

Solidarity in Just Heating Transitions: Decarbonization Potential Through Cooperation in the Post-Industrial City of Rotterdam

Erwin van Tuijl ¹  and Yogi Hale Hendlin ² 

¹ Faculty of Architecture and the Built Environment, Delft University of Technology, The Netherlands

² Dynamics of Inclusive Prosperity Initiative, Erasmus University Rotterdam, The Netherlands

Correspondence: Yogi Hale Hendlin (hendlin@esphil.eur.nl)

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Abstract

In debates on energy transition governance, heating transitions are a major factor; yet limited attention has been paid to the various justice dimensions involved. To address this gap, we combine literature on multi-stakeholder governance in heating transitions with energy justice, drawing on insights from an empirical case study of the post-industrial city of Rotterdam to identify three solidarity modalities (institutional, economic, and civic) to analyze cooperation drivers within, and governance limitations hindering, just heating transitions. Our findings reveal how collective action problems related to just heating transitions (strict climate goals, a shortage of installers, and willingness to address energy poverty) drive cooperation through solidarity initiatives by all actors. However, coordination failures, distributional conflicts, and institutional rigidity present governance challenges hindering implementation of just heating transitions, suggesting that solidarity alone is insufficient to achieve results. Nonetheless, we argue that iterated practices of solidarity together with institutional coordination can present cooperation opportunities to aid self-organization in just heating transition governance.

Keywords

energy poverty; heating infrastructure; just energy transitions; multi-stakeholder governance; post-industrial cities; solidarity

1. Introduction

In 1959, the discovery of Europe’s largest natural gas field in Groningen, the Netherlands, fundamentally transformed Dutch energy systems and economic prosperity. For decades, Groningen gas fueled Dutch

homes, industries, and export revenues, becoming a cornerstone of the national economy. Cheap domestic gas helped Dutch homes and industry wean off coal- and oil-based heating. Dutch infrastructure quickly became powered by gas. However, this prosperity came at a devastating cost to local communities. Beginning in the 1990s and intensifying through the 2010s, gas extraction increasingly triggered earthquakes that damaged thousands of homes, disrupted lives, and created profound feelings of injustice among Groningen residents who bore the burden of national energy security while receiving inadequate compensation (Herreras Martínez et al., 2025). The earthquakes exposed deep tensions between centralized energy governance, corporate interests, and local community welfare, ultimately forcing the Dutch government to commit to shutting down the Groningen field by 2024—a decision resisted by fossil fuel companies but demanded by principles of energy justice (Pardikar, 2025; Pereira et al., 2025).

The closure of Groningen gas extraction represents a policy decision resulting from the culmination of countless struggles reckoning with how energy systems distribute benefits and burdens across society. This outcome coincides with the Netherlands' ambitious commitment to phase out natural gas for heating in all 7.8 million homes by 2050, requiring unprecedented coordination among government agencies, private companies, and citizens (International Energy Agency, 2025). The heating transition is particularly urgent given that the Netherlands exhibits the highest dependency on natural gas for heating among International Energy Agency members, with natural gas covering 84% of residential heating demand in 2021 (International Energy Agency, 2025). This transition occurs against a backdrop of rising energy poverty, exacerbated by the 2022 Ukrainian war's impact on energy prices, and growing recognition that energy transitions must explicitly address justice concerns to avoid reproducing or amplifying existing inequalities (Carley & Konisky, 2020; Mulder et al., 2023; Sovacool & Dworkin, 2015; Zabel & Hendlin, 2025).

Despite growing scholarly attention to energy transitions, heating transitions remain understudied relative to their importance (Büttner & Rink, 2019). Heat accounts for approximately half of global final energy consumption and represents the largest single end-use service worldwide; yet decarbonizing heat has proven particularly intractable (Sovacool et al., 2021). Furthermore, the justice dimensions of heating transitions have received limited systematic attention, despite the increase of energy poverty and policy attention across the EU (Hanke et al., 2026), and evidence suggesting retrofit programs and subsidy schemes often fail to reach those most in need, potentially exacerbating rather than alleviating energy poverty (Hajarini et al., 2022). Likewise, an empirical study shows justice gaps between collective and individual heating systems and trade-offs between equity and autonomy of these systems (Djinlev & Pearce, 2025).

Existing research on the Dutch heating transition has largely focused on single-actor perspectives or specific themes, examining municipalities and municipality-led governance frameworks (Devenish & Lockwood, 2024; Herreras Martínez et al., 2022; Monstadt et al., 2025), installers (van Tuijl et al., 2025), energy communities (Herreras Martínez et al., 2025), or perceptions of homeowners and tenants (Jansma et al., 2020). While valuable, the fragmented state of research leads us to propose focusing on the complex governance dynamics through which multiple actors with divergent interests, resources, and capacities must coordinate to achieve just outcomes. Governance scholarship on heating transitions likewise has insufficiently theorized how actors might generate solidarity in pursuit of collective goals and start cooperation across differences. The concept of solidarity, understood as mutual recognition of interdependence and willingness to share burdens and benefits, offers analytical purchase for understanding how just heating transitions emerge (Allen, 2004; Scholz, 2008).

This article addresses these gaps by examining governance challenges in just heating transitions through the lens of solidarity, asking:

1. How does solidarity shape cooperation in Rotterdam's just heating transitions?
2. Which governance challenges hinder cooperation and the implementation of Rotterdam's just heating transitions?

The first question analyzes rationales for solidarity and how these shape cooperation potential, whereas the second question provides more insights into limitations to solidarity.

