CO_2 in cities [15]. The post-fossil city primarily contains an attribution of responsibility to the municipalities from the outside. This attribution results not least from the fact that the solution to the problem of climate change is not progressing at other political levels, such as the national and international levels [16]. In contrast to earlier debates on local climate protection, an aggravation or radicalization is taking place, i.e., a medium-term or short-term reduction to zero emissions or climate neutrality if necessary emissions are offset differently. The transformation to a post-fossil city should make it possible "to maintain modern and highly developed structures in the highly industrialized countries without sacrificing comfort despite reduced fossil energy resources" [17] (p. 189). Nevertheless, there is widespread consensus that the transformation to a post-fossil city is not only a technological process, but also requires economic, social, and cultural change [14,18,19]. According to Beveridge et al., a paradigm shift is needed to achieve this transformation [19], while Rink et al. emphasize that the "ruling traditional or classical growth paradigm" has to be overcome, and new types of governance have to emerge for fundamental changes to take place [20] (p. 17).

However, so far, the post-fossil city has not been an elaborated or formulated urban concept, but rather a vision or a guiding idea. The goal or vision of the post-fossil city is extremely complex and takes cities to the limits of their ability to solve problems. The post-fossil city addresses a number of topics and aspects, in particular the conversion of energy production to renewable sources, greater energy savings,

and higher energy efficiency, as well as the shift away from fossil fuels in the transport sector [17]. Furthermore, this discussion is about implementing the radical goal of reducing CO_2 emissions to zero in planning, policy, and governance, such as for example through roadmaps, master plans, and climate protection concepts, as well as planning instruments and tools [21]. The European Union (EU) project Post-Carbon Cities of Tomorrow (POCACITO) systematically tested the requirements for a "post-carbon city" and developed roadmaps for individual cities [22].

Yet so far, the post-fossil city has played a subordinate role in planning and urban development in Germany and Europe, and to date, only a few cities are addressing the transformation in a structured way. This is mainly due to ongoing uncertainty about the mechanisms required to effect such a fundamental shift [21,23]. There is only a small number of cities in various European countries—the so-called "100% communities" [24]—that have set themselves the goal of becoming CO_2 neutral. In general, local climate policy is far from being integrative and transformative. Rather, incremental approaches and procedures are being pursued in various municipal fields of action. Thus, for Heinelt and Lamping, incrementalism is a defining characteristic of local climate policy [25]. The stakeholders involved, such as utility and housing companies, landlords, urban policy and planning entities, tenants' associations, and consumer protection organizations, are confronted with uncertainties and risks with regard to future energy needs, a guaranteed energy supply, cost effectiveness, energy savings, and the effects of climate protection. While there is an increasing amount of research dealing with urban sustainable transformation [5,14,18–20,26–31], it is still unclear as to what can actually be achieved in this respect, and how this will have an impact on the social compatibility of the post-fossil transformation. The diversity of existing options and the expectations about the impact of technological and social innovations enable a quick conversion to renewable energies and energy savings. Thus, changing the whole energy system calls for strategic decisions regarding investments and new infrastructure systems [23]. Here, one of the Achilles' heels of the transformation to the post-fossil city is the centralized energy systems in developed countries that often have long-term obligations for substantial financial resources. Thus, a change to these systems can be considered as a truly fundamental transformation.

In addition, the transformation to a post-fossil city is confronted with a time trap, because if the goals of the Paris Agreement are to be met, far-reaching decisions have to be taken very quickly, and considerable resources have to be invested in the conversion of energy and heat production. So far, the topic of the heat transition has not been sufficiently addressed in this debate, or has not been treated as an independent transition. The German think tank Agora Energiewende recently commissioned the Fraunhofer research organization to run scenarios for the heat transition, but did not investigate how this transition could be implemented politically at the local level [32].

3. Case Background

3.1. The Leipzig Coal Mining Region

The urban region of Leipzig followed an old industrial development path until 1990. Its coal-based chemical industry and energy production facilities were built during and after the First World War. At that time and also during the time of the German Democratic Republic (GDR) (1949–1990), these industries were used to manufacture strategic products without oil, and were part of a self-sufficiency policy. A withdrawal from coal-based industries at the end of the 1970s did not take place, because of the oil crisis in 1973/74. However, these industries collapsed soon after the reunification of Germany's economic and monetary systems in the summer of 1990, and the post-socialist transformation led to extensive deindustrialization. Deindustrialization was accompanied by unintended ecological effects, known as "gratis effects", such as a reduction in air, water, and soil pollution—hence, it had a gratis effect on climate protection. The largest reduction in CO_2 emissions occurred in the early/mid-1990s with the closure of numerous industrial plants, particularly those in coal-based industries, and the shutdown of coal-fired power plants. A major role was also played by the first wave of renewal in the

housing stock, which involved conversions from coal to oil and gas. In the GDR era, no renovation measures were carried out on the old buildings, and the apartments continued to be heated with coal. In the 1990s, approximately 70% of the old apartments were modernized and equipped with oil or gas heating, or connected to the district heating network.

