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Renewable Energy as an Underutilised Resource in Cities: Germany's 'Energiewende' and Lessons for Post-Brexit Cities in the United Kingdom

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Abstract: Renewable energy remains an underutilised resource within urban environments. This study examines the ongoing German Energiewende (energy transition) as an example of renewable energy being treated as a necessary resource for urban development. It departs from existing literature by operationalising the Advocacy Coalition Framework (ACF), taking a policy systems approach to analyse (and explain) the cases of three German cities—Munich, Berlin, and Freiburg. This approach helps draw lessons for future UK energy scenarios by placing more abstract conceptions of Sustainable Energy Transitions (SETs) within the context of UK cities, post-Brexit. By discussing five main themes: the shift from government to governance; the need to break 'carbon lock-in'; renewable energy innovation as an underutilised resource; developing governance strategies for renewable energy resources; the shift from policy to practice, the study yields a detailed reconceptualisation of approaches to renewable energy resource-use policy. The novelty of this study lies in its response to these challenges, taking a policy systems approach to energy governance. The article concludes with a proposed integrated framework. The framework, which is based on multi-scalar and multi-stakeholder integrated energy governance strategy, reconsiders the way in which renewable energy resources are seen in current governance terms in the UK. The framework presents a new approach to renewable energy resource-use policy that embraces innovation, responsible governance, and inclusive processes, (alongside thinking beyond simply technical solutions) to considering the socio-economic impacts of policy decisions in cities.

Keywords: city planning; Energiewende; post-Brexit; renewable energy systems; resource-use policy; sustainable energy transitions; underutilised resources

1. Introduction

Renewable energy is an underutilised resource in many cities that is under-exploited. As cities are the largest consumers of energy and material resources, renewable energy production and distribution has become increasingly essential for ensuring that cities respond to modern environmental, socio-economic, and political challenges of de-carbonisation and efficient resource use. Prior to the United Kingdom's (UK) vote to leave the European Union (EU) in 2016 (commonly referred to as 'Brexit'), the assumption of policy-makers was that Sustainable Energy Transitions (SETs) would be made possible by integrated top-down approaches, mandating national governments to embark upon ambitious restructurings of energy systems [1]. Although the prospect of Brexit does not automatically

mean that the UK will entirely eschew common European commitments, practices and policies, it does raise the possibility that greater differentiation will emerge in tackling common issues [2,3]. Although UK cities have a number of existing structural advantages that potentially could allow for greater innovation and transformation, they have continued to lag behind their European competitors in terms of renewable energy innovation, productivity and sustainable resource-use. For example, since the Climate Change Act 2008, the UK's renewable energy policies have increasingly been focused on how to adapt existing energy systems and resources to innovative approaches [4]. Alongside this, devolution and other structural policy shifts have the potential to give rise to more sustainable energy governance, responding to changing needs in ways that are different from the rest of the EU [5]. Nevertheless, across Europe, given energy consumption patterns and dependencies, the issue facing municipalities and local governments is how to deal with complex and changing linkages between energy production, consumption, and governance systems. The novelty of this study lies in its response to these challenges, taking a policy systems approach to renewable energy resource-use policy, focusing on the governance and management of these resources within cities.

This article therefore embraces Germany's 'Energiewende' (energy transition)—the planned transition to a nuclear-free and low-carbon energy economy—as an example of renewable energy being treated as an underutilised resource that is necessary for urban development. It represents a different interpretation of the future of renewable energy systems, and therefore material resource-use—especially in relation to innovation and valorisation—and its approach stands out from the UK, as its cities are at the vanguard of this transformation. It departs from existing literature by focusing on changing inter-linkages between renewable energy systems, resource-use and cities, using three case studies—Munich (a solar-city), Berlin (Germany's capital) and Freiburg (an eco-city)—which frames the main research questions in this article as follows:

1. How can renewable energy be conceptualised as an underutilised resource in urban environments?
2. What do German experience(s) of sustainable energy transitions reveal about pathways towards mainstreaming renewable energy in the urban environment?
3. What lessons can be learnt from the German example(s) for other countries, particularly the UK and the EU, in relation to evolving energy approaches, post-Brexit?
4. How feasible are renewable energy resource-based systems as an alternative to current carbon-based centralised energy systems in the EU?

