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Decarbonising cities: exploring regional energy justice implications

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ABSTRACT

To meet energy demand and achieve climate and energy decarbonisation targets, cities adopt a range of mechanisms to facilitate renewable electricity development from their surrounding regions. These mechanisms are likely to have implications for regional community co-benefits, social acceptance of renewable energy projects, and energy justice. This research used document analysis to identify the procurement mechanisms being used by cities to source renewable electricity from surrounding regions and the types of actors involved. The analysis focussed on 27 cities pursuing ambitious 100% renewable energy or carbon neutrality goals and whose plans indicate engagement with their surrounding regions. The results point to eight types of mechanisms used by cities to develop renewable energy in their surrounding region. Of the 56 occurrences identified, 55 involved public actors, 25 involved private actors, and 12 involved civic actors. The findings demonstrate that cities are overcoming their local energy constraints by seeking to develop renewable electricity in their surrounding regions utilising mechanisms that are dominated by the involvement of public and private actors, leaving civic actors underrepresented.

Key policy highlights

- Cities with ambitious renewable energy goals require large amounts of renewable energy to decarbonise. To achieve their decarbonisation goals, cities are adopting a range of mechanisms to facilitate renewable electricity development in the regions that surround them.
- This study identifies eight types of mechanisms used by cities to drive renewable energy development within their surrounding region; power purchase agreements, project acquisition, city-led project development, incumbent-city collaborative project development, niche-city collaborative project development, centralised decision making, advocacy, and market stimulation. Of the 56 occurrences identified, most were dominated by public ($n = 55/56$) and private actors ($n = 25/56$), with little involvement of civic actors ($n = 12/56$) such as households, citizens and community organisations.
- Limited citizen involvement in renewable energy development can hinder equitable benefits and social acceptance for regional communities. Civic participation in regional energy development is essential for a just and successful energy transition.

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Introduction

Cities are centres of high energy demand and face a dual challenge of increasing electricity demand alongside pressure to meet emissions goals and decarbonise the energy systems they rely on (Araújo 2014; International Energy Agency 2024b). Factors such as climate change and energy policy, demand for the resilience of energy supplies, technological developments and falling costs of renewable energy technology all continue to drive the decentralisation of energy systems and their governance, offering city authorities new opportunities for driving renewable energy development (Funcke and Ruppert-Winkel 2020; Sioshansi 2014). Cities display diverse energy strategies, making variable use of local, regional or centralised actors and technology (Hoicka, Conroy, and Berka 2021; Kammen and Sunter 2016). These distinct approaches and pathways taken are shaped by spatial and socio-economic contexts, energy landscapes, infrastructural legacies, culture, structural institutions and political systems that influence decision making in energy governance – all of which are part of a cities' historical legacy (Dignum et al. 2020; Hommels 2005; Raven et al. 2019; 2017; Torrens, Johnstone, and Schot 2018). For example, federal or devolved systems of authority and governance may offer city authorities more opportunity to directly influence aspects of energy policy to progress their energy decarbonisation goals, than unitary states where energy policy is set by a national or centralised level (Torrens, Johnstone, and Schot 2018).

As part of their mission to sustainably develop or source electricity, cities may enter into new economic and business relationships with actors across the region, the broader geographic area encompassing cities. Little is known about these emerging relationships between cities and their regions, and their implications. This study seeks to fill an existing gap in the literature by identifying the mechanisms for facilitating regional renewable energy development implemented by a convenience sample of 27 early mover cities leading on climate and energy action and the actors involved in them – all of which are high-income and in the Global North.

An important consideration for cities facilitating renewable energy development located in regions is that clean energy infrastructure development itself presents avenues through which existing inequalities and injustices can be exacerbated (Sovacool 2021). Social inequality and injustice can contribute to public opposition to renewable energy development, resulting in project delays, cost-inefficiencies and project failure, as well as undermining deployment rates and public trust in climate and energy policy (Bessette et al. 2024; Cohen, Reichl, and Schmidthaler 2014; Segreto et al. 2020; Susskind et al. 2022). Involving local communities in energy development and ensuring local benefits provides an avenue to address legacy injustices as well as foster positive community outcomes and social licence for renewable energy projects (Berka and Creamer 2018; Bessette et al. 2024; Brummer 2018; Hoen et al. 2019; Hogan 2024; Rand and Hoen 2017; Saglie, Inderberg, and Rognstad 2020; C. Walker et al. 2022).

Understanding and documenting the ways that early mover cities with ambitious and innovative decarbonisation goals are pursuing the acquisition of renewable electricity on a regional scale can inform the work of other cities aspiring to decarbonise, as well as support communities and practitioners involved and affected by regional electricity sourcing. To this end, this study seeks to identify the mechanisms that early mover cities are employing to develop renewable electricity in the regions that surround them and the actors involved in these mechanisms. This sets the stage for a better understanding of the implications of the ways that cities are looking to regions to develop renewable energy.

Electricity decarbonisation

Power generation is the largest source of carbon dioxide emissions globally and electricity generation remains a key focus area for the transition to a low carbon economy (International Energy Agency 2024a). While electricity demand projections vary, even the most conservative estimates

predict a 75% increase in global electricity demand by 2050 (International Energy Agency 2022). Most of this demand growth is predicted to be in cities (Araújo 2014). A central factor driving rising electricity demand is electrification, a process wherein low-emitting electricity replaces fossil fuels in order to decarbonise (Abraham-Dukuma et al. 2021; Centi and Perathoner 2022; Connolly 2017; Greenblatt et al. 2017; International Energy Agency 2022). The electrification of numerous economic sectors including heavy industry and transportation is resulting in electricity replacing fossil fuels as an energy carrier (Greenblatt et al. 2017; International Energy Agency 2024a).