Empirically, we analyze Rotterdam as a case that illuminates both the possibilities and tensions inherent in pursuing just heating transitions within post-industrial urban contexts. As the Netherlands' second-largest city and Europe's largest port, Rotterdam faces substantial decarbonization obstacles: More than 10% of households experience energy poverty, concentrated in neighborhoods with aging housing stock and lower-income residents (TNO & Centraal Bureau voor de Statistiek, 2025); extensive industrial infrastructure creates complex interdependencies between industrial and residential heating systems; and social housing comprises a significant portion of the dwelling stock, requiring cooperation with housing associations operating under constrained budgets (OECD, 2023). Simultaneously, Rotterdam presents opportunities for innovative heating solutions through district heating networks connected to industrial waste heat, progressive municipal commitments to inclusive transitions, and established networks of energy coaches and community-based (or grassroots) organizations (CBOs) working to combat energy poverty (van Tuijl et al., 2024; Zabel & Hendlin, 2025).

Conceptually, we synthesize literature on multi-stakeholder governance, energy justice, and solidarity to understand cooperation dynamics. Our analysis draws on 28 semi-structured interviews with diverse actors, supplemented by policy document analysis. The article proceeds by reviewing relevant literature (Section 2), describing our methodological approach (Section 3), presenting empirical findings (Section 4), and discussing implications (Section 5), before concluding (Section 6).

2. Theory

2.1. Governance of Just Heating Transitions

Energy and heating (and wider sustainability) transitions are characterized by complex governance challenges due to multi-actor, multi-scalar, long-term transformation processes of socio-technical systems (Köhler et al., 2019). This complexity has further increased due to the breadth of energy transitions (including interdependencies with other sectors such as mobility; Andersen et al., 2023), and attention to energy poverty and justice in the multi-solving paradigm known as "just transitions" (Sovacool & Dworkin, 2015).

Energy justice scholarship enables analyzing these dynamics. We adopt the following definition of energy justice:

The notion that all individuals should have access to energy that is affordable, safe, sustainable and able to sustain a decent lifestyle, as well as the opportunity to participate in and lead energy decision-making processes with the authority to make change. (Carley & Konisky, 2020, p. 570)

This definition acknowledges that transitions encompass “winners” and “losers,” offering challenges (e.g., increasing inequality) and opportunities (e.g., new jobs; Jenkins et al., 2018). One specific injustice dimension is energy poverty, referring to households’ inability to obtain affordable access to energy (i.e., heating, cooling, and electricity) services (Pye et al., 2016), caused by the interplay between low incomes, high energy prices, and high energy needs due to poorly insulated houses (Doukas & Marinakis, 2020).

Heating, the focus of this article, is an essential factor influencing energy poverty in regions with significantly cold weather, and a key target for just energy transitions (Burguillo & Juez-Martel, 2024). Heating transitions encompass two interrelated fields of action: the decarbonization of the heating supply and the retrofitting of buildings (Büttner & Rink, 2019). Advanced retrofitting consists of replacing or adapting existing installations (e.g., heat pumps for gas boilers) and the building shell (e.g., windows and floor insulation) with the aim of improving energy efficiency and reducing heat leakage (Killip & Owen, 2020). Retrofitting encompasses the interlocking complexities of heating transitions, including the integration of energy, construction, and installation sectors (van Tuijl et al., 2025). Advanced retrofitting contrasts with the short-term solutions of energy coaching and “energy-fixing,” such as placing weather seals or heating foil (Croon, 2026).

Addressing justice concerns increases heating transition governance challenges. We perceive the just heating transition as an ongoing process addressing technological, social, and economic dimensions inclusively (Djinlev & Pearce, 2025). In comparison to electricity, heating transitions are more driven by local conditions and coordinated on a smaller scale, a context-dependent process shaped by local governance structures, social conditions, and technological arrangements (Weiß et al., 2018). Studies increasingly address municipal (“locally-led”) heating transition governance (Büttner & Rink, 2019; Devenish & Lockwood, 2024; Herreras Martínez et al., 2022; Monstadt et al., 2025), although the justice lens remains underexplored, despite major exceptions such as Djinlev and Pearce (2025). In sum, just heating transitions are complex multi-dimensional processes and encompass different actors with specific as well as similar governance challenges.

Municipal challenges include path dependencies and lobbying by the fossil energy sector; a lack of political support, (financial) resources, skills, and leadership; dependencies on external experts; weak institutions ill-equipped to guide the transition; and challenges in collaborating with the private housing sector due to conflicting economic interests (Büttner & Rink, 2019; Devenish & Lockwood, 2024; Herreras Martínez et al., 2022; Monstadt et al., 2025). Municipalities are also challenged with the trade-off between keeping heating affordable (e.g., preventing energy poverty through affordable collective heating systems) and offloading responsibility to individuals (Djinlev & Pearce, 2025; Hajarini et al., 2022). Likewise, municipalities must balance maintaining public trust and choice and ensuring efficiency (Devenish & Lockwood, 2024). Accordingly, to maintain public trust, municipalities tend to focus on improving poorly insulated buildings rather than decarbonizing heating supply systems, as residents are more open to heat savings (lower energy bills, healthier homes) than adopting expensive new heating systems without visible immediate benefits (Herreras Martínez et al., 2022).

Governance challenges that slow down just heating transitions linked to national and supranational governments and institutions include vague policy frameworks and a lack of binding instruments to guide implementation (Hanke et al., 2026). Moreover, policy instruments do not always align with local needs, resulting in municipalities developing their own instruments or searching for external advice (Herreras

Martínez et al., 2022). Finally, securing energy justice through new laws and disputes at courts involves long time horizons (Heffron, 2022).