To answer these questions, the study begins by describing the notion of resource underutilisation in the city (to argue that renewable energy is an underutilised resource in urban environments). This is followed by a description of the methodology and findings, and a discussion leading to conclusions and a proposed integrated energy governance framework.

2. The Notion of 'Resource Underutilisation' in the City and the Context of UK Cities, Post-Brexit

2.1. The Notion of "Resource Underutilisation" in the City

The current state of global urbanisation has led to increasing pressures on city dwellers and the urban environments in which they live. These urban challenges are likely to increase as a result of expected rises in urban populations by 2050 [6]. Cities account for 80% of global Gross Domestic Product, 60–80% of global energy consumption, 75% of carbon emissions, and more than 75% of the world's natural resource consumption—even though they only occupy 2% of the earth's land surface [6].

As a result, cities striving to serve all urban residents need to utilise resources efficiently. Resources are material or non-material products that are usable by cities to fulfil their function as human settlements. Hence, "resources are only resources to the extent that they have value, or usefulness" to the city [7]. They are the usable components—usually integrated in broader city action plans—that contribute to improvements in living conditions for people and the urban environment. This does not

imply that every material and non-material component of city development is a resource. According to Watts [7], "[. . .] things that can't be used to enhance life aren't resources, but just objects; things that used to be resources but are now worn out, obsolete, or otherwise have lost their usefulness aren't resources but just junk".

Resources enable cities to provide new, better quality, inclusive and lower cost products and services to its residents. The ability of cities to continually deliver these offerings over time constitutes an important determinant of its functionality as a human settlement. The use of the term 'underutilised' to refer to categories of city resources gives rise to a discussion of what the word actually means. In general, it is commonly applied to materials and non-material products (e.g., goods and services) whose potential has not been fully utilised or realised in the development of the city. This all-inclusive definition of underutilised resources embraces all resources that are currently abandoned by city planners (including administrators and developers), or that are in decline or undiscovered, but which could be discovered or revived through specific interventions, adding value to the functionality of the urban environment. Underutilised resources can be vacant land, knowledge, energy resources, services, demographic data, minerals, and many categories of natural resources, among others. This study considers renewable energy—that is, energy generated from natural processes that are continuously replenishable—particularly energy from solar and wind, as an underutilised resource. These remain underutilised resources in UK cities, because they are energy sources that cannot be exhausted, and that are constantly renewed.

Penrose's [8] *The Theory of the Growth of the Firm* provides the premise for understanding the relative (un-)importance of underutilised resources, by arguing that underutilised resources are core drivers of firm growth. Adding to this diagnosis, Penrose [9] effectively argues that the quest to put underutilised resources to use provides a critical source of motivation for firms (which can also be applied to cities). The other side of the argument is that underutilised resources present challenges for city management in finding ways to put to them to use. According to Penrose ([10], p. 76), underutilised resources present cities with "a challenge to innovate" and an "incentive to expand". "Underutilised resources entail costs" to cities, because they are resources that "are not producing the full value they are capable of" ([11], p. 17). Therefore, city managers often find themselves "under pressure to conceive of new approaches, processes and activities that are capable of more effectively extracting value from underutilised resources" ([11], p. 18). Thinking from the theory of the growth of the firm to the growth of the city, it becomes clearer that cities with abundant renewable energy resources may hold a competitive advantage in a global economy with increasing resource-use complexities. Cities with abundant renewable energy resources can support low-cost, efficient and high-return energy initiatives that promote job growth, and that reduce the cost of infrastructure maintenance. These insights have implications for UK cities, post-Brexit.