Sourcing enough renewable energy to meet electricity demand is especially challenging in cities due to power density of demand and supply. Cities require large amounts of electricity relative to rural or suburban areas, but often lack the geographic space to produce renewable energy at the scale needed to decarbonise through electrification (Hoicka, Conroy, and Berka 2021; Naumann and Rudolph 2020). For example, while a small house may use energy at a rate of 10–50W/m^2 – a measure of the spatial power density of demand, a high-rise building in an urban core could demand energy at a rate of between 300 and 1000W/m^2, that is, 20–100 times more energy for the same spatial footprint (Hoicka and MacArthur 2018; Smil 2015). Furthermore, the relatively low power density of renewable electricity sources poses a challenge in an urban context (Smil 2015). Thermal power plants operating on fossil fuels or nuclear power produce a much higher amount of energy per square metre of their spatial footprint of land than renewable sources like wind turbines or solar panels, meaning renewable sources need substantially more space to produce the same amount of electricity as a thermal plant. For example, fossil-fuel electricity plants can have power densities between 300-3,000W/m^2, this can be compared to the power density of a single wind turbine footprint being 50W/m^2 and solar facilities with power densities of 5W/m^2 (Hoicka and MacArthur 2018).

Even with significant renewable and storage deployment as well as demand side management, the combination of densely built and increasingly populated cities, the low spatial power density of the lowest-cost renewables (solar, wind), rising energy demand and the locations of high resource potential for renewable energy, means that cities that are seeking to be powered by renewable energy sources are looking beyond their geographical and legal borders to more rural regions as part of their strategies to source electricity to decarbonise (Araújo 2014; Balta-Ozkan, Watson, and Mocca 2015; Coenen et al. 2021; Hoicka and MacArthur 2018; Hoicka, Conroy, and Berka 2021; Mansouri Kouhestani et al. 2019; Mazur, Cieslik, and Czapp 2024; Naumann and Rudolph 2020; Poggi, Firmino, and Amado 2018; Schroth et al. 2012).

Decentralisation

A range of factors, from climate change and energy policy, the need for the resilience of energy infrastructure, technological developments, and falling costs of renewable energy technology are driving the decentralisation of energy systems and their governance (Funcke and Ruppert-Winkel 2020; Sioshansi 2014). Since the mid twentieth Century, the electricity sector has consisted of large-scale electricity infrastructure far removed from consumers, such as large scale hydroelectric dams, thermal generation (nuclear, coal, natural gas, etc), and long-distance transmission lines (Smil 2015), dominated by "incumbent" actors such as large public or private utility companies. Decentralisation has generated opportunities for actors such as citizens, households, community organisations, and local governments to become involved in energy infrastructure as "niche" actors (Berka and Dreyfus 2021; Brisbois 2020b). For example, with policy supports in place, households, community organisations, hospitals, and schools can purchase and install solar panels to generate, store, and trade power, reducing electricity costs and energy emissions; individuals can invest shares in local, regional or national renewable energy co-operatives; or communities may find local industrial or e-mobility outlets for excess renewable electricity supply. Civic actors ranging from citizens, community organisations, to non-profit organisations have become participants in the renewable energy transition alongside traditional public actors (governmental actors at any level ranging

from municipal to federal governments, ranging from government departments and agencies to publicly owned corporations) and private actors (profit-motivated firms such as corporations and banks, and smaller developers) (Berka and Dreyfus 2021; Brisbois 2020b; 2020a; Burke and Stephens 2017; Hoicka, Conroy, and Berka 2021). However, whether civic actors play meaningful roles in clean energy infrastructure depends on the material-economic, actor-institutional and discursive context; it requires supportive policy contexts that tend to arise where there are narratives and conscious strategies for participation, political opportunities and resources mobilised towards enabling participation, and high degrees of fiscal and legislative decentralisation and policy coordination (Berka, Hoicka, and Sperling 2025).

Understanding new and legacy injustices of incumbent energy systems

Energy systems have a longstanding legacy of inequality due to highly localised impacts with more diffused benefits of fossil fuel extraction and production, and disproportionate negative impacts of energy infrastructure and transportation on low-income, minority, and other marginalised communities in the form of air pollution, land and water contamination (Bennear 2022; C40 Cities 2021; Stefanelli et al. 2019; Tessum et al. 2021). Disadvantaged communities are susceptible to becoming "sacrifice zones" because of low land costs and political and social conditions that lower those communities' ability to mobilise opposition against energy infrastructure (Bennear 2022). By virtue of its deployability at a variety of scales, renewable technology provides an opportunity for the development of more just energy systems that are based on more careful consideration of costs and benefits of energy infrastructure.

While the negative impacts of renewable energy infrastructure differ from those of fossil-fuel systems, they can also be significant. A highly-cited review on the justice implications of renewable energy technologies provided eight categories of negative impacts perceived to be associated with renewable energy: pollution, waste, impacts on agricultural lands, impacts on cultural lands, limiting access to resources, impacts on wildlife, unequal benefits, and others including impacts such as the noise/strobe effect of wind turbines and aesthetic impacts to a landscape (Levenda, Behrsin, and Disano 2021). The same systemic factors driving historical siting of fossil-fuel infrastructure can generate sacrifice zones related to land-hungry, large-scale renewable energy projects, with the negative impacts of renewable energy falling unduly on disadvantaged communities (Bennear 2022; Levenda, Behrsin, and Disano 2021). For example, wind farms in the USA and UK have been found to be disproportionately located in regions with lower-socio-economic characteristics due to the limited ability of these "soft" communities to resist what are perceived as undesirable projects and such sites being seen as a "path of least resistance" by developers (Cranmer et al. 2023; Van Der Horst and Toke 2010). Another area of concern are the distributional effects of energy policies which have been observed to exacerbate existing inequalities in energy poverty (Bennear 2022; Jenkins et al. 2016). For example, a German feed-in tariff programme meant to encourage uptake of solar PV resulted in higher electricity costs for consumers which were found to disproportionately impact low-income households (Jenkins et al. 2016; Winter and Schlesewsky 2019).