Consequently, in the 1990s, Leipzig not only experienced a drastic improvement in CO_2 emissions in the economic sector with output decreasing from 4.83 tons per inhabitant to 2.66 tons, but emissions from private households also shrank from 4.79 tons per inhabitant to 2.32 tons between 1990 and 1998 (see Figure 1). By comparison, emissions in both sectors have only fallen by around 0.4 tons between 1998 and 2008. At the end of the 2000s, there was even an increase in emission values due to the city's improved economic conditions and an increase in traffic [9]. In the 2010s, only minimal improvements in the CO_2 balance are discernible. The climate protection targets for 2020 adopted in the Energy and Climate Protection Program 2014–2020 can no longer be achieved. To reach the goal for 2030, fast changes in climate change policy are needed.

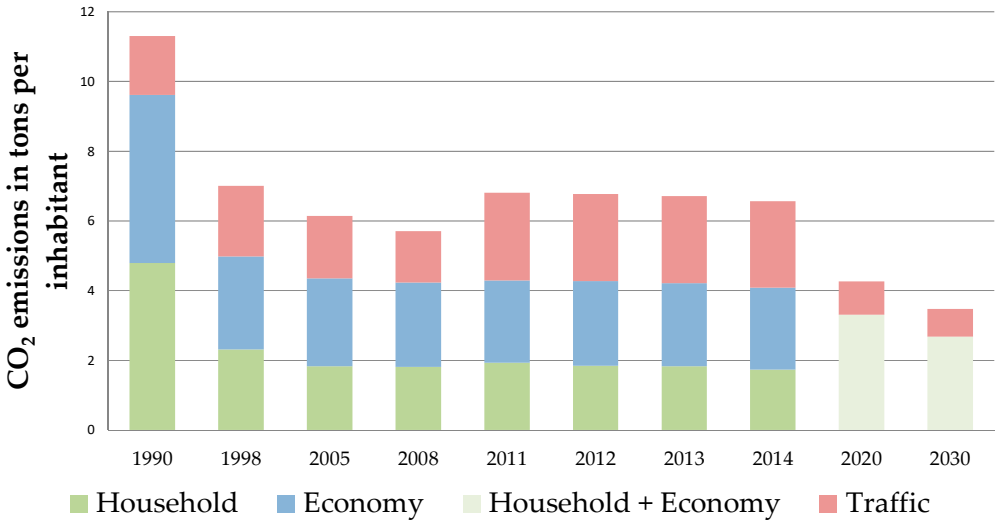

Figure 1. CO_2 emissions in tons per inhabitant [12,13]. The CO_2 emissions in the years 2011–2014 were measured using a more recent methodology (including CO_2 equivalences and upstream chains) than in the years until 2008. The CO_2 emissions for 2020 and 2030 are targets adopted in Leipzig's Energy and Climate Protection Program 2014–2020.

For social and labor market reasons, coal mining and coal-fired energy production were not completely abandoned. An opencast mine continued operating in the southern Leipzig area, supplying the Lippendorf power plant with lignite. In addition to the energy that Lippendorf feeds into the grid, the power plant supplies the city of Leipzig with district heating. After Leipzig's urban coal mining region experienced its first transformation toward a post-fossil city in the 1990s, today the city and region of Leipzig has an opportunity for a second, post-fossil transformation.

For the city of Leipzig, the 2038 exit date set by a structural change commission is too late, and the city plans to phase-out coal by as early as 2023. The transition has started: Stadtwerke Leipzig GmbH (hereafter: municipal utility) is planning to withdraw from the district heating supply provided by the Lippendorf coal-fired power plant in 2023, and build a gas-fired power plant as a bridging technology. Meanwhile, Leipzig has recently started to tackle energetic redevelopment at the district level, which is considered a promising approach for increasing East Germany's current retrofitting rate of less than 1% [33].

Together, this will make Leipzig one of the pioneering cities of post-fossil transformation, and a city whose experiences will provide valuable lessons for cities in other coal regions. Before we investigate how the heating sector transition is being planned and steered (see Section 5), we will first introduce

the city's current climate protection policy and discuss the institutionalization of climate protection, in order to understand the foundations of the heat transition debate.

3.2. Leipzig's Climate Protection Policy

The beginnings of Leipzig's climate protection policy can be traced back to the early 1990s. Leipzig joined the Climate Alliance in 1994, and the issue of climate protection became increasingly present in the city. As a result, the first Energy Concept from 1992 was rewritten in 1996 to create an Energy and Climate Protection Concept. One year later, the Leipzig Local Agenda was founded (renamed Forum Sustainable Leipzig in July 2018), and in 1998, the first Environmental Quality Standards and Goals were adopted by the city council, thus agreeing on official goals for the first time. The first Climate Protection Program with a catalogue of measures was adopted in 2005. Six years later, the first Integrated Energy and Climate Protection Program was finally developed, and today, we are in the implementation phase of the Energy and Climate Protection Program 2014–2020. Looking back and comparing the concepts, a positive development can be observed on a conceptual level. While measures were initially adopted without clear responsibilities, prioritization, and financing, these shortcomings were remedied in later concepts.