Challenges of social housing associations include high upfront costs, the multiple dimensions of energy poverty, and a lack of data which hinders them from providing tailor-made approaches (Croon, 2026; Desvallées, 2022). Whereas tenants benefit from retrofitting measures in the form of lowered energy bills, associations have little incentive for retrofitting, as they are barely compensated for investment costs due to limited options legally to increase rents (Weiß et al., 2018). Furthermore, associations tend to exclude their tenants from retrofit decisions, further hindering just transitions (de Feijter et al., 2019), focusing on insulation while resisting heating installation adoption (Desvallées, 2022).

Utilities face interrelated governance challenges. Governance models vary widely, including fully public-owned utilities that control the whole heating value chain, models largely controlled by private firms, and many intermediate ones based on unbundled value chains and public-private ownership structures (Herreras Martínez et al., 2023). Complexities of different technological paths (e.g., biogas or thermal heating), the integration of renewable technologies in legacy infrastructures built for fossil fuels, and the existence of heat systems based on hybrid networks and heat nexuses result in high investment and coordination challenges (Monstadt et al., 2025).

CBOs, which differ in size, scope, and structure (Hanke et al., 2026), serve a crucial but often overlooked role in just heating transitions, challenging other actors to collaborate with communities. CBOs experience interrelated barriers, including: limited financial and human resources; insufficient knowledge of new technologies and regulations; legislative and regulatory challenges; and a lack of long-term perspective (Hanke et al., 2026; Herreras Martínez et al., 2025; Zabel & Hendlin, 2025). They mainly support vulnerable households with services (e.g., energy coaching) rather than empowering them to participate in energy communities (Hanke et al., 2026).

All actors share challenges due to the interdependencies between different just heating dimensions, and between short- and long-term imperatives (see Figure 1), requiring sometimes difficult to achieve collaboration (Monstadt et al., 2025). As we will discuss, after detailing how solidarity works in heating transitions, encouraging signs of cooperation and solidarity are present, but real challenges persist, limiting cooperation and implementation of just heating transitions in Rotterdam.

2.2. Solidarity in Energy Transitions

The concept of solidarity offers analytical leverage to understand how disparate actors coordinate despite potential conflicting interests in pursuit of collective goals. Political theorists define solidarity as mutual recognition of interdependence combined with willingness to share burdens and benefits in pursuit of common objectives (Allen, 2004; Bayertz, 1999; Scholz, 2008). Solidarity differs from mere cooperation in emphasizing moral commitments and relational bonds that motivate actors to support others even at short-term cost to themselves (Sangiovanni, 2015; Scholz, 2008). Solidarity initiatives go beyond offering support (Boonstra et al., 2023) and can manifest at multiple levels—individual, organizational, and institutional—through diverse mechanisms ranging from formal policy frameworks to informal community practices (Wilde, 2007).

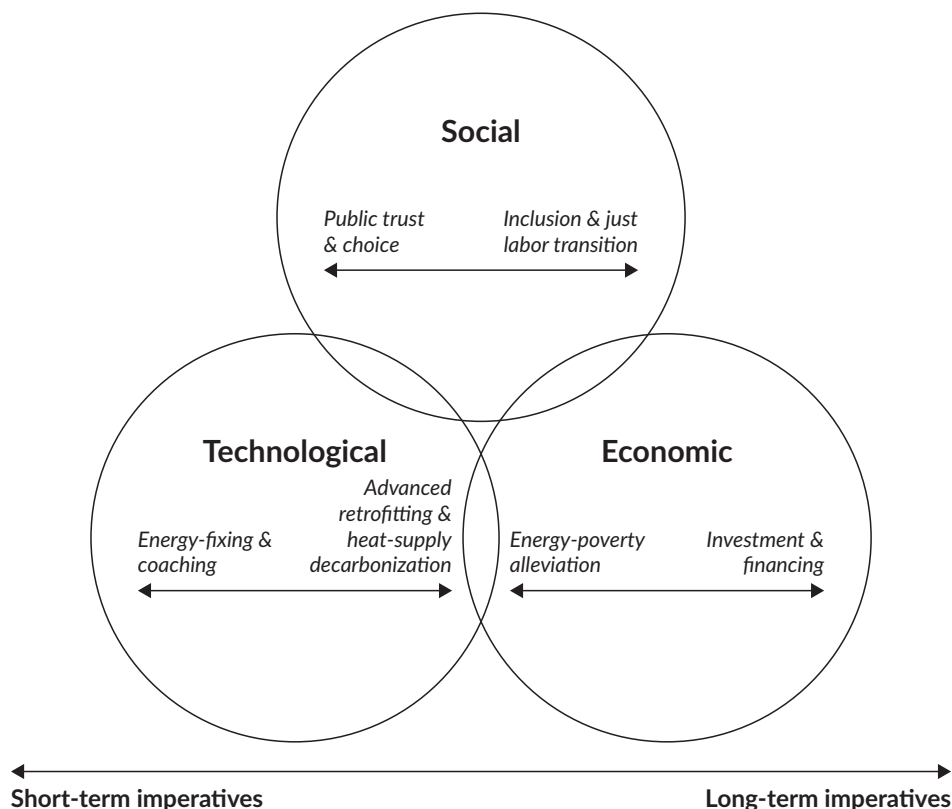


Figure 1. Interrelated dimensions of just heating transitions.