With growing recognition of the relationships between decarbonisation, renewable energy development and its potential to exacerbate existing vulnerabilities and inequalities, an emerging energy justice literature has developed around how to prevent the renewable energy transition from reinforcing or recreating systems of injustice established during the fossil fuels era (Bennear 2022; Jenkins et al. 2016; Sovacool 2021; Sovacool et al. 2021). Energy justice is an interdisciplinary field that applies principles of justice literature to the energy sector (Jenkins et al. 2016). Three major components of energy justice are: distributional justice, which is concerned with the distribution of the outcomes of energy systems; procedural justice, which encompasses issues of due process, governance, and the law related to energy systems; and recognitional justice, which focuses on the rights and identities of groups and especially historical marginalised groups within energy systems (Jenkins et al. 2016). Measures to improve justice or equity outcomes of the low-carbon transition fall within

these forms of justice. These include measures such as the inclusion of historically excluded groups in policy and planning processes, adherence to principles of meaningful Free Prior and Informed Consent, stronger social and environmental impact assessments, stronger impact benefit agreements, shared ownership, compensation and retraining for disrupted sectors, and improved consumer protections (Bessette et al. 2024; Hogan 2024; Sovacool et al. 2021).

Civic engagement, community benefits and social acceptance

Although our understanding of social resistance to renewable energy has substantially improved alongside industry best-practice, it remains a significant and ubiquitous problem. Social opposition to renewable energy development is often multi-faceted, with coalitions of groups concerned about a range of different factors including the "fairness" of cost and benefit distribution, environmental impacts, shortcomings in public inclusion and participation, health and safety, land values, and relevant opinions not being heard in energy-related decision-making (Bidwell 2016; Crawford, Bessette, and Mills 2022; Goedkoop and Devine-Wright 2016; McLaren Loring 2007; Rand and Hoen 2017; Susskind et al. 2022; G. Walker et al. 2010). A range of authors have suggested deep civic engagement in energy will be essential to foster the buy-in and land use change necessary to bring renewable energy to full scale (Bessette et al. 2024; Hoicka, Conroy, and Berka 2021; Segreto et al. 2020; Susskind et al. 2022). Exclusive approaches to renewable energy development generate organised opposition movements and have lasting impacts on public perceptions of renewable energy and climate change policy more broadly (Afanasyeva, Davidson, and Parkins 2022; Bues 2020; Toke, Breukers, and Wolsink 2008). A lack of social licence can lead to decreased project support, strained or divided communities, decreased cooperation from landowners, challenges in managing community expectations and project risks, site abandonment, and reputational harm for associated developers and governments (Hicks et al. 2018). This can cause significant delays and increased costs, and at worst, result in legal challenges, project failure, and in policies which restrict renewable energy deployment. There is therefore a clear link between community engagement, social licence, renewable energy deployment, and decarbonisation goals (Bessette et al. 2024; Crawford, Bessette, and Mills 2022; Segreto et al. 2020; Susskind et al. 2022).

The ways communities experience and participate in renewable energy projects, influences their acceptance of the project (Bessette et al. 2024; Hoen et al. 2019; Hogan 2024; Rand and Hoen 2017; Saglie, Inderberg, and Rognstad 2020). Unobtrusive renewable energy projects with a development process that are perceived to be fair have been shown to contribute to more support and positive attitudes from nearby communities than projects with substantial impacts with benefits going to a small number of individuals in the community (Bessette et al. 2024; Hoen et al. 2019; Hogan 2024; Rand and Hoen 2017; Saglie, Inderberg, and Rognstad 2020). The genuine engagement of civic actors in development processes is now broadly understood as necessary for a procedurally just development process that is perceived as fair (C. Walker et al. 2022; G. Walker 2011; G. Walker and Devine-Wright 2008). Leading practice on community benefit sharing involves the meaningful and early engagement of local communities in energy decisions, going beyond mere consultation to allow communities genuine opportunities to provide input and feedback, to providing opportunities for benefit sharing and co-ownership (Bidwell and Sovacool 2023; Hogan et al. 2022; G. Walker et al. 2010).

Social acceptance also correlates with beneficial socioeconomic impacts and alignment of projects to community needs (Hogan 2024; Rand and Hoen 2017). The socioeconomic impacts experienced by a community as a result of a renewable energy project is affected by the project's governance and ownership structure, the procurement of material and labour, the sourcing of capital, and the extent to which revenues are spent locally (Berka and Creamer 2018; Hogan 2024; Savic and Hoicka 2021; Slee 2020; Phimister and Roberts 2012; Walker 2011). There is substantial evidence that communities with a degree of ownership in local renewable energy projects experience higher levels of acceptance, perceive more just and inclusive development

processes, and more fairly distributed benefits and impacts (Hogan 2024; Hogan et al. 2022; G. Walker et al. 2010). As such, involving civic actors in procedural justice developmental processes may allow for the development of a just distribution of project outcomes (Elmallah and Rand 2022; Hogan 2024; Rand and Hoen 2017). In contrast, when projects are led by people outside of the community, the projects run the risk of imposing closed and institutional processes on host communities, with benefits flowing out of the community (C. Walker et al. 2022; G. Walker and Devine-Wright 2008).