2.2. Framing Energy Governance in the Context of the UK, Post-Brexit

The prospect of leaving the EU presents both challenges and opportunities for UK energy governance—and specifically the utilisation of renewable energy resources. One of the most significant short-term challenges will be in maintaining resilience and balance of supply across a domestic energy grid that has benefitted from being part of the EU Internal Energy Market (IEM) that has reduced the friction of energy flow between member states. Interconnectors to the IEM provided the UK with 4.2% of its electricity and 36.8% of gas in 2017 [12], and one commercial source has summarised the current importance of the IEM as follows:

> "Renewable energy accounts for almost a quarter of the UK's electricity generation in 2015, however due to the fluctuating output the benefit of interconnectivity with the EU increases the more renewable energy production the UK has. The UK is able to sell energy electricity at times where production outpaces demand and buy energy when demand outpaces production". ([13], p. 3)

Although interim arrangements may be put in place to maintain access to the IEM in the immediate aftermath of Brexit, longer term access looks uncertain, with the Lords EU Environment and energy sub-committee recently concluding that 'is unlikely to be possible if the Government pursues its policy of leaving the Single Market and the jurisdiction of the Court of Justice of the European Union' [14]. Although the UK would remain able to trade in energy with EU states through the interconnectors after a withdrawal from the IEM, it would be on less favourable terms, and with a possibility of tariffs that would increase the cost of energy imports [13]. The Lords committee concluded that 'Post-Brexit, the UK may be more vulnerable to supply shortages in the event of extreme weather or unplanned generation outages' [14]. We believe, therefore, that the potential decrease in energy security and the prospect of increasing imported energy costs contribute to a case for greater self-sufficiency in UK energy production, within which local renewable energy production—as illustrated later in the three German case studies—can play an important role.

There are also opportunities for devolutionary practices to play an enhanced role in the production of renewable energy in the UK. A number of state functions have undergone a process of 'rescaling' over the past two decades. The process began as a high-level programme of democratic outreach and renewal through the devolution of some political powers and responsibilities to new assemblies for Wales, Scotland and Northern Ireland, formed under legislation enacted in 1998, which provides significant powers for the planning of energy schemes [15,16]. A similar move to devolve power to English regional assemblies largely failed after a referendum in the northeast of England in 2004, and only the Greater London Assembly survives from this attempt to introduce English regionalism [17].

More recently, however, the rescaling of planning resumed in England under the Localism Act, 2011, which has given local communities responsibilities and powers for neighbourhood planning [17], and the process has continued with the introduction of regional mayors with powers similar to London's, and the devolution of cross-sectorial government funds through 'city deal' arrangements [18]. In addition, central government has enhanced its support for local energy production, with the publication of a community energy strategy in 2015, community energy funds, and a commitment to feed-in tariffs for small-scale low-carbon energy producers [19]. In summary, therefore, it would appear that many of the administrative and policy arrangements are already in place, should the UK wish to embark on the further devolution of energy production at the local scale.

The next section therefore presents the methods and materials that are used to analyse the cases of three German cities, to convey the increasing role that renewable energy plays within urban environments, and the nature of changing resource-use and management. Experiences drawn from these cities enable this study to draw lessons of policy relevance to other cities, especially those in the UK, helping them to take bold action towards tapping into underutilised renewable energy resources that have currently been neglected.

3. Materials and Methods

The study presented in this article draws upon inter-disciplinary foundations in its exploration of the German Energiewende (energy transition), and its broader links to the areas of energy policy and sustainable resource-use. The themes and concepts used in this article include sustainable energy transitions (SETs), Germany's Energiewende, Brexit energy policy, renewable energy systems, distributed generation, polycentric/adaptive governance, underutilised urban resources and common pool resources. These themes were used to query and select literature, using the Web of Science Citation Index. Furthermore, the literature search was categorised, focusing on the foundations of the Energiewende, its core drivers, and the application in German cities. A content analysis and synthesis of selected literature helped to identify experiences on the Energiewende in Germany.

