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Article

Urban Heat Transition in Berlin: Corporate Strategies, Political Conflicts, and Just Solutions

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Abstract
In the field of urban climate policy, heat production and demand are key sectors for achieving a sustainable city. Heat production has to shift from fossil to renewable energies, and the heat demand of most buildings has to be reduced significantly via building retrofits. However, analyses of heat transition still lack its contextualization within entangled urban politico-economic processes and materialities and require critical socio-theoretical examination. Asking about the embeddedness of heat transition within social relations and its implications for social justice issues, this article discusses the challenges and opportunities of heat transition, taking Berlin as an example. It uses an urban political ecology perspective to analyze the materialities of Berlin's heating-housing nexus, its politico-economic context, implications for relations of inequality and power, and its contested strategies. The empirical analysis identifies major disputes about the future trajectory of heat production and about the distribution of retrofit costs. Using our conceptual approach, we discuss these empirical findings against the idea of a more just heat transition. For this purpose, we discuss three policy proposals regarding cost distribution, urban heat planning, and remunicipalization of heat utilities. We argue that this conceptual approach provides huge benefits for debates around heat transition and, more generally, energy justice and just transitions.

Keywords
Berlin; energy justice; energy retrofitting; green gentrification; heat transition; just transition; low-carbon policy; urban metabolism; urban political ecology

Issue
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1. Introduction

Around 70% of the world's carbon emissions occur in cities. Simultaneously, cities could potentially be forerunners of sustainable transformation in the 21st century. Accordingly, a major focus of global climate mitigation efforts is on the decarbonization of urban areas. As the housing sector accounts for a significant proportion of cities' carbon emissions, principally due to hot water and heating, the heat transition is crucial for the urban transition towards carbon neutrality (Van der Schoor & Sanders, 2022; Weiß et al., 2018). Not only must heat production be changed from fossil to renewable energies but the heating needs of most buildings must be decreased significantly (see Ruhnau et al., 2019).

However, advocates of green urbanism often ignore the fact that sustainability policies are embedded in neoliberalized urban structures, which facilitate corporate interests and aggravate socio-spatial injustices within the city (Gould & Lewis, 2016; Kohl & Andersen, 2022). Hence, the heating transition is also shaped by the strategies of energy and real-estate enterprises, often resulting in ecologically questionable outcomes, increased heating costs due to expensive technologies, and building renovations that lead to higher rents. This is increasingly important in light of sharply rising energy

prices due to the geopolitical conflict surrounding the Russian invasion of Ukraine and the political will to decrease fossil dependencies. Social and ecological principles must therefore be reconciled in a just and sustainable transformation. Conceptual visions and concrete policy proposals are required to provide socially and ecologically just solutions and enable a democratically designed urban heat transition (see Agyeman, 2008).

This article deals with these challenges and opportunities, taking the contentious heat transition in Berlin, Germany, as a case study. We propose the heuristic concept of the heating-housing nexus to consider the multiple entanglements between the heating and the housing sectors. Our central questions are: In which social relations is the heat transition embedded and what does this mean for social justice issues? How should a social and ecological heat transition therefore be designed?

The growing body of research on heat transition (Abbasi et al., 2021; Herreras Martínez et al., 2022; Weiß et al., 2018) still lacks contextualization of heat transition within entangled urban politico-economic processes and materialities and requires critical theoretical examination. Our analysis thus adopts a power-sensitive analytical foundation to grasp the complex and interwoven urban processes and their actors and the political-economic strategies involved within the heating-housing nexus. We use urban political ecology (UPE) to understand this nexus as a socio-material metabolism that is mobilized to serve specific interests and needs. This draws attention to the constant (re-)production of the particular materialities of the heating and housing sector and corresponding social relations of power, injustices, and conflicts through these metabolic processes.

While various studies use UPE to examine urban infrastructures of, for instance, water, electricity, and food supply (for an overview, see Gandy, 2022), there are few articles exploring questions of urban heating from a UPE perspective (see Bouzarovski, 2022; Bridge et al., 2018; Moss et al., 2016). Such analyses have not yet connected the spheres of urban heating and housing. However, these two spheres must be considered in their interrelatedness. A UPE perspective on energy transitions has huge potential to benefit debates on just transition. Through analyzing and questioning the politico-economic foundation and context of transition policies, it challenges the potential co-optation of the concept by mainstream political discourse (see Stevis & Felli, 2020). Directing its profound and power-sensitive analytical lens onto the mobilization of urban metabolisms enables a holistic perspective on the sectors and parties involved and affected by the transition, as called for by critical transition literature (see Bouzarovski, 2022; Stevis & Felli, 2020).