However, to date, better prioritization of individual fields of action (energy and buildings) can be identified, while measures in the industry and trade sector remain in the background. In addition, the transition of the heating sector, especially the heat supply system, has not yet been the subject of an urban concept. This can be explained by the increasing influence of economic actors and stakeholders in the city's climate policy process, among other things. While in the 1990s neither municipal subsidiaries nor economic actors played a specific role in the climate protection policy, these actors became increasingly present in the 2000s. New governance structures emerged at the start of the millennium, the time when Leipzig also began to use climate protection policy as a marketing strategy with the guiding principle "Sustainable Leipzig". The involvement of new actors and stakeholders became visible with the adoption of the first Climate Protection Program, in addition to a wide range of city departments, and the municipal utility became a main implementation actor of the climate protection measurements. The emergence of new actors and stakeholders in the field became visible again with the foundation of the Energy Team in 2008, in which economic interests were well represented. Various interviews showed that the focus on economic growth had a great impact on Leipzig's climate protection policy. For example, according to the statement of an interviewee, the focus on electric mobility instead of the expansion of local public transport or cycle paths was due to the establishment of Porsche and BMW in Leipzig and their strong influence on the city's climate policy. Instead of critically questioning and curbing the influence of large companies on Leipzig's climate protection policy, the city has instead embraced sustainable urban and economic growth by launching the slogan "Leipzig is growing sustainably". This slogan is designed to promote the vision that sustainable urban development is compatible with the model of a growing city. However, how these two guiding principles can be implemented together has not yet been shown.

3.3. Institutionalization of Climate Policy in Leipzig

Over the years, climate protection has also been increasingly anchored institutionally in the administration and local structures. Today, primary responsibility for climate protection policy lies with the Environmental Office, and the policies are coordinated by two employees in a Climate Protection Unit (see Figure 2). With the establishment of this unit in 2016, the city not only decided to create an institution that coordinates the energy and climate protection process, but also to anchor the issue within the administration at a higher level through a direct connection to the Lord Mayor. Based on the responses of our interviewees, the establishment of the Climate Protection Unit delivered the following improvements:

- Easier cross-office and cross-departmental cooperation on climate change issues due to higher positioning in the city administration hierarchy.

- Enhanced approachability; the public find it easier to approach the city administration with regard to climate protection issues.
- Clearer responsibilities and mandates that facilitate the coordination and implementation of measures.

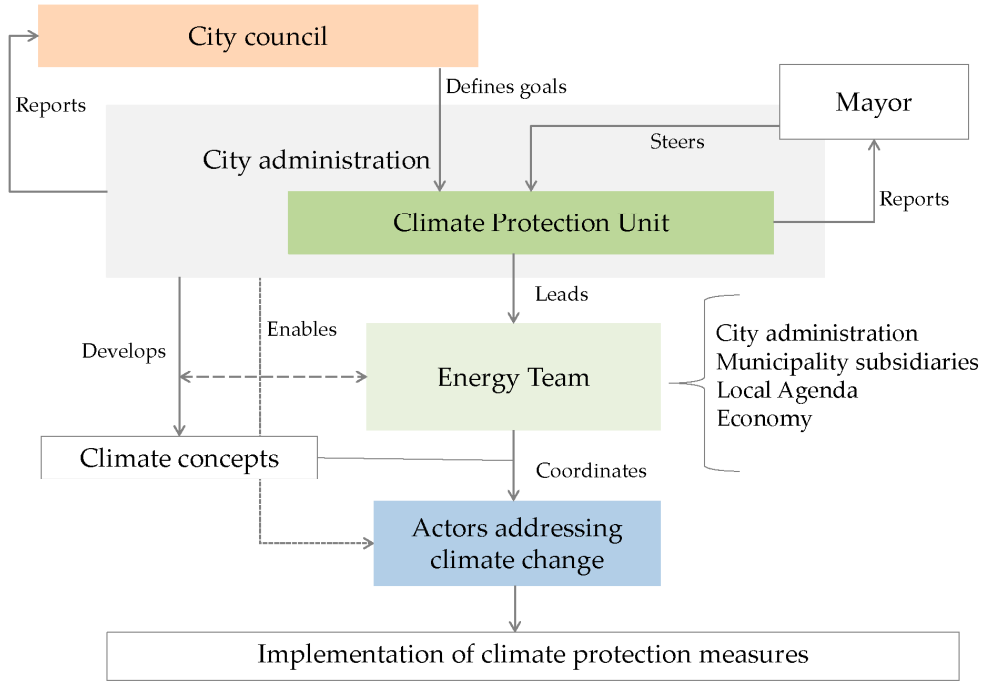

Figure 2. Inner administrative governance structure for climate protection in Leipzig.

Nevertheless, the Climate Protection Unit is a rather weak institution due to its comparatively few competences, lack of personnel resources, and no budget of its own to manage. In addition to the Climate Protection Unit, there is another climate protection body in the city administration called the Energy Team, which has been managed by the Climate Protection Unit since 2016 (see Figure 2). This team was established in 2008 as a result of its participation in the European Energy Award (EEA), and is the only institutionalized group for inter-agency exchange. The EEA led to far-reaching changes and a much stronger anchorage of climate mitigation in the city. According to the interviewees from the city administration, this development partly overcame many of the challenges that existed before 2008: a lack of support from the highest administrative level, long lines of communication between the employees in charge, lack of responsibilities and mandates within the administration, and hardly any inter-sectoral exchange. Together with the Energy Team, an inter-agency working structure was set up with a total of six working groups in various fields of action, such as mobility or waste management [9]. Here, representatives of the city administration and the municipal subsidiaries meet with the economic sector as well as experts from civil society. Actors such as the Chamber of Industry and Commerce or the Chamber of Crafts are represented to a great extent, which underlines their influence on the planning and coordination of Leipzig's climate protection process. The city's cooperation with environmental associations is less institutionally anchored, and only the Local Agenda is part of the Energy Team.