Applied to just heating transitions, solidarity implies recognition that decarbonization presents collective challenges requiring coordinated action across society rather than defaulting to individual responsibility (Campos & Marín-González, 2020; Chiara et al., 2025). In contrast to neoliberal framings that position energy consumers as rational individual actors optimizing private choices, as a collective action problem, energy solidarity takes interrelated modalities. Building off the work of Scholz (2008), we identify three distinct but overlapping modalities of solidarity in our empirical research on just heating transitions. Institutional solidarity manifests through government-led policy frameworks that redistribute costs and benefits across society, such as progressive tariff structures, subsidy schemes funded through general taxation, or abstaining from further gas exploitation for fairness with those most affected due to their proximity to extraction sites (Parliamentary Committee of Inquiry into Natural Gas Extraction in Groningen, 2023). Economic solidarity appears in mechanisms that pool financial resources to enable transitions for those lacking upfront capital, including public investment funds, community financing models, or cross-subsidy arrangements (Gillard et al., 2017). Civic solidarity emerges through grassroots initiatives, community energy projects, and mutual aid networks that build social cohesion while advancing transition goals (Hanke et al., 2026; Herreras Martínez et al., 2025). Often, solidarity types overlap, as in the case of neighborhood district heating networks that combine both civic and economic solidarity.

Solidarity in energy transitions is neither automatic nor frictionless. Different solidarity modalities or mandates may conflict: Institutional solidarity expressed through district heating mandates might reduce individual energy sovereignty in ways experienced as unjust by residents preferring (often less expensive) autonomous systems. Economic solidarity mechanisms such as subsidies may inadvertently overly benefit

middle-class households able to navigate bureaucratic processes while excluding those most in need (Gillard et al., 2017). Civic solidarity initiatives often operate at local scales insufficient to address systemic challenges without institutional support and resources (Zabel & Hendlin, 2025).

Empirically, solidarity dynamics in heating transitions remain understudied. Existing research documents instances of community energy initiatives exhibiting solidarity principles (Creamer et al., 2018; Hoicka et al., 2021) and analyzes how policy frameworks distribute transition costs (Rosenow et al., 2017), but rarely examines how different solidarity modalities affect cooperation. Still needed is a systematic understanding of what enables or limits solidarity, how diverse actors cooperate, and how to institutionalize solidarity without creating paternalistic or exclusionary dynamics.

To take on this challenge, we explore how the different solidarity modalities affect cooperation and challenges to implement heating transitions. Within our analysis, we attend to justice implications across distributional, procedural, and recognition domains. Distributional justice concerns who benefits from transition investments, who bears costs, and how benefits and burdens are allocated across social groups and spatial contexts. Procedural justice concerns whose voices influence decisions, what decision-making processes exist, and how effectively these processes enable meaningful participation by affected communities. And recognition justice concerns which perspectives and knowledge claims receive validation, how different actors' identities and experiences are acknowledged, and whether governance arrangements reproduce or challenge existing marginalization patterns (Jenkins et al., 2018; Sovacool & Dworkin, 2015).

3. Methodology

3.1. Research Design

To explore how solidarity affects cooperation in just heating transitions, and governance challenges, we conducted a qualitative case study on just heating transitions in the post-industrial city of Rotterdam. Dutch political culture has a long tradition of collaboration (Devenish & Lockwood, 2024), and the municipality of Rotterdam set explicit goals on different dimensions of just heating transitions, including job creation, reduction of energy poverty, and decarbonization, even if decarbonization is difficult to achieve due to large industrial infrastructure (van Tuijl et al., 2024).

3.2. Data Collection and Analysis

The primary data for this study were gathered through 28 in-depth interviews, totaling 30 interview partners (some interviews included two interviewees) involved in the heating transition ecosystem, with representatives of: public authorities (6 total); associations (3); CBOs (6); installer (training) firms (13); and others (2). We also conducted two validation workshops (see Supplementary File, also for participant IDs). This diversity allowed us to identify solidarity initiatives from plural perspectives and better understand relations and conflicts that affect cooperation between actors. We did not interview utility companies, but could provide insights into this sector via other interviews where we inquired into relations with utilities. Interviews lasted on average 60 minutes.

The semi-structured interview guide consisted of questions on: (a) actors' roles in heating transitions; (b) barriers faced; (c) relations with other actors; and (d) perceptions on justice and solidarity. To ensure equity, diversity, and balanced representation across these different groups, recruitment actively targeted a diverse range of local stakeholders. Two workshops were conducted, one with researchers only, and the second with policymakers, CBOs, associations, and academics (some of whom were previously individually interviewed). During this workshop, participants validated our preliminary findings and reflected on each other's needs and obstacles. We participated in two sessions of an energy learning community in Rotterdam that included presentations and discussions by different actors. Following formal institutional ethical approval, all participants provided written informed consent prior to data collection. We audio-recorded the interviews and anonymized research participants through IDs, and securely stored all data in compliance with GDPR guidelines and the ethical regulations of Erasmus University Rotterdam.

The ID system is based on the two previous studies on: (i) installers in energy transitions (codes starting with R for Rotterdam; van Tuijl, 2026; van Tuijl et al., 2024, 2025) and (ii) energy poverty (codes starting with 2R for second study of Rotterdam; Zabel & Hendlin, 2025). Code numbers after the R and 2R refer to the chronological order of the interviews. Recordings were transcribed and analyzed with codes based on the (sub)dimensions of our study: solidarity, cooperation, and governance challenges. We triangulated interview data with desk research on Dutch energy policy frameworks, including national climate agreements, and Rotterdam-specific heating transition plans.