Civic engagement as an indicator

Involvement of the communities impacted by energy systems is critical to working towards energy systems that are both sustainable and just (Avelino et al. 2024; Berka and Creamer 2018; Devine-Wright 2019; Jenkins et al. 2016; Sovacool 2021; G. Walker and Devine-Wright 2008). Civic engagement of actors in renewable energy projects provide an indication of whether cities' approaches to encouraging renewable energy development in their regions are potentially considering fair development processes and local community benefits (Berka and Creamer 2018; Bessette et al. 2024; Hoen et al. 2019; Rand and Hoen 2017; Saglie, Inderberg, and Rognstad 2020). Community or civic actors located near renewable energy project sites such as residents, citizens, individuals, community organisations, unions, and not for profits are representative of some of the types of civic actors whose participation in renewable energy projects is aligned with open and participatory processes and outcomes that are local and collective (Hoicka, Conroy, and Berka 2021; C. Walker et al. 2022; G. Walker 2011; G. Walker and Devine-Wright 2008).

We currently know little about how cities are engaging with regions to promote the development of renewable energy and whether their methods of regional engagement typically involve communities located close to projects. This lack of knowledge could result in the design of decarbonisation strategies and related policies that fail to incorporate the current state of literature regarding the benefits of community involvement in energy development, thereby serving to hinder decarbonisation and miss the opportunity provided by decarbonisation to address the inequality and injustice associated with historic energy systems. Understanding the people and communities involved in city decarbonisation arrangements could provide insight into how those projects may be working towards justice.

This paper seeks to fill an existing gap in the literature by identifying the ways in which cities with ambitious renewable energy and decarbonisation goals are encouraging renewable electricity in the regions that surround and by using civic actors as an indicator for community involvement or engagement. This research serves as a first step towards understanding how city energy planning potentially influences local community interactions with and experiences of renewable energy development. The research also responds to an established need within decarbonisation research to perpetually examine who low-carbon transformations are sustainable for (Sovacool et al. 2021).

Materials and methods

The research consisted of several steps. First, cities with energy strategies that incorporated their surrounding regions were identified. With additional document searches and analysis, the ways these cities interacted with their wider regions to encourage renewable energy development were examined, recorded, and categorised. Finally, each recorded occurrence of regional engagement was examined to identify the types of actors involved and how. Figure 1 outlines the methodological process.

Sampling and data collection

To understand the ways in which cities facilitate renewable energy development in their a regions scale and the actors involved, cities were identified from a pre-existing dataset composed of energy-

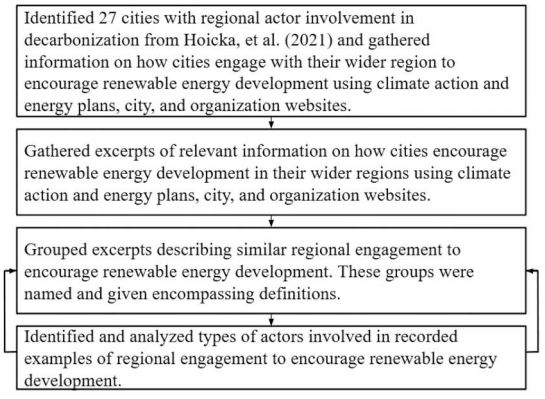

Figure 1. Methods process.

dense cities with formally adopted targets for achieving either carbon neutrality or 100% renewable energy city-wide (Hoicka, Conroy, and Berka 2021). An initial sample of 47 cities was gathered between January and July 2020, and focussed on high power density cities, defined as cities with a minimum population of 100,000, and a population density of at least 200 people per square kilometres. High power density cities are more likely to engage with the surrounding region to source renewable electricity and reflect the type of large-scale, systemic change that will be required to achieve decarbonisation. Only 27 cities were found to have involved the participation of regional actors in energy decarbonisation. This was determined by identifying the involvement of authorities, residents, local businesses, or neighbouring communities in the regional area and identifying the location of energy production as being in a neighbouring community or surrounding region to a city.

To identify which regional actors were engaged by cities to encourage renewable energy development, we drew on documents ranging from climate action and energy plans, strategy documents, city websites and websites of relevant organisations such as utilities. These were identified through internet searches conducted in English for specific cities or relevant organisations using terms such as; [city name] energy plan, [city name] climate plan, [city name] renewable energy project, [organisation name] renewable energy project, [organisation name] energy plan, and [organisation name] climate plan. These searches were conducted from January to August, 2023.

Thematic analysis

All excerpts that mentioned cities participating in the construction of new renewable energy projects in their wider region were grouped together and analysed for similarities and trends. Grounded theory was used to develop categories of mechanisms found to be driving renewable energy development within the region surrounding the cities. Grounded theory allows for the identification of trends present within a dataset by continually analysing and processing relevant documents to develop several distinct categories, rather than providing and developing a specific hypothesis (Ritchie et al. 2014). Excerpts with similarities were grouped into categories and a characterising definition for each category was developed. A descriptive name for each category was chosen, resulting in the identification of distinct mechanisms for motivating renewable energy development in the regions surrounding cities. A list of the mechanisms that each city was using to encourage renewable energy development in their surrounding regions was developed. For instance, City A could be using three of the identified mechanisms while City B is using only one.

In the next step, this research examined the actors involved for each mechanism identified. This study distinguished three categories of actors that could be involved in the mechanisms; public, private, or civic actors, defined in Table 1. The types of actors were identified in the resources collected and through additional internet searches regarding the identified energy projects and for documents mentioned in the collected resources. Excerpts from the collected documents that discussed the involvement of the actor types as defined in Table 1 were recorded. For example, for City A, excerpts illustrating the different actor types involved in each of the three identified mechanisms would be recorded. Involvement in encouraging the regional development of renewable energy could include but is not limited to: ownership, investment, purchasing, developing a project, or participating in policy development and implementation.