4. Materials and Methods

In this article, we aim to analyze the case in its entirety and used the triangulation method to improve the validity of our research [34]. In the first stage, we carried out an extensive desk research, reviewing scientific papers about climate policy and transformation in Leipzig, media articles on the heat transition in Leipzig, press releases of Leipzig's political parties, and proposals in the city council, as well as city council resolutions. In the second stage, we processed the data using document

analysis [35]. Policy documents were scanned, such as strategies and programs as well as municipal environmental reports from 1990 to 2019, and the following urban documents were analyzed in relation to their relevance for the city's climate protection policy: the Environmental Quality Objectives and Standards 1997, the Climate Protection Program 2005, the Integrated Urban Development Concept 2011, and the Energy and Climate Protection Program 2014–2020.

In order to get a differentiated view on the heat transition in Leipzig, we acquired knowledge about processes, the relationships between actors and actor groups, and information on current planning. This knowledge and information was gathered by conducting semi-structured expert interviews. The interview guides were developed using the SPSS method based on Helferrich [36], thus questions were collected in a broad brainstorming session, then tested, sorted and subsumed to large questions blocks. The overall guiding questions were:

- How would you describe the city of Leipzig's climate protection policy so far and the previous debate or process surrounding the heat transition?
- Who is involved or who are the relevant actors and stakeholders, and what are their roles? Who has the competences and resources to decide on changes? Which actors and stakeholders are obstructive?
- What challenges and opportunities have arisen so far or are imminent given the development that is taking place?

Due to the different foci of the experts, the key questions were specifically adapted to their areas of expertise. For the selection of the interview partners, we used a theoretical sampling strategy originally developed by Glaser and Strauss [37]. Doing so involves the risk of selecting interview partners who are too high up in the organizational hierarchy and thus talk about processes too generally, or of selecting interview partners who are too concerned with the concrete implementation so that they cannot, for example, make statements about the bigger picture [38]. For us, it was important to find experts who, on the one hand, were able to oversee the entire process and also assess the role of other actors, while on the other hand, were also directly involved in the implementation and therefore knew the challenges and opportunities presented by the development. We decided to interview the experts from the various stakeholder groups who were directly involved in the implementation (city administration, municipal subsidiaries, civil society, and engineers). In total, 11 of the 12 potential interview partners we contacted were willing to be interviewed. In some cases, we interviewed more than one person from a particular institution to cover different perspectives or responsibilities. Each interview lasted about 45 to 90 min, and two interviewees were interviewed at the same time at their own request. We selected the face-to-face method, and the interviews always took place at the experts' chosen location, which was usually the institution where they work. From the city administration, we spoke with representatives from the Office for Housing Promotion and Urban Development and the Climate Protection Unit. Further interviews were conducted with representatives from the municipal housing company and the subsidiary company WSL Wohnen and Service Leipzig GmbH, which is responsible for services related to housing. Another interview was conducted with two restructuring managers from Seecon Ingenieure GmbH, and one interview was with a member of the Green Party. From civil society, interviews were conducted with the Local Agenda and the Leipzig Coal-Free initiative, after they had been identified as relevant actors. We also tried to conduct an interview with the municipal utility. Unfortunately, nobody was available to talk to us, and the experiences of other interviewees suggested that it is generally difficult to obtain information from the municipal utility. Given that we conducted the interviews during a period that was very critical for the future of the municipal utility, they were reluctant to make any statements about their future plans. The interviews were analyzed using the qualitative content analysis method described by Mayring [35].

5. Results

In the following, we want to deal with the heat transition and analyze two important fields of action: retrofitting in the building sector, and the transition of the heat supply. Around 44% of the electricity supplied to Leipzig in 2014 was used for heating (latest data) [13]. While electricity production and supply have already undergone far-reaching changes in recent years, the heating sector, which accounts for a much larger share of local emissions, has so far been largely coal-based [13].

5.1. Energetic Retrofitting of Leipzig's Building Stock

The building sector is of crucial importance for the transition of the heating sector. At the beginning of the 1990s, almost 40% of Leipzig's housing stock consisted of old, unrenovated buildings, and about two-thirds of the apartments were still heated using coal stoves. The first wave of renewals in the 1990s also included the energetic retrofitting of old and prefabricated buildings, especially the conversion of heating systems to coal and gas, as well as thermal insulation. While in the 1990s, the retrofitting rate was at times almost 4% in East German cities, today, the rate of energetic retrofitting lies below 1% [33].