To explore our research questions, the next section contextualizes the theoretical approach within critical sustainability and low-carbon policy research and then introduces our heuristic concept of the heating-housing nexus and operationalizes the UPE perspective to analyze the heat transition. This analytical framework is then applied to the heating-housing nexus in Berlin and the debates and strategies surrounding its transition. Finally, we discuss our empirical findings and possible strategies towards a just transition and conclude with further research questions.

2. Analytical Framework

Heating and housing are based on materialized infrastructure, which comprises systems of heating production and supply and residential heating units. This historically evolved fossil-based structure has mostly remained untouched by urban sustainability policies, which focus largely on urban greening, smart growth, and technology-oriented efficiency policies (Long & Rice, 2018). Some scholars criticize how recent urban climate policy efforts and carbon neutrality programs have become integrated into capitalist production and consumption patterns (see Castán Broto & Robin, 2021; Kohl & Andersen, 2022; Long & Rice, 2018). Yet, ambitious multilateral emissions reduction targets and growing climate activism are increasingly challenging common technical approaches. It is important here to pay attention to evolved structures, materializations, and ownership patterns in key infrastructures like heat and housing and the respective constellations of actors. Such constellations influence how ambitious urban climate policy is, whether it is coopted by capitalist dynamics, and whether it tries to integrate social justice aspects or reproduce established power geometries (see Kohl & Andersen, 2022; Long & Rice, 2018).

To capture these complex phenomena in an analytically meaningful way, we need a concept that can analyze their materialities, dynamics, and actor constellations in a power-sensitive, interrelated manner. In the following, we explain and apply UPE as a suitable analytical perspective. Using the concept of the socio-natural metabolism of cities, it examines the myriad forms of the societal transformation of nature and the circulation of natural resources and its products as a driver for the production of urban environments, so-called "socio-natures'' (Rice, 2014, p. 82). In particular, UPE explores how these metabolisms are mobilized to sustain capitalist urbanization and particular actors and interests, how urban inequalities and injustices are thus (re)produced and how corporate and political strategies become contested and challenged (Heynen et al., 2006).

Hence, UPE represents a useful approach to investigating the persistence and transition possibilities of materialized energy systems and their consequences for urban inequalities in terms of their underlying power structures. It enables a focus on energy production facilities and networks but also widens the analytical perspective to include the transformation of energy and its consumption in private households. We capture these interwoven segments as the heating-housing nexus. We understand this nexus as a heuristic analytical approach to connect research on energy systems and their management with energy-related questions of housing and residential retrofitting.

To operationalize UPE for our analysis, we divide this perspective into four analytical categories: (a) materiality of the heating-housing nexus, (b) its political economy, (c) its implications for inequality and power relations, and (d) its disputed strategies and conflicts. We explain these categories below and apply them to our case study in the subsequent section.

2.1. Materiality

Urban heat supply is based on and functions through built infrastructure, which itself depends on the resource (e.g., coal, gas) enabling heat production, the form of transportation, and transformation into space or water heat. These materialized infrastructures result from past societal strategies and conflicts that have historically coagulated into socio-material structures (see Heynen et al., 2006). These specific structures, in turn, form the material basis for their contested transformation. Urban heat supply cannot be regarded in isolation but only in dialogue with residential building complexes, their heating systems, and structural heat demands. Heat supply emerged from the energetic demands of residential construction, as one key recipient besides industrial demand, and co-evolved in a reciprocal process. Coagulated socio-natures like fossil-based heating with its massive built infrastructure of heat production (e.g., nearby gas- or coal-fired plants) and supply (e.g., district heating networks) and residential buildings can create path dependencies and impede the realization of, for instance, decentralized renewable heat production and supply.

2.2. Political Economy

The energy system, which evolves through the production and transformation of resources and its supply management, is substantially influenced by the structural capitalist context and the concrete interests and business models of involved companies (see Bouzarovski, 2022). It reflects past economic policies and socio-political disputes and negotiations, which determined the resource path (e.g., fossil-based heat supply) and property and management structures (e.g., public utilities or privatized heating production and networks). Integrating housing into this perspective involves considering ownership structures in the residential sector and corporate strategies of (non)investment in the energetic condition of buildings. This, again, depends on the market, i.e., demand/shortage of housing in a city and availability and price of energy sources. The legal frame is also relevant, including legal limits on rent increases (allocation of costs), state subsidies, etc.