Six interviews were conducted in Germany (during to the months of June and July 2017). Out of the six interviews, two were conducted per case study area. The interviews were necessary to ensure that the data derived from literature (especially from grey publications of the City Councils of Berlin, Freiburg and Munich) were valid. The interviewees (or respondents) were purposively selected, based

on their having in-depth knowledge of resource governance affairs in the cities (especially in urban planning, energy policymaking and implementation). The interviews were discursive, and lasted between 40–60 min per interview. All interviews were conducted in the English language, and all respondents preferred anonymity. The analysis of the interview data followed an interpretational approach; hence, it was neither necessary nor important to directly quote respondents.

Another core element of the research process was focused on reviewing the Energiewende as a policy system, and thus its implications for post-Brexit UK energy and resource-use policy. Researching the background of the Energiewende led to a focus on two specific drivers with parallels for the UK: the role of constitutional arrangements for local decision-making, alongside spatial planning and territorial development. The case studies of Munich, Berlin and Freiburg were purposively chosen, as they represent some of the divergence in approach to the Energiewende within the urban environment in Germany. All of these cities have had extensive debates over sustainable resource-use and energy policy. While not representative of all experiences, especially not reflective of either former East Germany, nor current north–south regional divides, what these case studies do show is that even within a single project or vision like the Energiewende, outcomes can vary significantly, depending on a variety of factors. Geography was not a critical factor in choosing case studies, but it should be noted that both Munich and Freiburg are in the wealthier south of Germany. All case studies have had good exposure, allowing for the robust analysis of respective energy policies and resource-use policy discourses.

In order to analyse the case studies, and to draw out wider elements for discussion, the Advocacy Coalition Framework (ACF) was deployed to examine (and explain) critical features, similarities, and differences between the approaches of Munich, Berlin and Freiburg. A core premise of the ACF is that "policymaking in a policy sub-system, which is a policy area that is geographically bounded and encompasses policy participants from all levels of government and multiple interest groups ([20], p. 124) (see Figure 1). The use of ACF in this study helped to understand and explain the policy issues that are involved in the energy transitions in the context of Munich, Berlin and Freiburg. The ACF was initially developed in 1988 [21], and then revised afterwards [22–24]. The approach of this study was to frame interview questions to probe key aspects of energy as underutilised resources in cities.

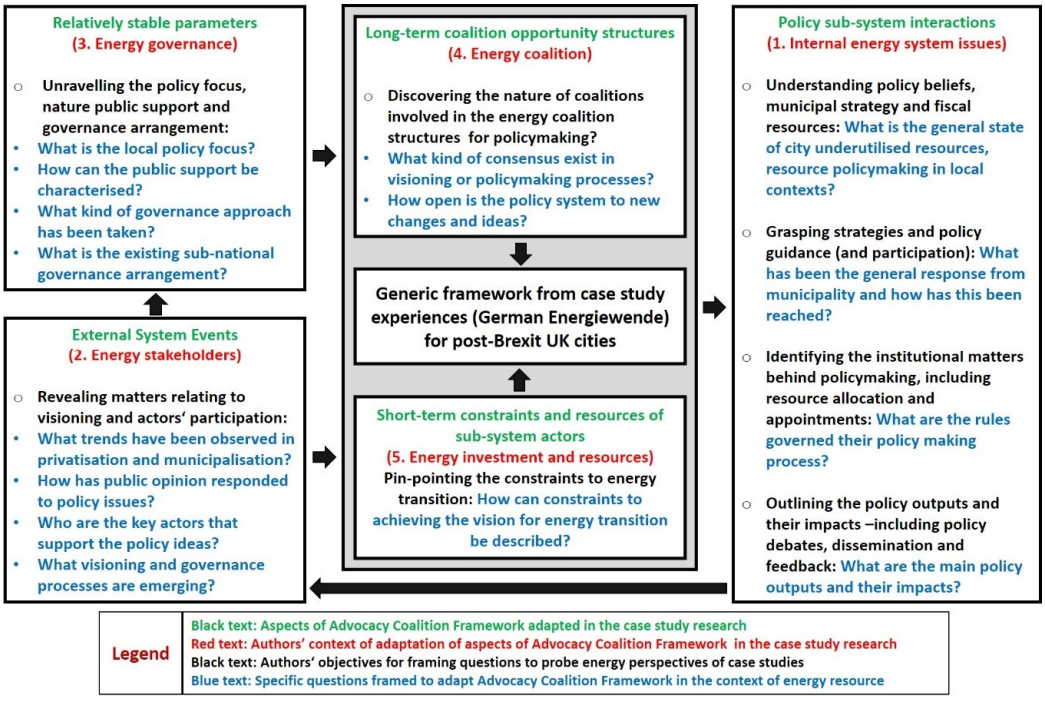

Figure 1. The Advocacy Coalition Framework (ACF) applied to the governance of renewable energy resources (author's own work).