4. Findings

4.1. *Solidarity and Cooperation*

Rotterdam's heating transition involves a diverse actor ecosystem with conflicting individual and collective challenges inflecting cooperation in solidarity initiatives. The Municipality of Rotterdam occupies a pivotal coordinating position, responsible for developing the heat transition plan, which was done in collaboration with other actors such as utilities, CBOs, and housing associations (Gemeente Rotterdam, 2021). Associations follow this plan assiduously (R28). The plan has explicit goals linked to various just heating dimensions, including alleviating energy poverty and job creation for vulnerable citizens with a distance to the labor market (R6, R32, R33a, R33b). To reach these goals, municipality initiatives support solidarity initiatives through energy coaching, retrofitting tasks, supply to citizens of energy efficiency fix kits (e.g., weather seals), and installer training programs (R6, R32, 2R6).

Job training, because of the crucial collective action problem of installer capacity constraints, was mentioned as an acute bottleneck by all interviewees. They emphasized that achieving transition targets requires dramatically upscaling retrofit implementation, while recognizing that installer capacity cannot expand quickly enough given extended on-the-job-learning and frontloaded equipment investments. Issues included not only a generic shortage of installers due to this craft's lack of popularity among young people, but also the precipitous retirement of older installers. Incumbent installers must additionally learn new skills linked to renewable heating installation. An installer firm subsidiary director (R9) explained this hurdle: "We currently employ, I think, 800 to 900 installers, all of whom are gas installers. They'll need to become electricians in a few years. How are we going to do that?"

Solidarity initiatives to tackle this collective action scarcity issue are many. The Rotterdam Beroepentuin initiative, for example, recruits and trains vulnerable citizens excluded from traditional labor markets (e.g., marginalized migrants, the formerly incarcerated), and has proved valuable for installation, as attested by one institution manager (R10):

Of course, government money goes into it, and money from [institutional] funds goes in as well. But it [the initiative] precisely [addresses] those target groups so hard to reach...which truly benefits everyone.

The municipality, installers, and utility firms also support this initiative. The latter's support goes beyond being a customer of the initiative, as utilities also provide materials and training staff. Here, the hiring process itself is an act of outreach, including marginalized "unemployable" people, offering them training and a stable, decent-paying job.

Housing associations also emerge as critical actors given their management of substantial housing stock requiring retrofitting. Rotterdam's housing associations own approximately 45% of the city's housing stock, often concentrated in neighborhoods with higher energy poverty rates. Association managers (R28, 2R1a, 2R1b) described competing pressures: obligations to meet national energy performance standards and contribute to municipal transition plans; responsibilities to maintain affordable rent and protect tenant welfare; and financial constraints limiting investment capacity, given regulated rent structures and aging building portfolios requiring multiple simultaneous interventions beyond heating systems. Associations' know-how of renewable heating technologies is limited, as put forward by a manager (R28): "Within our organization, we have someone in charge of central heating contracts, but no one is responsible for contacting the sustainable installations." Intersectoral collaboration is essential: Associations depend on installers, who collaborate in the development of joint long-term retrofitting plans including stepwise interventions to keep the transition affordable and feasible (R9, R21, R28).

Associations and the municipality share three interrelated constraints. First, both mentioned tensions between urgent support to tenants to lower their energy bills and the long-term process of advanced retrofitting (2R1a, 2R1b, 2R2). Second, both referred to the complexity of the just heating dimensions and the lack of knowledge about new technologies. Third, associations, the municipality, and also utilities, have difficulties reaching the most vulnerable households (and the other way around) due to privacy concerns, long-term mistrust, bureaucracy, and poor communication channels (e.g., online access only, not answering the telephone, or services only available in Dutch; R18, R34, 2R3, 2R5). As mentioned by municipal official R6: "I find it really difficult, reaching the right people. And then I hear from people who don't dare to request [free] energy support services [due to shame] because their house is already completely covered in mold."

CBOs initiate civic solidarity initiatives to fill this institutional gap. They work primarily with households experiencing energy poverty (and poverty in a wider sense), building relationships through sustained engagement rather than one-time interactions. As CBO representative 2R5 explained: "We visit people at home who are hard to reach for the municipality or associations and develop a relationship with them." They provide frontline support to vulnerable households, offering personalized guidance on energy-saving behaviors, subsidy applications, and retrofitting measures (R18, R34, 2R3, 2R5, 2R7, 2R8). They initiate activities to redistribute uniform measures by the municipality, such as energy-bill compensation and energy

efficiency kits from more wealthy citizens who do not need these, exchanging products from their kits (R18, 2R3, 2R5, 2R7). To achieve this, CBOs collaborate with each other to reach vulnerable households in other neighborhoods where they do not possess local ties (R18, 2R2, 2R5), and to pool and redistribute final resources such as energy-bill compensation (2R8).

CBOs also experiment with alternative economic solidarity models emphasizing collective ownership and democratic governance. For example, energy communities pool member investments to finance renewable heating infrastructure, distributing returns equitably rather than maximizing individual shareholder profits (2R8). Likewise, a social enterprise implementing local energy transition projects shares revenues with its staff (mostly vulnerable citizens), going to the extreme where the founder sometimes does not draw salary for herself to avoid laying off people (R18).

All CBOs interviewed identified capacity limitations: Effective energy support requires sustained relationship-building with vulnerable households, but funding constraints limit staff availability relative to need. These shortages create dependencies on other actors, as energy cooperative manager 2R8 explained:

We are still dependent on the municipality when it comes to money....We are actually looking for rooftop space on public buildings, so we are looking for rooftops of community centers or municipal real estate, so in that respect too, we are dependent on them.

Other CBOs indicated their dependency on short-term project-based funding from public and private actors, frustrating implementation of structural changes, such as through job creation for vulnerable citizens (e.g., long-term unemployed people) or to mount large-scale home retrofits.