In its Energy and Climate Protection Program 2014–2020, the city of Leipzig set itself the goal of achieving an average energetic retrofitting rate of 2% per year [9]. This is an ambitious goal, since a first wave of retrofits was already completed in the 1990s, and there are a relatively large number of Wilhelminian-period houses (over 15,000), a high density of heritage-protected buildings, comparatively low rent, and a very fragmented ownership structure [39]. Since the adoption of the first Climate Protection Concept in 2005, the city has been undertaking various measures to improve the energy efficiency of buildings using two modes of governance based on Bulkeley and Kern [40]. Firstly, Leipzig has been trying to reduce GHG emissions in the municipal building stock through the mode of "self-governance". Important milestones here include the introduction of 'intracting' in 2006, the adoption of the Passive House Resolution in 2008, the Energy Guideline from 2009, and the Half-Half Project in 2017. All these decisions can be traced back to a motion by one of these three parties: the Left Party, the Green Party, or the Social Democratic Party of Germany. However, since the amount of emissions caused by the municipality itself only accounts for 2% of the city's total energy and CO_2 balance, it is difficult to exert any direct influence though measures associated with the municipal building stock [13]. Secondly, Leipzig has been trying to reduce GHG emissions through the governance mode of "enabling" others. The city administration offers advisory services for private owners and housing companies as well as tenants, which are designed to enable and encourage these actors to undertake energetic retrofits to their building stock or to reduce their energy consumption. Advisory services for janitors have also been introduced by the city [13]. Furthermore, the city has increased citizen participation, for example through the civic platform "Leipzig think further", which was established in 2012 and focuses on energetic retrofitting. Nevertheless, the city has made only limited use of its resources, and no overall and long-term concept can be found since the beginning of the 1990s on how to increase the retrofitting rate in the city.

The municipal housing company and the Office for Housing Promotion and Urban Development recently developed the first-ever integrated, energetic concepts for some of Leipzig's city districts. The concepts represent an attempt to strategically plan and subsequently implement the heat transition. The municipal housing company developed an integrated concept for the energetic retrofitting of an inner-city prefabricated housing area from the 1980s with 1058 housing units known as the Kreuzstrassen district. This quarter is a relatively small, structurally closed district with a homogeneous ownership structure. Initiated by the Office for Housing Promotion and Urban Development, two integrated concepts for the energetic redevelopment of city districts were created. The resulting modernized districts are called "climate quarters". These districts are heterogeneous city quarters with different building age classes, building materials, and states of redevelopment, as well as a small-scale ownership structure.

While the implementation of the concept in the Kreuzstrassen district was rated positively by the interviewees, the implementation of the two "climate quarters" concepts proved to be more difficult.

Based on our results, one important explanatory approach focuses on the different governance structures involved in the planning and implementation phases (see Figure 3), the differing interests among the owners, as well as the different competences and resources of the responsible actors. The interviews showed that heterogeneity in the building stock and owner structure makes the energetic retrofitting of existing buildings more complex. Firstly, standardized solutions are not possible; many buildings are heritage listed, and the large number of owners increases the number of interests. According to statements made by the city administration employees and the engineers, two of the greatest challenges were the difficulties involved in communicating with the owners and the lack of incentives for owners to undertake retrofitting measures. According to Habermann-Nießе [41], private owners usually have a very short-term interest in profit, which explains why the owners were not the driving force behind energy-efficient retrofitting in these districts. The municipality had to take on this role instead. In the interviews with city administration employees, it became clear that the role was inadequately performed for two reasons: a lack of support from the highest administrative level, as well as a lack of political legitimacy, since the concepts for the district redevelopment were never approved by the city council. As a consequence, the Office for Housing Promotion and Urban Development had difficulties asserting the importance of the issue over the priorities of other departments. For example, this can be seen in the sobering statement of an interviewee on the importance of climate protection in urban development processes: "It is not a priority issue in urban development." Another obstacle was the lack of a central heat supply system for the entire urban quarter. As a result, various interests came into play on the energy supply side as well, which made it even more difficult to activate the actor triangle consisting of the housing industry, energy supply companies, and the city. In contrast, interviewees from the city administration and the municipal housing company reported that it was noticeably easier to implement retrofitting measures in the Kreuzstrassen district, because it already had a central heating system, and that made the actor triangle easier to activate.

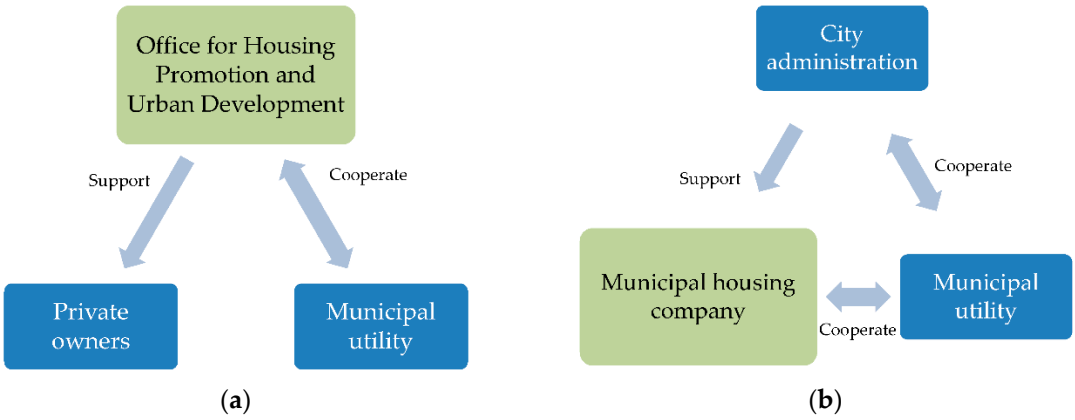

Figure 3. Actor triangle in the transition of the building environment in Leipzig. (**a**) Key actors of the energetic retrofitting of Leipzig's building stock in heterogeneous districts such as the "climate quarters"; (**b**) key actors of the energetic retrofitting of Leipzig's building stock in a homogenous housing district such as the Kreuzstrassen district.