Following the ACF policy-system approach, five aspects of tackling renewable energy (as underutilised resources) were investigated towards deriving lessons for UK cities post-Brexit. In this regard, five aspects of energy policy issues were investigated in the case studies (Figure 1). They include (1) policy system interactions, referring to governance arrangements, (2) external system events, referring to core agreements, (3) relatively stable parameters such as the role of municipalities, (4) long-term coalition opportunity structures, and (5) short-term resource constraints. Thus, this approach showcases mechanisms behind decision-making that is absent elsewhere. Germany's Energiewende therefore can be viewed as an evolving policy approach that is seen through multiple lenses, but also framed through stakeholder interactions. A major limitation to the use of ACF is that it can be difficult to apply, and it can be very time consuming when adapted by using data from questionnaires. To avoid this limitation, this study only conducted a "quick qualitative ACF-style analysis of subsystem policies" of city-level energy resources as prescribed by Weible and Sabatier ([20], p. 132). The results from the ACF analysis are presented in the next section.

4. Results

4.1. Background and Foundations of the Energiewende

In its current form the 'Energiewende' (literally meaning energy transition) refers to the ongoing German energy experiment aimed at creating SETs by (radically and) increasingly opting for renewable energy sources and systems, and opting out of non-sustainable energy resource-use. The term emerged out of the seminal German work by Krause et al. [25], entitled "Energiewende: Growth and Prosperity without Oil and Uranium" in the context of the growing awareness of the environmental costs of fossil fuel usage through the environmental movement in what was then West Germany [25,26]. Germany's energy policy is also as much strategic as environmental [27]. As an importer of fossil fuels, and dependent on foreign oil exports, the Energiewende has also been about Germany gaining control over its own energy policy and reducing import dependence and the insecurity that this has implied. Between 1990 and 2008, Germany reduced its greenhouse gas (GHG) emissions by 26.5%, which exceeded the 21% commitment made by Helmet Kohl under the Kyoto Protocol in the 1990s [26,27].

Although the German energy approach has gained much attention since the 2011 decision to phase out the use of nuclear energy in the wake of the Fukushima disaster, it has a much longer trajectory since it was first institutionalised in the 1980s [26]. It has several strategic objectives to be achieved by 2050: to reduce primary energy use by 50% (compared to 2008 levels), to reduce GHG emissions by 80% (compared to 1990 levels), and to increase the national share of renewables to 60%, while also increasing the share of renewably generated electricity in overall electricity consumption to at least 80%. Therefore, in many ways, the Energiewende has been seen as critical to enforcing the narratives of Germany improving its environmental sustainability, as well as reducing its dependence on fossil fuels in recent decades. Schiermeier's [28] summary of the Energiewende reveals the strong will of the German Federal Government to pursue this agenda, with high levels of research and technical investment occurring, alongside rising cost-burdens on German taxpayers.

Despite this recent background, the ideas that have fed into and sustained the Energiewende have a much longer history. In the 1970s, when Meadows et al.'s [29] work, Limits to Growth, first postulated that the Earth's finite resources were being used unsustainably, questions emerged regarding how to address the complex interlinkages between cities and resource-use. The aftermath of the oil crisis that affected major western economies during that decade had a lasting impact across Europe in highlighting the fragility of non-renewable energy systems [30,31]. Ikenberry [32] points out that in Germany, this was the foundation that spurred municipalities to rethink how energy resources were embedded into the built environment. There have been two main drivers that have helped to ferment this change: constitutional arrangements that favour state-level decision-making, and Germany's spatial planning system.