2.3. Inequality and Power Relations

The emergence of a specific energy system is based on structures of power relations and affects urban inequalities (see Heynen et al., 2006). A privatized heat supply needs to produce profit for the operating company, generating this from consumer fees. Low-income consumers spend a higher proportion of their income on heating, and since they are more likely to live in poorly insulated buildings, this proportion increases further, as does their vulnerability to increased heating costs. However, while building retrofits reduce energy demand and thus energy costs for tenants, if cost shifting of investments to tenants is permitted, they can lead to sharp rent increases and, ultimately, displacement (see Grossmann, 2019; Weißermel, in press). Moreover, to maintain market power, companies tend to stick with existing (centralized) production and supply systems, thus possibly opposing alternative modes of production and supply that could be cheaper for consumers (in the long run). This perspective on the heating-housing nexus connects the debates of energy poverty and energy justice around power structures within the energy sector, cost distribution and access to energy (see Bickerstaff et al., 2013; Bouzarovski & Simcock, 2017) with debates around energy retrofitting and its socio-spatial consequences (Grossmann, 2019; see also Bouzarovski et al., 2018; Rice et al., 2020).

2.4. Disputed Strategies and Conflicts

These structures and constellations emerge from and form the basis for municipal and corporate strategies that are power-driven but potentially disputed among diverse urban actors. Conflicting interests and strategies are expressed in policy disputes and contested debates. However, this conflict is not simply derived from these structures; it has its own momentum and can, in turn, transform them (see Heynen et al., 2006). The question of de- and repoliticization of urban politics of resource management is central to UPE, which stresses the thoroughly political character of urban metabolism and its power-driven mobilization for particular interests. It is, thus, decidedly opposed to any consensus politics based on allegedly value-neutral technical solutions to environmental problems (Rice, 2014; While et al., 2004).

Applying a UPE perspective to the heating-housing nexus and its potential transition enables us to trace the metabolisms of heat energy through the urban landscape with an understanding of such a metabolism being embedded in the political architecture of power- and interest-infused materialities, networks, and concrete actors. This perspective connects to the just transition debate in general and the energy justice debate in particular, which increasingly focuses on the decarbonization of energy systems and the possibilities of just transitions (see Bickerstaff et al., 2013; Bouzarovski & Simcock, 2017). We argue that the holistic and power-sensitive lens of UPE on the mobilization of urban metabolisms has a huge potential to enrich these debates. Relating to our four analytical categories, we argue that a just heat transition is feasible if (a) the urban metabolism of the heating-housing nexus is politicized and challenged

to be organized/mobilized in a more sustainable manner, (b) corporate interests are pushed back, in order to (c) enable ecologically and socially more equal and just access to energy; however, a central precondition for such a process is (d) the existence and acceptance of (open) conflicts and the politicization of urban politics.

3. Contentious Heat Transition in Berlin

We now discuss these questions using the example of the urban heat transition in Berlin. We present the main findings and conclusions regarding the transition of heat generation and related conflicts about renovations and present three constructive policy approaches discussed in the literature and politics. We use the UPE perspective to analyze the case study through the lens of the four categories discussed above, focusing on the contested transformation of the heating-housing nexus.

3.1. Methodology

The empirical data primarily stems from a recent report conducted for Friends of the Earth Berlin in 2021 (Sander & Wohlfahrt, 2021). At the beginning of the project the research questions and design were defined with the NGO. The partners from the organization are experts in the field and proposed a list of important studies to be read (cited in this Section 3) and a list of key representatives from relevant actor-groups covering the complete field (see Supplementary File). Complementary, further studies and policy papers were identified via (online) literature research. Furthermore, additional interview partners were pinpointed by a subsidiary mapping or recommended by other interviewees. Finally, 28 expert interviews were held with relevant stakeholders, including members of political parties and the administration, people from business, trade unions, tenant organizations, and initiatives, environmental NGOs, and academia. Most of the semi-structured, guided interviews were conducted in the first quarter of 2021 (online or in presence). All interviews were recorded and excerpted. The extracts were evaluated by means of a qualitative content analysis. Initial findings were drafted and discussed in two stakeholder workshops in June and November 2021. In the following, empirical sources are coded by the survey method (I = interview) and the abbreviation of the respective interviewed organization (for explanations see Supplementary File).