Table 1. Actor Types (Hoicka, Conroy, and Berka 2021, 8).

Actor Types	Definition
Civic	Residents, citizens, individuals, community organisations, unions, not for profits.
Public	Government, local authority, regulatory bodies, public sector organisations, publicly owned utilities.
Private	Firms, financial institutions, private utilities.

Table 2. Example of tracking actor involvement in Copenhagen.

City	Mechanism for Driving Regional Renewable Energy Development	Involved Actors Types
Copenhagen	Project Acquisition	Public, Private
Copenhagen	City-led Project Development	Public
Copenhagen	Incumbent-City Collaborative Project Development	Public
Copenhagen	Niche-City Collaborative Project Development	Public, Civic

Identifying the actors involved in each mechanism revealed new similarities and patterns within the mechanisms. This resulted in an iterative process of recategorization and redefinition, refining the mechanisms to better represent variations in actor involvement. Table 2 illustrates how actor involvement was tracked. In this example, the city of Copenhagen has four mechanisms with four instances of public actor involvement, and one instance of private and civic actor involvement respectively. The prevalence of mechanisms and actor involvement were analysed by identifying which and how many cities used each mechanism and the frequency that each actor type was involved in each mechanism. Tables and visualisations were then developed.

Results

Table 3 shows the geographical distribution of the 27 cities identified as deploying regional mechanisms for renewable electricity development. These cities are located in thirteen countries across four continents.

Eight mechanisms for driving renewable energy development within the region surrounding the city were identified. There was a total of 56 occurrences[1] of these eight types of mechanisms across 25 cities.[2] The renewable energy technologies associated with the mechanisms included geothermal, wind, solar, hydropower, and biomass. Each mechanism is only counted once per city, regardless of how many times it was deployed for different renewable energy projects. The identified mechanisms, their definitions, and the cities using each mechanism can be found in Table 4. The most common mechanisms were power purchase agreements (12/27), followed by city-led development (10/27). Advocacy, incumbent-city collaborative project development, and niche-city collaborative project development were used by an identical number of cities (8/27). The findings also show that in rare instances, cities leave decision making to centralised utilities (2/27) or acquire existing renewable energy projects (3/27) that are led by public or private actors.

In terms of actor engagement, some occurrences included all three actor types while others could include only one or two. Counting each actor type separately within each mechanism, there were 96 instances of actor participation. Figure 2 shows the prevalence of each actor type by mechanism. Public actors were involved in 55 of 56 occurrences, private actors in 29 of 56 occurrences, and civic actors in only 12 of 56 occurrences. Perhaps not surprisingly, only public actors were involved in the city-led development project mechanism. Both public and private actors were present in all remaining types of mechanisms. There was one occurrence of a lone private actor in the centralised decision making mechanism. Civic actor participation was found in the following mechanisms: one power purchase agreement, four iterations of market stimulation, and seven occurrences of niche-city collaborative project development. Civic actors were absent in the city-led development,

Table 3. Cities selected for regional mechanisms from the Hoicka, Conroy, and Berka (2021).

City	Country	Continent
Vancouver	Canada	North America
Guelph		
Houston	United States	
St.Paul		
New York City		
San Francisco		
Seattle		
Fort Collins		
Freiburg	Germany	Europe
Osnabruck		
Heidelberg		
Frankfurt		
Bonn		
Hannover		
Leuven	Belgium	
Ghent		
Islington	England	
Reykjavik	Iceland	
The Hague	Netherlands	
Amsterdam		
Paris	France	
Copenhagen	Denmark	
Oslo	Norway	
Turku	Finland	
Yokohama	Japan	Asia
Tokyo		
Melbourne	Australia	Oceania

advocacy, incumbent-city collaborative project development, project acquisition, and centralised decision-making mechanisms.

Table 5 provides the details for the involvement in the 12 instances of civic actor presence in mechanisms. These results show that civic actor involvement in the development of renewable energy for cities can vary in type of involvement. Power purchase agreements can have civic actors playing major roles in the electricity system such as in Bonn where a co-operative generates and sells renewable amounts of electricity. On the other hand, mechanisms such as market stimulation involve the civic actors playing a far more passive role by essentially becoming advertisees. Given the role of civic participation in shaping energy justice outcomes, this variation in how civic actors are involved in ways cities facilitate renewable energy development in their surrounding regions carries energy justice implications.

Discussion

As a result of the transition to renewable sources of electricity, new relationships and trends of development are evolving between cities and the regions that surround them (Balta-Ozkan, Watson, and Mocca 2015; Hoicka, Conroy, and Berka 2021; Naumann and Rudolph 2020). Identifying the distinct mechanisms through which cities facilitate and drive the development of renewable energy in their surrounding regions, this research shows how innovative cities with ambitious climate goals are promoting renewable energy development in regions. Eight types of mechanisms were identified; power purchase agreements, project acquisition, city-led project development, incumbent-city collaborative project development, niche-city collaborative project development, centralised decision-making, advocacy, and market stimulation. The analysis indicates that power purchase agreements, various forms of project development, and advocacy make up a significant portion (46/56) of the strategies implemented by the cities in the dataset.

Regionalism

The identification of 56 specific occurrences of mechanisms across 25 of the 27 examined cities in the Global North confirms the importance of regions in the sourcing of renewable electricity, demonstrating that cities with the most ambitious climate plans are taking action to encourage the development of renewable electricity on a regional scale. As more cities look to decarbonise their electricity grids or otherwise improve their access to renewable electricity, these eight mechanisms will likely be replicated. Further research that helps to provide a better understanding of these mechanisms and their implications could help decision-makers make informed decisions on the regional sourcing of renewable electricity.