A comparison of these two large-scale urban renewal projects clearly shows the level of interest of the owners on whom the heat transition depends. Due to a lack of interest from the private owners, the desired effect could not be achieved in the "climate quarters". The owners are not pursuing the goal of energy-efficient retrofitting, in particular because there are no financial incentives for them to do so. The Office for Housing Promotion and Urban Development does not have the necessary instruments or financial and human resources to effectively influence the rate of retrofitting. The municipal housing company showed much greater interest than the private owners, and they also had the resources and competences required to implement the concept. Thus, a post-fossil transition of the building sector seems to be more feasible in large housing estates.

5.2. Transition of Leipzig's District Heating System

The second main sector for the heat transition is the heat supply system. With 485 km of pipes, Leipzig's district heating network is one of the largest district heating networks in Germany [42]. The system supplies about one-third of the population of Leipzig, and 66% of the city's district heating comes from LEAG's lignite-fired power station in Lippendorf [13]. Therefore, through the wholly owned municipal utility, the city has excellent scope to maneuver and can directly influence the energy supply system. Nonetheless, the current debate about phasing out coal is relatively new; for a long time, coal-based district heating was regarded as relatively climate-friendly. This discourse was only changed by the actions of civil society actors.

The Leipzig Coal-Free initiative can be seen as the initiator of the debate. This local group is made up of representatives from three environmental associations (German Federation for the Environment and Nature Conservation, Greenpeace, and Ökolöwen/Ecolions) and was founded to promote the local phase-out of coal. Its demands and the resulting discussions prompted the Green Party and the Left Party to submit a request in 2017 for an investigation into the phasing out of coal by the municipal utility. Following this joint parliamentary request, the municipal utility developed exit strategies for quitting coal in 2023 and 2030. The contracts between the municipal utility and LEAG (the operator of the coal-fired power plant) include an exit option in 2023. The municipal utility finally came to the conclusion that a phase-out in 2023 is technically feasible and economically sensible [43]. The municipal utility's exit strategy envisages the construction of a gas-fired power plant with combined heat and power generation as a bridging technology [44]. The Lord Mayor of Leipzig, Social Democrat Burkhard Jung, declared his support for the phase-out and stated in an interview in December 2018: "Now is an ideal historical time window. The possibilities for support are provided by the federal laws, and therefore, it has to be now." [45]. The decision to phase out coal was made in June 2019 by the supervisory body of the municipal utility, which approved the municipal utility's proposal and decided to build the gas-fired power plant by 2022, as construction will be highly subsidized until then [46].

Although the decision to build the gas-fired power plant has been made, it is still not certain whether the phase-out will actually take place in 2023, as there are still some uncertainties. To understand why post-fossil transformation is progressing so slowly and decision-making is difficult, we need to look closer at the existing governance structures (see Figure 4). The discussion was initiated by extra-parliamentary actors, in particular by Leipzig Coal-Free. In addition, the Ende Gelände initiative (Enough is Enough) mobilizes acts of civil disobedience in the region to demand an immediate stop to the use of coal. Further political pressure is building through the demonstrations of the Fridays for Future movement, which calls for the declaration of a "climate emergency" and the phase-out of coal in the region by 2025. So, civil society initiatives and social movements were not only decisive for the emergence of the debate; their main role is to exert pressure on decision-makers.

While in the beginning, most of the political parties were skeptical about the coal exit, our interviewees confirmed that there has been a change in the attitude within the parties and in the city administration. The Greens and the Social Democrats have adopted the issue (interview with Leipzig Coal-Free), and the Left Party also largely supports the exit, although it has some reservations due to potential job losses. However, even if the majority of political parties now back the phasing out of coal, only the Greens tend to demand a complete post-fossil transformation of the heating sector. This lack of interest could be observed in June 2019, when the city council rejected (by a large majority) a catalogue of questions submitted by the Green Party on the further development of the district heating contract and a possible exit from coal [47]. The decision about whether to withdraw from lignite-based district heating by 2023 was thus passed to the supervisory board of Leipzig's utility and transport company (LVV), and therefore moved behind closed doors. This shows that interest in a direct, sustainable transformation is still restrained, or at least that the parties' interest in a sustainable heat supply is still overshadowed by social and economic concerns. According to statements made by the city administration employees, the municipal utility has been generating a huge surplus for

the city budget for years, and this money covers a large part of the costs for local public transport. The city would initially have to make considerable investments in order to achieve the heat transition, and other solutions must be found to cover the budget gap.