3.2. Case Study Analysis

The transition of the socio-natural metabolism of the heating-housing nexus should be considered as a controversial politico-economic process shaped by the political economy of heat production and the real estate market. Moreover, different strategies and paths have substantial implications not only for ecological sustainability, but also for energy justice as they affect prospective heating and rental costs. Different actors pursue conflicting strategies to transform or sustain the current structures of provision and demand in the city's heat supply.

Within the heterogeneous spectrum of interviewed stakeholders, we identified three groups of actors with relatively similar interests and positions regarding the key questions. These are economic/corporate actors (private energy utilities, real estate companies, business associations, and chambers); environmental actors (NGOs, green research institutes, and green consulting and engineering companies), and social actors (tenants' associations and initiatives, consumer protection agencies, and some trade unions). Other actors are positioned in the field between these three poles.

3.2.1. Materiality

In Berlin, the urban heat supply as well as the housing sector is based on fossil infrastructure. The built environment of heating plants, networks, and buildings was historically shaped by past capitalist and municipal strategies and balances of forces. Due to the path dependency of these built structures, the city's heat production and supply is still predominantly based upon fossil energies.

Natural gas dominates the capital's district heating as well as local heat supplies: This fossil fuel is still a major source of heating with 40% of Berlin's buildings directly supplied by the gas network. The second important heating infrastructure, district heating, accounts for over 30% of Berlin's heat demand and is predominantly based upon natural gas in the heating plants (74%) with a minor proportion using hard coal. Heating the building sector thus accounted for 47% of Berlin's carbon emissions in 2020 (Dunkelberg et al., 2021). Furthermore, the city's building stock is largely characterized by high energy demands met by the fossil heating system. According to the federal government's efficiency strategy for buildings (2015), heat demand in Berlin must be decreased from about 135 to about 80 kWh/m^{2}a to allow full supply by renewable energies (Dunkelberg et al., 2020). However, neither the characteristic Wilhelminian-style buildings nor most of the recently renovated houses meet this target.

The built structures of Berlin's heating-housing nexus form the basis of a socio-natural metabolism characterized not only by a tremendous demand for fossil energy, which is converted into heat energy in dwellings, intensifying the climate crisis, but also by the political economy of the energy and real estate sector. The conditions for a green transition of Berlin's heat supply only become intelligible by analyzing this interrelation.

3.2.2. Political Economy

In particular, the heat transition depends on the dominating utilities, their business models, and strategies. The urban heating infrastructure is largely controlled by two companies. A subsidiary of the Swedish

state company Vattenfall runs the district heating and the private utility GASAG owns the gas infrastructure. Together they control more than 70% of the heating market. Furthermore, they are closely linked with cross-ownership and a supply relationship (Vattenfall procures the gas for its heating plants from GASAG; Ritzau et al., 2019). Both companies favor gradual and controlled decarbonization. They are trying to conserve the centralist structures of heat production and supply (gas network, district heating, and heating plants) as well as the high demand from consumers as their business models depend on the conventional fossil heating-housing nexus.

Besides individual private owners and landlords, the real estate market is largely controlled by private equity, institutional investors, and return-orientated real-estate enterprises. Recently, large real-estate companies like Deutsche Wohnen or Vonovia (now merged) bought up many buildings in the German capital (I_DWE; Wijburg et al., 2018). Municipal companies, housing cooperatives, and other non-profit proprietors own the remainder of the housing stock (Trautvetter, 2021). The most powerful association of private and public companies as well as cooperatives is the Verband Berlin-Brandenburgischer Wohnungsunternehmen (BBU).

In recent years many proprietors used energy retrofitting to raise rental prices and, thereby, profits and revenues (I_MV). Recently, they seem to have changed their strategies, focusing on production-side heat transition and refraining from energy-related modernizations. They rely here on the strategies and measures of the energy utilities (I_IÖW, I_BBU, I_MS). These structures and interests mean that the political economy of Berlin's heating-housing nexus conserves centralist, energy-intensive heat production and supply and corporate housing strategies to the detriment of the tenants, as shown below.

3.2.3. Inequality and Power Relations

The heating-housing nexus is based upon asymmetrical power relations between capital factions and tenants or consumers. Due to this balance of forces and the organization of housing as a commodity, rental prices have risen significantly in the German capital, further aggravated by rising heating costs.