Table 4. Mechanisms implemented by cities to source renewable electricity on a regional scale and their definitions.

Mechanism for Driving Regional Renewable Energy Development	Definition	Cities Using Mechanism
Power Purchasing Agreement	Cities enter into agreements with other entities to purchase renewable energy produced in the region surrounding the city. For example, these entities could be commercial or cooperative power producers.	Bonn, Fort Collins, Frankfurt, Heidelberg, Houston, Melbourne, New York City, Osnabrück, Paris, San Francisco. Seattle, Turku ($n = 12$)
City-Led Project Development	Cities develop and own renewable energy projects in the city's wider region, often in collaboration with municipally-owned utility companies.	Copenhagen, Guelph, Hannover, Heidelberg, Oslo, Osnabrück, Paris, Reykjavik, Seattle, Turku ($n = 10$)
Advocacy	Cities advocate to the energy sector and higher levels of government, for measures to increase deployment of and access to renewable energy.	Frankfurt, Houston, Islington, Leuven, Paris, The Hague, Tokyo, Yokohama ($n = 8$)
Incumbent-City Collaborative Project Development	Cities collaborate with incumbent actors to develop renewable energy in the region surrounding the city. These incumbent actors can be public or private utility companies (not including municipally-owned utilities), energy companies, and state-owned enterprises that have an established presence in the energy sector (Hoicka, Conroy, and Berka 2021).	Amsterdam, Bonn, Copenhagen, Heidelberg, New York City, Oslo, Osnabrück, Turku ($n = 8$)
Niche-City Collaborative Project Development	Cities participate in a collaboration that involves niche actors, such as civic actors including energy cooperatives, citizens, and households, in the development of renewable energy projects in the region surrounding the city.	Amsterdam, Copenhagen, Frankfurt, Islington, Leuven, Paris, The Hague, Yokohama ($n = 8$)
Market Stimulation	Cities campaign to raise awareness of renewable energy options to encourage city-based consumers to retail packages of renewable energy signaling demand for renewable energy to the energy market.	Houston, Islington, Paris, San Francisco, Yokohama ($n = 5$)
Project Acquisition	Cities purchase renewable energy projects that are already operating in the region surrounding the city, often with the involvement of municipally-owned utility companies.	Copenhagen, Hannover, San Francisco ($n = 3$)
Centralised Decision-Making	Cities leave decision-making around regional renewable electricity to an entity that the city lacks control over such as an incumbent private energy company or state-owned enterprise. Within this mechanism, cities do not actively participate in the regional sourcing of renewable electricity.	Saint Paul, Vancouver ($n = 2$)

Civic actor engagement

In order to gain insight into the potential impacts of the ways cities are encouraging renewable energy development in their surrounding regions, we examined the involvement of different types of actors. The presence of civic actors served as an indicator for whether the mechanisms cities are using to encourage renewable energy development in their region could potentially be categorised as open and participatory processes with outcomes that are local and collective, thereby challenging the historic power structures and institutions that contribute to injustice and unsustainability in energy development. One of the most significant findings of the study is that civic actor involvement was found in just 12 out of 56 (21.4%) identified mechanisms. Given that who participates in energy development is closely aligned with social acceptance and how the benefits and negative impacts of energy

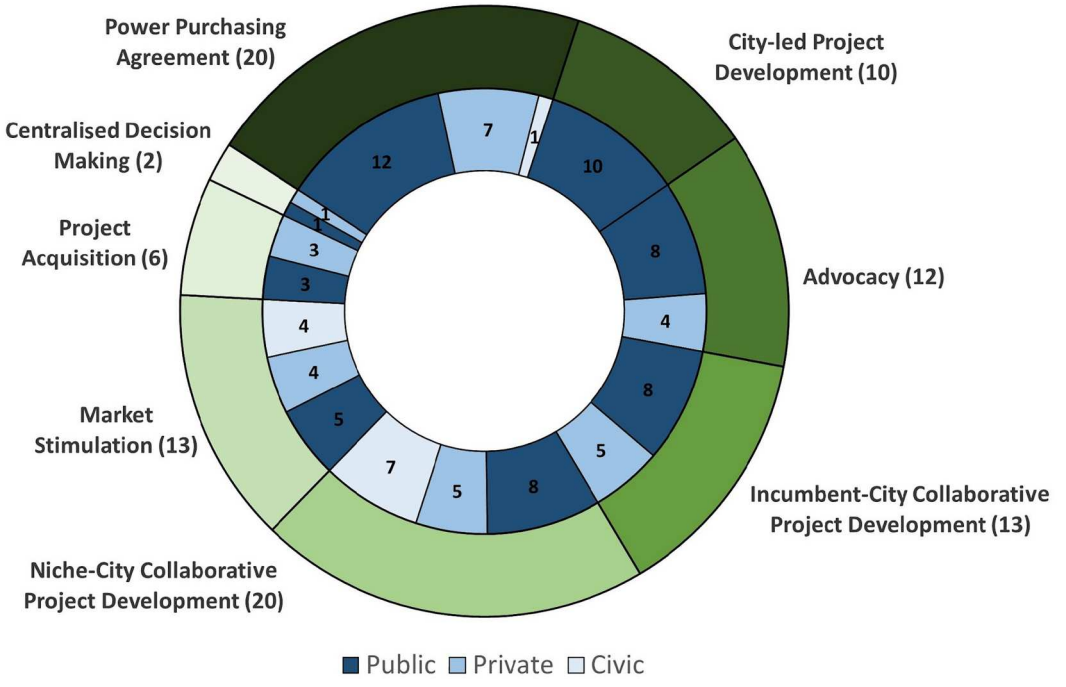

Figure 2. Results graph showing actor prevalence by mechanism ($n = 96$).

development are distributed (Bennear 2022; Berka and Creamer 2018; Bessette et al. 2024; Brummer 2018; Cohen, Reichl, and Schmidthaler 2014; Hoen et al. 2019; Rand and Hoen 2017; Saglie, Inderberg, and Rognstad 2020; Susskind et al. 2022; C. Walker et al. 2022), the findings of limited civic actor participation potentially presents a missed opportunity.