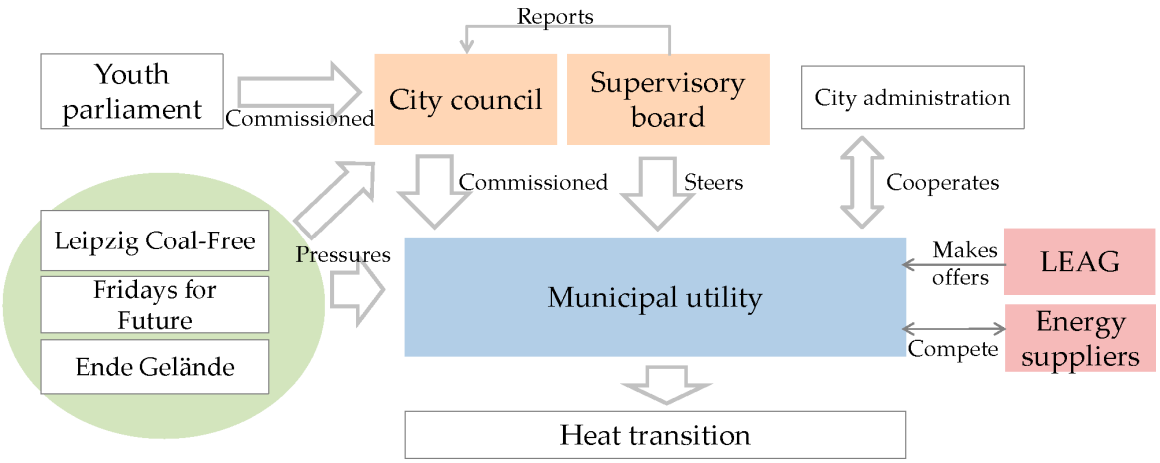

Figure 4. Actors in the transition of the heating supply in Leipzig.

Even though the decision was taken by the LVV supervisory board regarding the expiration of the contracts with LEAG, the actual competencies and resources, however, lie in the hands of the municipal utility. This will remain the case until the city develops its own long-term strategies for sustainable heat supply. Otherwise, the conversion of the heat supply will be determined by the options that can be realized in a certain period of time—so in other words, short-term solutions that are possible within the framework of already available knowledge. Due to the type of expertise required to change the heating supply, neither the city administration nor politics and civil society are often in a position to grasp the possibilities of a change in its entirety. Furthermore, the process of the heat transition was described by the interviewees from Leipzig Coal-Free as a very non-transparent process, where information was hard to get and no participation from civil society was intended. Consequently, the municipal utility is the only actor with enough information, resources and know-how to think about possible ways of transforming the heat supply system.

In the past, the municipal utility did not show much interest in ecological and climate-friendly solutions for the city's district heating supply, nor is the municipal utility's decision to withdraw from coal primarily a climate protection measure. Although it is influenced by the federal climate policy, it is primarily a strategic decision for the municipal group or a decision to minimize the risk for the group, as the future of coal is uncertain. Statements made by the city administration employees indicate that the conversion is an attempt by the municipal utility to secure its business model for the next 20 years. In addition, the economic conditions for the changeover are suitable at this moment in time due to favorable production conditions for gas-fired power plants. According to one interviewee from the city administration, the climate-friendly nature of the municipal utility will be demonstrated by the share of renewable energies in the future energy mix and the increase in renewables over the following years. Currently, only a 20% share of renewable energies is planned.

The consequences of the district heating system transition for Leipzig's climate protection policy remain uncertain. Whether and to what extent the city of Leipzig will be influenced by the decisions of the municipal utility is still unclear. To ensure that a post-fossil transformation takes place, the city must define goals and design a long-term concept for the heat transition. However, the problem here is the city administration's large information deficit vis-à-vis the municipal utility.

6. Discussion

Leipzig is an instructive example of the thematization of the post-fossil city. In the 1990s, the city of Leipzig underwent its first transformation in the wake of German reunification and integration into the EU. In addition to changes in the political and economic systems, this also meant the end of a large part of the coal-based industries. The strong path dependency can be seen in the fact that part of the coal mining industry continued operating, and a coal-fired power plant still generates electricity and a substantial amount of the city's heat. The heat transition here is directly related to the (complete) phasing out of coal. In the course of the post-socialist transformation, numerous factories and power plants were shut down and operations ceased, which, as a side effect, led to an enormous reduction in CO_2 emissions. However, this was an unintended consequence, a "gratis effect of deindustrialization", as it predated the beginning of the city's active climate policy.

The findings in our article show that no major changes should be expected in the building sector without fundamental changes in the housing market or the conditions for the owners. Large-scale redevelopment in large housing estates remains conceivable, as we have a second driving force here besides the city in the form of the housing company, but large-scale redevelopment measures in heterogeneous urban districts are unlikely under the given conditions. Due to the housing industry's lack of interest, progress lags behind, and it is improbable that Leipzig will reach its climate protection goals. In contrast, a heat transition involving the phase-out of coal could be a big step toward a post-fossil city. However, whether this is really going to happen remains to be seen. Nevertheless, the construction of a new gas-fired power plant, which will be in operation for at least 15 to 20 years, will lead to a renewed path dependency resulting from investment as well as planning and construction decisions. As described by Romero-Lankao et al. [5], these path dependencies constrain transformative action: "Once adopted, infrastructure, low-density urban form, and institutional and social practices become enduring and difficult to change" (p. 755). No efforts are currently being made to develop the heating supply on a renewable basis in the near future. Therefore, no solution for exiting fossil energy sources is foreseeable at present.