Hence, decisions about future heating technologies and sources (see Section 3.2.4) are important not only for climate protection but also for energy justice (I_LI; see Sander, in press). The latest scenarios indicate that under current market conditions, renewable energies are indeed more expensive than gas boilers regarding installation and operation (I_CW2, I_BIM, I_SW). However, heat pumps are expected to be more cost-efficient than gas heating for single-family homes by 2025 (I_GR, I_HI, I_VDGN). By 2035, gas-fired systems will be twice as expensive as heat pumps (Braungardt, 2022). Furthermore, hydrogen-based heating systems are expected to be 50% more expensive than heat pumps (Matthes, 2021, p. 28). An interviewee from the field of consumer protection predicts that district heating based on hydrogen or gas-fired heating plants will be significantly more expensive for households than that based on renewable energies or waste heat (I_VZBV).

Demand-side strategies to enhance the energy efficiency of buildings are potentially the most sustainable way to reduce the social burdens of rising heating costs and the ecological impacts of high energy demands. However, energy retrofitting has been utilized by property owners to increase the market value of their assets and replace tenants (Grossmann, 2019). Consequently, many Berlin tenants suffer from rising rental prices and are often forced to move to less expensive and less energy-efficient flats (I_SvU, I_DWE). A 2017 study commissioned by an urban tenants' association (Berliner Mieterverein) revealed that energy-related modernizations raised rental prices by €2.5 euros per square meter on average. Many proprietors demanded considerably higher payments—sometimes €4–6 per square meter (I_MV; Wild, 2017).

Consequently, in the Berlin heating-housing nexus, rising gas prices, inefficient green solutions (like hydrogen), and modernizations to enhance the energy-efficiency of buildings can inflate total rental prices, sharpening energy injustice as poor households suffer disproportionately.

3.2.4. Disputed Strategies and Conflicts

Policies and discourses around the urban heat transition are quite controversial in Berlin due to the ecological harmfulness of the built structures in the city's heating-housing nexus, the opposing corporate and social interests resulting from the political economy of that nexus, and the unequal power relations and energy injustices associated with it. This applies to the field of heat production as well as that of heat consumption and housing.

Beginning with heat production, we observe conflict between an electricity- and a gas-based trajectory of transition in district heating and in local supply. Current decarbonization strategies for heat generation in the European Union and in Germany either focus on electrification (via heat pumps; Abbasi et al., 2021; Kicherer et al., 2021) or green gases (Jensen et al., 2020; Ruhnau et al., 2019). Since both options are associated with conflicting business interests, different networks of actors try to advance their favored technological trajectory, which has substantial implications for the distribution of benefits and burdens.

In Berlin, many commercial actors also argue that *natural gas* is an important bridging technology and should be replaced by (green) *hydrogen* for local supply in the medium term. They refer to the narrative of "openness of technological solutions," advocate a diverse and flexible energy mix, and suggest that the urban gas network should be made "hydrogen-ready" (I_BBU, I_MS, I_HWK, I_VF, I_BEA, I_WEB; see, e.g., Vattenfall, 2020; see also

Sander, in press). Especially GASAG pursues this strategy, as an interviewee from the company reports (I_GSG). Environmentalists and politicians from left-wing parties criticize this as massive lobbying by a broad alliance of actors from industry and politics (I_HI, I_LI, I_GR). Instead, they call for a gas phase-out to avoid a lock-in effect. Hydrogen should only be used where there is no other technological solution to decarbonize production processes (e.g., steel and chemical industry; ifeu et al., 2018). There should be a clear focus on the most efficient technologies, thus rejecting the narrative of a diversity of technological solutions, respectively the energy mix that would also include inefficient options like hydrogen (I_HI, I_BBK).

The crucial alternative to gas and hydrogen in local supply is *heat pumps* (I_GR, I_LI, I_BIM, I_HI). A recent study commissioned by environmental NGOs demonstrates that by 2035 the heat demand of most (residential and commercial) buildings can be covered by heat pumps combined with a heat store (I_BBK). The advantage of this technology is that it can be run almost everywhere with green electricity from the grid, given appropriate legal and technical conditions. Only a small number of houses, especially unrenovated old buildings with high heat demands, will have to revert to biomass (6%) or hydrogen (3%; Egelkamp et al., 2021).