Driven by a willingness to support the most vulnerable households, to cope with climate goals, and resolve the shortage of installers, nearly all actors actively engage in cross-sector solidarity initiatives. This also creates—sometimes productive, sometimes fraught—mutual dependencies: CBOs receive municipal financial support, whereas municipalities and housing associations are dependent on CBOs to reach vulnerable households.

4.2. Governance Challenges: Coordination, Capacity, and Conflict

4.2.1. Coordination Failures

Despite rhetorical emphasis on integrated approaches and examples of collaboration, actors frequently operate in silos with inadequate information exchange and decision-making coordination. For instance, municipal official 2R6 described frustration with national policy changes occurring, creating implementation difficulties discovered only after policies enter force. Nearly all other actors share this frustration of the irregularity in national policies, such as the vacillating position of heat pumps as the norm to replace gas boilers, which hinders installers, training firms, and associations from investing in skills linked to these technologies. Other actors refer to the lack of coordination within the different departments of the municipality. This frustrates actors who want to simultaneously tackle different just heating dimensions, fatiguing those needing to find the “right” partner and subsidies within the municipality (R13, R18, 2R5). Moreover, CBOs that tackle various transition dimensions compete for subsidies with commercial actors that focus on one dimension only. CBO director R18 mentioned that these commercial firms often

mainly tackle short-term challenges (e.g., providing energy-saving advice), but do not bring long-term changes as her CBO does, by training local residents to become installers through these subsidized retrofitting projects.

Housing associations noted similar frustrations. They have to implement local heating transition plans, support their tenants to cope with high energy bills, and fulfill national performance agreements. As manager 2R1b noted:

EFG label [poorly insulated] buildings must be phased out by 2029. So we still have five years to do that, and we have about 2,500 of them. We'll also be building new ones. Another challenge is that we have to lower rents and decarbonize [our stock]. So, there are many performance agreements that we're actually being asked to fulfill...[yet,] because all those prices have risen so dramatically, it's a very difficult puzzle.

Finally, CBOs identified another severe coordination gap regarding vulnerable households. Various actors offer energy support services such as municipal programs, housing association initiatives, CBOs, and national subsidy schemes. But these operate with minimal coordination, creating confusion for households unsure where to seek help and duplication where multiple organizations serve the same households while others receive no support. Vertical and horizontal self-organization among actors has been neither normative nor provided for. This fragmentation particularly harms vulnerable households with limited capacity to navigate complex organizational landscapes, exacerbating distributional injustices (R18, 2R3, 2R4, 2R5, 2R7). Nearly all interviewees confirmed this and stressed that the heating transition in Rotterdam so far has led to increasing inequality.

4.2.2. Distributional Conflicts

District heating expansion plans generated intense distributional conflicts. Expansion of the district heating network is regarded as an affordable heating source to phase out gas boilers in the municipal heat plan (Gemeente Rotterdam, 2021), and municipal officers and housing associations initially indicated good relationships with utilities to implement this expansion (R6, R32). However, the expansion encounters societal resistance to high prices (as Dutch district heating is coupled to natural gas prices), and residents lack provider choice, as mentioned in many interviews. The municipality arranged lower district heating tariffs for residents in neighborhoods that are newly connected to the network; but this leads to distributional conflicts as existing customers in other neighborhoods pay a much higher price (Keete, 2025). Due to such conflicts, associations withdrew their commitment to the expansion. Utilities have also been hesitant to invest in the network due to vague understandings about a new heat law which aims to give public and community actors a majority stake in district heating companies (R26, R32).

Subsidy distribution also generates conflicts. Public programs offer retrofitting subsidies, but accessing these requires navigating complex application processes and often providing upfront financing and knowledge before receiving subsidy reimbursement. Nearly all interviewees noted that high- and medium-class homeowners disproportionately benefit from these subsidies because they possess the financial literacy to navigate applications, capital to provide upfront financing, and housing ownership enabling eligibility, while vulnerable renters lack access despite greater need. Installer R27 expressed: "That feels harsh, because

those who are financially more comfortable have the means to save money [by accessing retrofit subsidies], while those who don't and can't afford to invest are confronted with high costs."

The municipality also has a difficult time differentiating between different societal groups, as put forward by impact funder R7:

The municipality is hiding behind the equality principle. Only status holders [recognized refugees granted a formal residence permit] have a separate status, but they also literally have a separate status. But otherwise, the municipality believes they should treat everyone the same.

Accordingly, the municipality cannot dedicate subsidies to the most vulnerable households, whereas higher-income ones can often get quicker access to available subsidies.

These observations highlight how ostensibly supportive policies can inadvertently exacerbate distributional injustices when design fails to account for vulnerable populations' specific circumstances and constraints.

4.2.3. Institutional Rigidity

Housing allocation rules represent an institutional rigidity constraining just transitions. Dutch social housing allocation prioritizes placing lowest-income households in lowest-rent dwellings, which tend to be older housing stock with the poorest energy performance. Associations indicated struggling with this, as by law they cannot increase rents or cross-subsidize retrofitting of these dwellings by other income streams as their core mission is to provide affordable housing. Moreover, they cannot obtain retrofitting subsidies for their housing blocks that contain a mixture of tenants with high- and low-incomes (2R1a, 2R1b). Associations were also highly sensitive to past legal troubles, and representatives spoke to these legal constraints as justifications for their inaction. For instance, they are not allowed to participate in municipal area-based development projects, local energy communities, or innovation pilots with installers (R9, R28, 2R1a).