The outcomes of this article show that while the city of Leipzig has committed itself to ambitious climate goals, so far the city has not taken a systemic approach in order to reduce local emissions, and climate protection has not been a central policy area in Leipzig. The city conducts political marketing with individual measures, and received the 'Gold' European Energy Award. Thus, climate protection policy appears to be a symbolic policy. The city is far from systematically implementing effective measures to achieve its own climate protection goals, especially in the heat sector. Instead, it is only pursuing incremental approaches, which is a characteristic feature of local climate policy, according to Heinelt and Lamping [25]. This is exacerbated by the fact that only a small part of the funds from the structural change fund is set to be invested in innovative and regenerative projects for the energy and heat transition, which also shows that transformation is not being driven forward in a purposeful and structured manner. The city is only implementing mitigation measures in individual sectors rather than carrying out systemic changes, which is typical according to the analysis of Reckien et al. [48].

The example shows that it took a very long time before climate policy was firmly anchored in local politics. The symbolic accession to the Climate Alliance in the early 1990s was only followed 11 years later by the adoption of the first climate protection concept. It was not until Leipzig received the European Energy Award that the first governance structures were established. These governance structures were initially of an informal nature and remained largely confined to the city administration. In the 2010s, governance structures were established in the field of energy-related retrofitting from within the administration. While the structures were successful in facilitating cooperation with the municipal housing association and the municipal utility, private owners remained difficult to reach due to differing economic interests. These governance structures were also informal and remained of a temporary nature. In 2016, the first—albeit very small—administrative unit was created in the form of

the Climate Protection Unit. Given that the new climate protection concept is to be adopted in 2020, there will finally be a formal municipal budget to implement measures.

Actually, Leipzig is currently in a very good position to pursue a heat transition, since the municipality has sufficient influence over the grid-based heat supply—an important factor according to Weiß et al. [7]. However, it turns out that this influence alone is not sufficient. Access to the necessary resources and competencies for an actual transformation is still very limited to individual actors, such as the municipal utility and the housing industry, who are driven by economic interests. Municipal actors, such as the Climate Protection Unit, have so far only had limited competences and no budget of their own; therefore, the municipality is not yet a strong player either in climate protection policy in general or with regard to the heat transition in particular. Although the Lord Mayor is pursuing a work program entitled "Leipzig is growing sustainably", climate policy plays a subordinate role, and we do not find strong political leadership in this field. Hence, we find that those elected to leadership positions, such as the city council and the Lord Mayor, do not demonstrate strong support for the actors implementing the heat transition. There is a lack of political support, financial support, and an insufficient allocation of competencies. As a result of the Fridays for Future protests, the issue of climate policy has now for the first time entered the political agenda of the election campaign, and obviously this is also influencing the decision-making processes regarding the phase-out of the heat supply from the Lippendorf coal-fired power plant. Current debates in the city are not being driven by the institutionalized structures that have been set up over the years, such as the Climate Protection Unit or the Energy Team. Rather, formal and temporary governance structures are pushing the issue forward. This shows once again that public and political pressure from civil society actors and social movements is needed to advance climate policy and heat change.

With its decision to phase out coal by 2038, the German government's structural commission has set a framework for post-fossil transformation. This could also provide a key incentive for the mining and energy region of Leipzig to undertake a transformation. However, at present, it is not apparent that the switch to renewable energy sources is being approached in a structured manner in the heating sector. When this paper was finalized in the summer of 2019, Fridays for Future Leipzig, via the Youth Parliament, had submitted a city council proposal to declare a climate emergency. If implemented, all city council decisions would need to be examined in relation to their impact on the climate. The proposal also instructs the Lord Mayor to initiate effective climate protection measures at the local level. It remains to be seen whether the proposal will be implemented, and if so, what impact this will have on the heat transition.

7. Conclusions

The aim of this article was to examine the heat transition in depth on the basis of a case study focusing on the actors involved. For Leipzig, the assertion in Section 2 applies, i.e., that the heat transition is not pursued as an integral part of the transformation into a post-fossil city. Starting in the 2010s, the heat transition was partially instigated in the area of energy-efficient retrofitting. From 2017 onwards, the central heat supply became the focus of the activities of civil society actors. Yet so far, the heat transition has been pursued using an unstructured approach that reacts to pressure from various actors. The German government's decision to phase out coal by 2038 has opened up a window of opportunity for the heat transition. However, the path dependencies of the fossil energy and heat economy are still strong in the Leipzig region, as manifested by lignite mining and the coal-fired power plant. In contrast, the forces for a post-fossil transformation, including the heat transition, are weak. The region lacks a powerful actor who has a significant interest in the transition and assumes leadership. Therefore, it is unclear at the present time whether and how the heat transition will continue. Considering the exploratory approach in this article, much more research is needed to identify the challenges that make it difficult for municipalities to carry out systematic heat transitions. Based on our results, further research should especially address the question of how path dependencies in the heat

sector manifest themselves and what effects they have. Another key question is how municipalities can gain the necessary competences and resources to accelerate the heat transition.

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