The technological conflict between the gas- and the electricity-based paths can also be witnessed in *district heating* (I_WEB, I_GR). A feasibility study commissioned by the Berlin government and the utility Vattenfall (Gonzalez-Salazar et al., 2020; Ritzau et al., 2019) concluded that coal-fired heating plants should be phased out by 2030 and substituted with low-carbon sources, aiming for climate-neutral district heating by 2050. Geothermal energy, biomass, and waste heat should contribute 40% and modern gas-fired cogeneration plants 60% to the replacement of the coal-fired plants (I_WEB; I_IHK).

However, environmental NGOs and left-wing parties criticize the study for adhering to gas-based generation and insist that district heating should be changed to renewable sources at pace (I_BBK, I_GR, I_LI). A Fraunhofer Institute study concludes that Berlin and its hinterland have ample renewable and waste heat potential to shift district heating to climate-neutral generation by 2030. This would involve different low-temperature heat sources being opened up via large-scale heat pumps. Such sources include industrial waste heat and heat from river water. Further options are geothermal energy and solar heat (Egelkamp et al., 2021).

On the demand side, namely housing, the economic logic of the real estate market and state policies result in a praxis of retrofits, creating conflict between ecological and social purposes. In Germany, the modernization allocation scheme (*Modernisierungsumlage*) allows 8% of retrofit costs to be added to the "cold rent" (rent excluding heating costs; Grossmann, 2019). Generally, tenants must accept these measures. Even after amortization, rents may remain on the higher level permanently, making modernization lucrative for real estate companies and investors in the long run. As the modernization allocation relies solely on total modernization costs and not on actual energy saving after modernization, it incentivizes proprietors to conduct retrofitting schemes even if their ecological effectiveness is questionable, as some scholars criticize (see Grossmann, 2019). Thus, under the current ownership structures and legal framework, ecologically reasonable solutions contradict principles of energy justice (I_SvU).

In particular, private equity and real estate companies often invest in high-risk assets with a short-term valorization, treating houses as investment properties. Interviewees from tenant organizations argued that such companies often invested in energy-related retrofits to increase value and rental prices permanently and deliver on the promise of revenue vis-à-vis their shareholders (I_MV). Unsurprisingly, most of Berlin's tenants have reservations about retrofits. They worry that a new renovation offensive will lead to further rent increases (I_MV, I_SvU; Holm, 2021).

However, many proprietors seem to have changed their strategies recently, refraining from further investment in extensive renovations (I_IÖW). Referring to Vattenfall's decarbonization program, the real-estate industry organized in the association BBU argues that generation-side heat transition would be more cost-effective. Moreover, utilities and proprietors argue that a broad renovation strategy is too expensive (I_BBU, I_MS, I_VDGN, I_VF). BBU published a study which forecasts high costs for owners and tenants if Berlin's entire housing stocks were retrofitted (Nymoen & Niemann, 2020).

However, relying only on a production-side strategy could lead to a techno-fix that sustains existing business models, infrastructures, and consumption patterns without substantially reducing heat demands and the need for resources and energy (I_IÖW, I_LI). New renovation policies—as promoted especially by environmental NGOs—need not only to meet ecological requirements but also to find solutions to distribution conflicts between tenants and landlords (I_DWE, I_SvU). The key question is about who bears which portion of the substantial costs of modernization. Interviewees from owner organizations argue they cannot cover most of the costs but have to allocate them (I_BBU, I_MS, I_HWK). In contrast, tenants' initiatives insist that tenants similarly cannot bear a large share of the costs, as the energy efficiency of building stock is a public challenge (I_MV, I_SvU, I_LI).

3.3. Strategies for a Just Heat Transition

In our analysis of the heat transition in Berlin, we illuminate a socio-natural metabolism mobilized to reproduce and advance capitalist urbanization and necessitating strategies that promote a just transition. In explicating this, we contribute to the debate on how to avoid

green gentrification and reconcile social and ecological principles. In this endeavor, the democratic municipality must play a more active role with concrete policies and planning instruments in order to design the transformation of heat supplies in a socially and ecologically just manner. Yet, public solutions are characterized by some limitations, as discussed below, and need to be combined with a democratization of state institutions and public companies. We discuss three policies or strategies that address different levels of intervention, also referring to debates in science. We argue that these strategies have the potential to enable a more equitable design of heat supplies and a democratic repoliticization of the metabolism of the heating-housing nexus.