A number of cities in this study are taking innovative approaches to encouraging renewable energy development in their surrounding regions involving civic actors in energy development. These types of programmes require that cities ensure the proper regulatory, financial, and technological contexts are present so that such a decentralised approach to electricity generation is viable and successful. Documenting these innovative programmes allows other cities to implement them and recreate the conditions that resulted in their success.

The observed low levels of civic actor involvement in this study suggest the potential for a lack of social acceptance towards renewable energy projects developed using the mechanisms identified in this research. Given that social acceptance is influenced by the perceived fairness of cost and benefit distribution, the nature of public participation, and potential responses to concerns relating to health, safety, and land values (Goedkoop and Devine-Wright 2016; McLaren Loring 2007; Susskind et al. 2022; G. Walker et al. 2010), a lack of civic actor involvement suggests that the mechanisms cities are using to drive renewable energy development in their surrounding regions may not have the characteristics necessary to result in positive community perceptions and social acceptance of the renewable energy project. Given that issues of social acceptance have been identified as a hindrance to developing the renewable energy projects necessary to meet decarbonisation goals (Bessette et al. 2024; Segreto et al. 2020; Susskind et al. 2022), the lack of civic actors in the identified mechanisms could also have implications for the broader success of decarbonisation efforts overall.

Further, the literature suggests that a lack of civic actor involvement in the identified mechanism could have implications for how local communities experience nearby renewable energy projects. Involvement from the community in a project's governance and ownership structure, as

Table 5. Examples of civic actor involvement in regional renewable energy procurement mechanisms.

Mechanism	City	Types of Actors Present	Involvement of Civic Actors
Power Purchasing Agreement	Bonn	Public, Private, Civic	The publicly-owned utility in Bonn has a number of power purchasing agreements with regional producers of renewable electricity. One such agreement is with a civic energy cooperative in the nearby municipality of Obergriesbach. This energy cooperative is a collective of 319 citizens that jointly own a wind farm capable of producing enough electricity to power 2,000 homes.
Niche-City Collaborative Project Development	Amsterdam	Public, Private, Civic	Amsterdam will participate in the North Holland South Energy Region project to develop solar panels on roofs, above parking spaces, and along infrastructure such as roads across the entire region, in order to increase the regional mix of renewable electricity. Planning documents for the program specifically mention working with farmers to add solar to agricultural buildings as well as owner's associations and energy cooperatives to develop local solar projects that residents can participate in.
	Copenhagen	Public, Civic	The municipally-owned utility in Copenhagen has constructed numerous wind farms in the regions surrounding the city. One such project is located on the island of Lolland and is composed of 11 wind turbines with enough capacity to power 24,000 homes. HOFOR has allowed residents to buy shares in the project.
	Frankfurt	Public, Private, Civic	Frankfurt is working with an organisation that involves municipalities from across the wider metropolitan area to promote the adoption of rooftop solar across the region, increasing the amount of renewable electricity into the mix the city draws electricity from. The metropolitan organisation is working to implement rooftop solar campaigns that encourage residents to develop rooftop solar systems.
	Islington	Public, Civic, Private	Islington is part of the greater London Metropolitan region. Islington is participating in a programme operated by the office of the Mayor of London to promote the adoption of rooftop solar panels across the greater London area. This programme seeks to increase the amount of renewable electricity in the mix by increasing the uptake of solar panels on the roofs of domestic and commercial properties.
	Leuven	Public, Civic	The city of Leuven is planning to construct 20 wind turbines across the region surrounding the city. A part of this project is the establishment of a local energy cooperative to invest in the project. The city is hoping that 40% of households in the city will be members of the cooperative by 2030.
	Paris	Public, Civic	The city of Paris works with a number of organisations that seek to promote renewable electricity development across the greater Paris metropolitan area. Participants in these organisations include other local authorities and energy unions. One organisation has constructed two anaerobic digestion plants to produce electricity from food waste generated across greater Paris while another is involved with the development of citizen solar projects in the metropolitan area.
	The Hague	Public, Private, Civic	The Hague is part of an energy region that includes a number of regional communities. The energy region is implementing a number of strategies to develop renewable electricity across the region. Documents produced by the energy region organisation promote consultation to improve support for the projects by residents and landowners. The organisation also is aiming for 50% local ownership in new wind and solar projects developed in the region.
Market Stimulation	Houston	Public, Private, Civic	The liberalised electricity market in Texas is driven by competition. The city of Houston seeks to increase the share of carbon-free electricity supplied to the grid by encouraging consumers such as households, to purchase electricity from

(*Continued*)

Table 5. Continued.