Municipal agencies perceive such challenges through their budgets and responsibilities, often linked to their own narrow domain (e.g., energy or housing), making it hard to tackle the different dimensions of just heating transitions (R13, R18, 2R5). These institutional arrangements create recognition justice deficits where housing policies fail to account for energy costs in defining affordability, treating housing and energy as separate domains despite their interconnectedness for household wellbeing.

Privacy regulation is another rigidity thwarting support of the most vulnerable households. Municipal officer R6 mentioned knowing which vulnerable households receive financial compensation to pay their bills, but due to privacy concerns the municipality cannot approach them to provide additional retrofitting subsidies. Other actors, including CBOs and associations, were similarly hampered to effectively help due to privacy rules (R30, 2R1).

4.2.4. Limitations to Solidarity

Our data revealed limitations to the solidarity modalities and negative effects on cooperation and implementation of just heating transitions.

Institutional solidarity required collaboration experience. As illustratively put forward by association manager 2R1a on area-based collaboration (*gebiedsgericht samenwerken*), where local organizations, residents, and authorities work together on a specific neighborhood's unique needs:

And now you see gaps emerging, and people have to relearn how to collaborate. With many of the things we changed after 2015 [a new social housing law], we're exploring how to organize in area-based collaboration. And if we can find that, it's easier to get that collaboration back on track. But that won't happen overnight.

Likewise, installers are not traditionally involved in housing design, but now need to enter discussions with architects and real estate developers to ensure that new installations (like heat pumps) fit in houses traditionally designed for gas-based heating systems (R11). This requires mutual learning processes on how to collaborate, to avoid bureaucratic red tape or ad hoc, makeshift workarounds.

Civic solidarity is often driven by, but also depends on, volunteers. CBOs provide time-intensive support to vulnerable households, motivated not primarily by compensation but by commitment to supporting community members. As mentioned by CBO secretary 2R3:

I talk about them as colleagues. I don't say volunteers, I think that's such a cheap word. They are volunteers, but I don't think that fits our system because they are available and busy 24 hours a week [three eight-hour working days per week]. So I actually consider it more as a job than volunteer work, even though they do it voluntarily because they don't get that much money.

Energy communities often embody civic solidarity through collective action addressing shared challenges: neighbors collaborating on renewable heating projects, sharing knowledge and labor, building relationships extending beyond instrumental energy transactions. Crucially, they often rely on volunteers, e.g.: "energy cooperatives in Rotterdam; these are predominantly volunteers, Rotterdam residents working together in their neighborhoods on the energy transition" (2R8).

Economic solidarity also encounters limitations. Alternative economic models initiated by CBOs (Section 4.1) struggle to scale beyond early adopters with available capital, preventing their engagement with vulnerable households most needing economic solidarity. Community organizer 2R8 described:

It is not so much about money, but much more about clean energy, sustainability, and autonomy....And the fact that it's actually paying off is great, but we've had to make a real shift because we simply aren't the answer to the energy poverty issue in that respect, not in the short-term.

The organizer explained that even with deliberate low-fee membership in neighborhood clean heating projects, state-subsidized fees remain too high for the most vulnerable potential members.

Economic solidarity can reveal tensions between efficiency and equity. Subsidy programs must balance targeting resources to those most in need (equity) with administrative simplicity and preventing fraud (efficiency). Current subsidy designs prioritize efficiency through standardized eligibility criteria and application processes, but this creates equity problems as discussed above: Bureaucratic requirements

exclude vulnerable households lacking literacy, documentation, or capital for upfront investments. CBO founder R18 observed:

I understand those subsidy programs [only] to a limited extent, but enough to apply for them. But if you live in this neighborhood and have financial problems...you don't have the mental capacity to spend days at your computer diving into such a program. So, it's not that people can't do it mentally, but they can't because they're struggling to survive. They have to figure out what to eat for dinner without any money. So, all the programs are only available to people who have the mental capacity to even apply for them. And then you quickly end up with people who don't actually need them.

These observations highlight how economic solidarity requires not just cost-sharing mechanisms but governance arrangements ensuring solidaristic values guide resource distribution decisions.

While the majority of interviewees from all sectors expressed willingness and desire to work with the other sectors, in many cases the lack of practice was an obstacle. For just heating transitions, working outside typical sector silos for the first time, in many cases, was challenging, but rewarding when successful. Justice concerns remained, however.

5. Discussion

5.1. *Solidarity as Governance Mechanism*

The heating transition in Rotterdam is characterized by a municipal-led governance framework in line with other studies on Dutch and German cities (Devenish & Lockwood, 2024; Herreras Martínez et al., 2022; Weiß et al., 2018) that also acknowledge various barriers hindering such transitions. However, most studies pay limited attention to justice concerns. We add to this literature by taking a solidarity lens to explain how actors work together to tackle interrelated collective action problems (a shortage of installers, climate goals, and willingness to support vulnerable citizens) in Rotterdam's just heating transitions.

Our findings show that the concept of solidarity offers analytical and practical value for understanding cooperation in just transitions. Solidarity provides normative language for articulating shared fates and mutual obligations that motivate actors to support collective goals even at short-term individual cost, as evidenced by contributions from associations, the municipality, and utility and installer firms in the solidarity initiatives conducted by CBOs in Rotterdam.

Furthermore, identifying three distinct solidarity modalities—institutional, economic, and civic—contributes to energy transitions literature (e.g., de Looze et al., 2024) by specifying mechanisms through which solidarity operates and explains tensions among actors. Existing scholarship discusses solidarity primarily at an abstract level (Szulecki, 2018) or focuses on a single solidarity modality such as community energy initiatives (Campos & Marín-González, 2020). Our study shows that solidarity in practice involves multiple mechanisms operating simultaneously with different logics, scales, and actors. For example, civic solidarity by CBOs turned out to be important to fill institutional gaps and cope with governance challenges (cf. Croon, 2026; Devenish & Lockwood, 2024). Institutional solidarity establishes formal structures for cost-sharing and benefit distribution that make cooperation feasible; economic solidarity pools resources enabling

participation by under-resourced actors; and civic solidarity builds relationships and trust that facilitate cooperation. Each modality enables certain governance approaches while constraining others, with combinations either reinforcing or conflicting.