3.3.1. A Distributive Approach

The so-called "thirds model" (*Drittelmodell*) proposes a way to deal with distributional conflicts about building renovations. It suggests justly apportioning costs among the three parties—owners, tenants, and the public authority. First and foremost, the state or municipality should increase subsidies for energy retrofits, enabling proprietors to invest cost-effectively in modernization and simultaneously disburdening tenants from unacceptable rent increases (I_LI, I_CDU, I_BAU, I_MS, I_BIM). Admittedly, the financial capabilities of the administration are limited as well. For instance, the previous center-left government of Berlin (2016–2021) established a program to support investments in building retrofits, providing 50 million euros (I_WEB). However, this is a relatively small amount vis-à-vis the 3 billion euros per year that a study by the real estate industry's association suggests is necessary (I_BBU; Nymoen & Niemann, 2020).

This approach especially addresses the justice dimension of the transition of the heating-housing nexus. It takes the question of cost-sharing out of the market-led relationship between landlord and tenant. Instead, it treats the costs of heat transition as a public responsibility and could thereby mitigate energy injustices. Not least, it prevents a sole production-side strategy and could initiate a just modernization strategy.

3.3.2. Heat Planning

Heat planning is a relatively new strategic instrument in Germany, which the federal government recently introduced nationwide. Baden-Württemberg is the only state where municipalities are already obliged to establish urban heating planning. Recently, it has also been discussed with growing intensity in Berlin, which has begun to establish a heat register as a basis for the planning process. The aim is to provide a systematic, cost-effective, affordable, and climate-friendly heat supply with the municipality as the key actor in strategically and proactively organizing the heat transition (I_CW1, I_LI, I_HI; Herreras Martínez et al., 2022). Heat planning comprises long-term spatially coordinated and (often) binding strategies transferred into a cartographic presentation that gives an overview of the entire urban area. It connects heat potentials and heat consumers, approaches for renewable generation and demand reduction, generation sites and networks, and district heating-based areas and those with a local supply. It thus provides guidance for future investments and local potential in the districts (Riechel & Walter, 2022).

Urban heat planning in Berlin could organize the heat transition and, thereby, the socio-natural metabolism in a more democratic, comprehensive, and reasonable way, rolling back the logic of a market-driven transition and the protective interests of dominating companies. Furthermore, it could soundly combine production- and demand-side strategies. Yet, the legal and effective assertiveness of this instrument vis-à-vis proprietors and utilities is somewhat limited as it cannot force or prohibit certain investments by utilities. Moreover, it risks becoming a technocratic approach if civic actors and citizens are not substantially integrated into the process.

3.3.3. Public Companies as Pioneers

Another promising strategy could involve strengthening the economic role of the municipality by empowering public companies to pioneer a climate-neutral heating sector (I_LI; I_MV; I_HI; I_CW1). There is already close and productive cooperation between the public utility and municipal facility management administrating the public properties in Berlin (I_BIM; I_SW). Recently, the grid was remunicipalized after persistent pressure from a broad civil society alliance, opening up new opportunities for collaboration with the aforementioned companies.

Furthermore, the new government in Berlin—formed of the same parties as the previous coalition in 2021—aspires to return district heating to public hands. There are even debates within Berlin's coalition about remunicipalizing the gas network or the whole company GASAG. The public housing companies have expanded their building stocks with new residential construction and purchase in recent years. Furthermore, a broad leftist alliance called "Deutsche Wohnen&Co enteignen" (Expropriate Deutsche Wohnen&Co, DWE) won a public referendum in Berlin demanding that the assets of the city's big real-estate companies be socialized (I_DWE). The alliance keeps on pressing the new government to implement this (Kunkel, 2022).

4. Discussion

Following Heynen et al. (2006, p. 6), the specific material arrangements and ownership structures that mobilize metabolisms in a particular way benefit certain sectors of society and compromise others. This reproduces unequal social relations and power structures. However, recognizing the powerful entanglements of

urban metabolic processes can radically challenge social and politico-economic relations. Yet, we need to take into account that material arrangements and their stabilizing practices pre-structure and give a certain form to the conflicts around transformation.

The metabolism of the heating-housing nexus is embedded in and constantly reproduces the social relations, which are characterized by an unequal distribution of political and economic power and of the benefits (profits) and burdens (costs) of the heating and housing sector. Accordingly, low-income tenants living in poorly insulated buildings are affected by increased rents and rising heating expenses due to high demand and increased heating costs. Heating utilities, in contrast, benefit from the preservation of heating infrastructure and constant high demand, while real-estate companies profit from high rental payments without having to invest significantly in the energetic conditions of their housing or even achieve higher rents after modernization.