Mechanism	City	Types of Actors Present	Involvement of Civic Actors
			renewable sources. The idea is that increasing demand for clean energy will lead to increased investment in renewable electricity across the state.
	Paris	Public, Private, Civic	Paris promotes the benefits of renewable energy to businesses and residents in the hopes that they will choose to subscribe to utilities that offer renewable energy. By increasing demand for renewable energy, the city of Paris hopes to promote the development of more renewable energy projects across the greater region.
	San Francisco	Public, Private, Civic	San Francisco promotes the adoption of 100% renewable electricity products to all San Franciscans in order to boost investment in renewable electricity by the utilities servicing the city.
	Yokohama	Public, Private, Civic	Yokohama has required that energy retailers provide information to consumers regarding the emission factors of their electricity production. The city hopes to combine this new legislation with awareness campaigns in order to encourage consumers to purchase low-carbon electricity. This increased demand could serve to promote investment in renewable electricity by the established electricity retailers.

represented by the involvement of civic actors in this research, influences the socioeconomic impacts of a project on the community (Berka and Creamer 2018; Hogan 2024; Savic and Hoicka 2021; Slee 2020; G. Walker 2011). There is a concern that projects that lack community engagement will result in less benefits for the local community. This is because projects led by people who lack geographical proximity to the project run the risk of following a process that is closed, institutional, and extractive, with the benefits of the perceivably imposed project leaving the community rather than remaining in it (G. Walker and Devine-Wright 2008). Additionally, projects that lack substantial community involvement through processes that are open and participatory and outcomes that are local and collective, mean that local actors are unable to enjoy the benefits associated with community engagement as described by the literature (Berka and Creamer 2018; Devine-Wright 2019; G. Walker and Devine-Wright 2008). Approaches to renewable energy development that exclude local communities generate organised opposition movements and can result in negative public perceptions of renewable energy and climate change policy more broadly (Afanasyeva, Davidson, and Parkins 2022; Bues 2020; Toke, Breukers, and Wolsink 2008), further hindering decarbonisation (Bessette et al. 2024; Cohen, Reichl, and Schmidthaler 2014; Segreto et al. 2020; Susskind et al. 2022). However, the mere presence of community involvement in an energy project does not precipitate the local manifestation of benefits, given that projects most able to prioritise the achievement of specific local environmental, social, economic, or infrastructural objectives are specifically led by locals (Devine-Wright 2019; Seyfang, Park, and Smith 2013; G. Walker and Devine-Wright 2008). One potential alternative approach that bridges the gap may be to develop projects under the leadership of both local and outsider civic actors in order to be able to benefit from the resources accessible to outsiders while ensuring the project is contextualised to ensure the localisation of benefits as a result of the project and the potential alleviation of pre-existing localised inequalities (Simon 2008; C. Walker et al. 2022).

By contributing to the development of new avenues for research on similar topics, these findings serve as a starting point for research concerning regional equity and justice implications of energy decarbonisation broadly and the energy planning of cities specifically. In depth examination of civic actor involvement across mechanisms could provide insight into the resulting socio-economic impacts and outcomes at local and regional levels. Detailed case studies could also help explain

the relationships between project characteristics, forms of civic actor engagement, and the social acceptability of renewable energy projects. For example, specific combinations of mechanisms, civic actor participation, and renewable technologies could be more socially acceptable than others. Context-comparative studies could help identify the factors that shape decisions around civic engagement such as infrastructural and institutional legacies, place-based landscape, socioeconomic and cultural characteristics, and the fiscal and legislative powers of involved authorities of regions and cities. This future research can contribute to the fields of energy justice, decarbonisation, and decentralisation to develop an evidence base to allow for equitable and effective city-regional renewable energy transitions.

Limitations

As the researcher is predominantly English-speaking, some of the documents were translated into English from other languages, which may have resulted in missed or misinterpreted examples. Reliance on internet searches conducted in English could have missed resources that were not in English. The study was limited in scope, with implications for generalisability of results. Cities included in the sample had ambitious climate plans, which means that cities without ambitious plans but that are trying to encourage renewable energy development in their surrounding regions were not included. As a result, the cities present in the dataset are entirely located in high-income countries, mainly in Global North countries. Strategies used to approach the regional development of renewable electricity in the Global South may differ and our findings may have limited generalisable applicability to cities in other economic and social contexts. For example, energy systems in the Global South are often highly centralised with limited scope and opportunity for local authorities to intervene and drive renewable energy development (Berka, Hoicka, and Sperling 2025; Levin and Thomas 2016).

Conclusion

This research presents a preliminary exploration of the mechanisms through which cities are trying to encourage renewable energy development in their surrounding regions. It builds on relevant literature on participation in relation to social acceptance and social outcomes, including regional development, and examines how cities are engaging with different actors to drive the development of renewable electricity in their wider regions, pointing to a number of fruitful research avenues on this topic. Together these findings point to a need for regional renewable energy developments to allow greater civic involvement, resulting in the localisation of benefits and the potential alleviation of social resistance to renewable energy developments. Ultimately, we hope this work contributes to the development of equitable and effective city-regional renewable energy transitions within and beyond the study sample. Moving forwards, leaders and decision-makers pursuing city-level decarbonisation through regional renewable energy development should consider the benefits of civic actor involvement in pursuing energy justice and identify avenues for renewable energy development that are sensitive to pre-existing social inequalities and opportunities for regional development. Given the scale and extent of renewable energy deployment that regions are likely to face, these regional energy justice considerations are important for the development of just and effective decarbonisation strategies.

Notes

1. Greater details on all 56 occurrences of the mechanisms can be found in the supplementary materials.
2. Within the sample of 27 cities, two cities (Freiberg and Ghent) showed no evidence of using mechanisms to promote renewable energy development in the regions surrounding their cities.

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Data accessibility statement

The resources used to make the conclusions within this paper can be found in the supplementary materials file.

CRediT authorship contribution statement

Adam J. Regier: Conceptualisation, Data Curation, Formal Analysis, Funding Acquisition, Methodology, Project Administration, Resources, Validation, Visualisation, Writing – Original Draft, Writing – Revision. **Anna L. Berka:** Conceptualisation, Validation, Writing – Original Draft, Writing – Revision, Supervision, Project Administration. **Christina E. Hoicka:** Conceptualisation, Funding Acquisition, Methodology, Project Administration, Resources, Supervision, Validation, Writing – Original Draft, Writing – Revision.

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