5.2. Governance Challenges as Justice Challenges

However, solidarity alone is not enough. Despite important exceptions, such as the long-running training initiative Beroepentuin, most solidarity initiatives were brief, as evidenced by project-based funding and temporary subsidies to support vulnerable households during the energy crisis, similarly to solidarity initiatives conducted in Rotterdam during the Covid-19 crisis (Boonstra et al., 2023). Our findings reveal that solidarity is not automatic or unproblematic: Different solidarity modalities can conflict; solidarity boundaries must be negotiated; and claims of solidarity can mask power asymmetries or strategic positioning. Effective cooperation requires not just invoking solidarity but actively working through solidarity tensions and ensuring that solidarity practices advance rather than undermine justice goals.

The governance challenges identified—coordination failures, distributional conflicts, institutional rigidities, and limitations to solidarity—are not merely technical obstacles but fundamentally justice challenges. Coordination failures produce procedural justice deficits when relevant knowledge goes unheard and affected communities lack meaningful participation in decisions (Newell & Mulvaney, 2013). Capacity constraints are limitations to solidarity that generate distributional injustices when scarce resources flow to well-positioned actors while vulnerable populations languish. Distributional conflicts reveal underlying disagreements about whose interests should take priority and who should bear transition costs. Institutional rigidities reflect injustices of recognition where existing arrangements fail to accommodate diverse needs, local preferences, and governance models.

Reconceptualizing governance challenges as justice challenges provides important insights. It suggests that addressing governance challenges requires not just improving technical coordination or increasing funding but transforming power relations and institutional arrangements that produce injustices. For example, installer capacity constraints reflect not just training pipeline bottlenecks but also political-economic choices about where to invest in workforce development: Current vocational education systems were designed for fossil fuel industries and have been slow to adapt to renewable energy needs (van Tuijl et al., 2025). Addressing installer capacity meaningfully requires not just more training programs but restructuring education systems, creating quality jobs in renewable energy sectors, and ensuring just transitions for fossil fuel workers facing obsolescence. Similarly, coordination failures often reflect power asymmetries where dominant actors can do without coordinating with marginalized actors who lack leverage to demand engagement. Improving coordination requires not just better communication channels but shifting power dynamics so that all actors' participation becomes necessary for successful implementation.

The limitations to the solidarity modalities (Section 4.2) reveal fundamental tensions in just transitions that solidarity language cannot resolve by itself. Two stances emerge invoking solidarity: one for collective climate action, the other for community self-determination, as seen in the district heating mandate versus energy autonomy conflict. Each position alone leads to incompatible governance preferences. Resolving such tensions requires political negotiation and compromise rather than assuming solidarity framing automatically harmonizes interests. This insight challenges technocratic approaches treating just transitions

as optimization problems solvable through proper technical design, and instead recognizes transitions as inherently political processes involving value conflicts requiring democratic resolution.

6. Conclusion

This article introduces the concept of solidarity as a lens to understand cooperation dynamics and governance challenges in heating transitions. Extant literature demonstrates limited attention to justice dimensions. Based on solidarity (Scholz, 2008), energy justice (Sovacool & Dworkin, 2015), and heating transitions governance studies (Devenish & Lockwood, 2024), an empirical case study of the post-industrial city of Rotterdam led us to identify three solidarity modalities (institutional, economic, civic) to analyze cooperation drivers and governance limitations in just heating transitions. We describe how collective action problems (strict climate goals, a shortage of installers, and willingness to address energy poverty) in Rotterdam drive cooperation through solidarity initiatives by all actors.

However, coordination failures, distributional conflicts, and institutional rigidity persist as governance challenges that hinder implementation of just heating transitions, suggesting that solidarity alone is insufficient. Limitations to each solidarity modality explain tensions between actors. To conclude, we argue that solidarity is key to understanding cooperation and governance dynamics in just heating transitions, but is insufficient by itself to successfully implement just heating transitions. Iterated practice of coordination across sectors is necessary.

This explorative study is based on a single case study, and its results cannot be generalized. Further (comparative) research on solidarity initiatives in just heating transitions in other cities and on how governments deal with possible distributional conflicts between cities (for example, between Rotterdam and Groningen) will provide additional insights. Another avenue for further research is longitudinal studies to strengthen our conceptualization of the three solidarity modalities by exploring interactions between them in time and through periods without and with energy crises, including the recent conflicts in the Middle East.

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Conflict of Interests

The authors declare no conflict of interests.

Data Availability

The data are not publicly available due to information that could compromise participant privacy. De-identified excerpts may be available from the corresponding author on reasonable request.

Supplementary Material

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

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About the Authors



Erwin van Tuijl is a researcher in urban studies at Delft University of Technology. He has done several (comparative) urban case studies in Africa, Asia, Europe, Latin America, and the United States of America. His current research interest lies at the crossroads of just urban transitions and digitalization.



Yogi Hale Hendlin, principal of the Feral Ecologies Lab, is tenured in the Erasmus School of Philosophy, and core faculty in the Dynamics of Inclusive Prosperity initiative at Erasmus University Rotterdam. Hendlin's research examines questions at the intersection of planetary health, environmental justice, and the commercial determinants of health.