What do we learn from the Berlin case study? Historically created structures of heat generation and distribution, as well as the structural energy needs of buildings, create strong path dependencies that are difficult to change. These material structures are reinforced by the dominant companies in both subsectors, which perpetuate these structures due to their interest in profitability and maintaining power. While the strategy of energy modernization has reduced demand for the sales of heating utilities and created tension between these two capital groups, in recent years, a strong convergence of the strategies can be observed in the close cooperation between Vattenfall, GASAG, and BBU.

These material and economic structures suggest the continuation of a gas-based system. Furthermore, even with conversion to renewable generation, high energy demands must be met if efficiency cannot be substantially increased. This would reproduce the capital-driven, socially, and ecologically detrimental metabolism. Both a continuation of the gas-based pathway and energy retrofits (under the current regulatory framework) would further increase costs for tenants, thereby exacerbating energy injustices. Because of these unequal structures and interests, the project of heat transition is contested. Open conflict can be observed in relation to real estate rental and retrofit policy between owners, tenants, and the municipality. Conflict potential is inherent in the conversion of heat generation and, associated with this, the social question of future heating cost allocation.

How could a just transition be achieved? The empirical analysis demonstrates that a just transition requires both a focus on efficient technologies (especially decentralized heat pumps and, in dense populations, district heating based on waste heat and local renewables) and an efficiency revolution in buildings, the costs of which must be justly shared. Social and environmental goals, which are played off against each other in the capitalist model, would then become compatible. Looking through the theoretical lens of UPE shows us that a key condition for this is the pushback of economic logic and the repoliticization and democratization of the metabolism.

Section 3.3 presented three major strategies for the realization of a socio-ecologically more just heat transition. All the strategies assign a more central role to the public domain. In combination, the distributive approach and heat planning could reform the mobilizations of the heating-housing metabolism, shifting the focus to some extent away from the logic of profit towards social and ecological criteria. However, this does not necessarily imply the democratization of the heating-housing nexus. As the key actors would remain largely the same, the power geometries of the nexus would not be radically transformed, nor would the nexus be detached from market logics.

In contrast, remunicipalizing the entire heat supply and socializing a relevant share of the building stock would dismantle corporate power in the sector and allow the municipality to design the heat transition in an ecologically and socially just manner, combining production- and demand-side measures (Sander, in press). Detaching the nexus from market logics would permit a more radical shift in the mobilization of the metabolism towards ecological and social ends and its materializations. The “Deutsche Wohnen & Co enteignen” alliance has already begun to publicly promote further arguments for expropriation (I_SvU, I_DWE). Relieved of the profit orientation of private companies, a socialized heating-housing nexus could pave the way for an urban commons beyond neoliberal constraints. However, formal nationalization should be combined with substantial democratization of public companies to enable a profound repoliticization and deliberate shaping of the socio-natural metabolism.

5. Conclusion and Outlook

In this article, we analyzed and discussed the challenges and opportunities of the urban heat transition, taking Berlin as an example. We used a UPE perspective that acknowledges the material, political, and organizational challenges of transforming a materialized and consolidated heating-housing metabolism. We direct attention towards the pivotal politicization and democratization of the project of heat transition and, consequently, the entire heating-housing nexus in order to consider and involve all affected parties and enable a socio-ecologically just transition.

The three approaches we presented towards a more just heat transition are currently being debated in policy and public discourse. All strengthen the public domain and shift away from a profit-driven logic towards ecological and social ends. However, only the strategy of municipalizing the heating and housing sector bears the potential of radically altering the mobilization of the heating-housing metabolism and detaching it from market logics. Such a socialized heating-housing nexus offers

a good foundation but must be organized in a democratic manner.

The findings from this article are conceptually important. The radical approach of a UPE perspective enriches debates around such complex multi-sector endeavors as heat transitions and, more generally, about energy justice and just transitions. We operationalized our concept by using four analytical categories to explore the interconnectedness of the heating-housing nexus and its metabolic processes. This approach can be transferred to other cities, as it responds to the complexity and political character of the urban organism. Further case studies are needed to challenge and extend our findings and to account for dynamic changes in (urban) energy production and supply. Moreover, as municipal actors only have a marginal role in our analysis, further research should investigate the importance of municipal policies and state institutions for the organization and transformation of metabolic processes within the heating-housing nexus. As cities and their heating and housing sectors are embedded within multiple scalar configurations, legislations, and politico-economic relations, multilevel analyses that include the translocal, national, and EU levels would be analytically fruitful.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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