By the late 20th century, it was clear that the socio-economic and physical infrastructures that had emerged with the industrial revolution (1852–1883) had been cemented in the highly centralised modes of energy production and distribution, segregating consumers from large energy companies [33–35]. As European cities recovered from the Second World War (1939–1945), they were forced to confront new realities, including the rise of increasingly carbon-dependent urban environments. For Germany, the development of the environmental movement coincided with the debate over re-unification, especially in the 1980s and 1990s. In recent decades, the Energiewende has been gathering pace, especially since the EU's Renewable Energy Directive 2009, in the face of environmental, socio-economic and political discourses that have struggled to consider how to deal with the confluence of challenges facing society, especially the increasingly dominant influence of human activity on both the modern climate and the environment.

Theoretical discussions on the Energiewende can also be seen as part of a wider discourse on how to approach modern environmental issues that are connected to resource-use policy. As Dryzek [36] notes, at the centre of discussions on sustainable urban futures have been questions of how far society should depart from pathways of industrialism, and whether or not societal change is needed away from economic growth and materialism. Yet, as Pellow and Brehm's [37] survey of environmental sociology points out—depending on the characterisation of the relationship between the built and natural environment—differing attention has been placed on various aspects of modern environmental challenges. For Lewis and Maslin [34], in discussing the emergence of the Anthropocene, by the post-war era the exponential rise of modern energy resources, including nuclear power—had irreversibly impacted in transforming the relationship between the natural and built environment. As Unruh [38] notes, this has created what can be termed 'carbon lock-in', which can be described as the socio-technical fix, through which centralised energy generation systems are perpetuated by the co-evolution of governing institutions, technical expertise, modes of thought and technological infrastructure. Breaking this 'carbon lock-in' has been fundamental to the Energiewende in shifting both renewable energy production and consumption within German cities.

4.2. Core Drivers of the Energiewende in the Urban Environment: Constitutional Arrangements and Spatial Planning

In the context of Germany in the late 20th and early 21st centuries, the Energiewende has involved a continually evolving approach to energy policy and governance. Among the various drivers of policy commitments and transformations, it has been framed by multi-scalar discourses on local–regional and national decision-making, which have been essential to promoting responsible decentralised governance. The federal nature of decision-making in Germany allows for different decision-making configurations at the local scale, putting more focus on Länder (state) and municipal strategies. Alongside this, the growth of territorial development and spatial planning approaches in Germany has also framed contextual discourses. Questions over the feasibility and success of the Energiewende are thus grounded in both visioning and implementing SETs through the German planning system.

4.2.1. Constitutional Arrangements for the Local Government

Firstly, as a federal republic, Germany's decision-making process reflects the distribution of powers between the federal, regional and local governance scales. As Kommers and Miller [39] note, German re-unification in 1989 led to the introduction of an approach to constitutional jurisprudence and governance that reflects attempts to deal with stark regional divisions between east and west that emerged as the result of partition. As a result, under German 'Basic Law' (the constitution), the balance of power between the Länder (state) and the federal government is of critical importance, and frames the outcomes of decentralisation. The German Federal Government is elected through the Bundestag (German Parliament), while the 16 Länder elect the Bundesrat (regional parliament). In the German context, the arrangement of sub-national structures also frames issues of sovereignty, identity and political control.

These ideas are fundamental to understanding the organisation of the Energiewende and its conception of distributed energy generation as a socio-technical system that is linked to German federalism. Focusing textually on the German Basic Law, the concept of German federalism first emerges in Article 20 (sections 1 to 4), which sets out five main principles of Germany's social democracy, with the idea of 'self-government' being critical to building engagement and bottom-up governance processes. Article 28 (sections 1 to 2) gives the Länder a clear constitutional position, with Article 28(2) stating:

> 'The municipalities shall be guaranteed the right to manage all affairs of the local community on their own responsibility within the limits of the law [. . .] The guarantee of self-government includes the basis for financial autonomy'. [40]

This structures the relationship between the Länder and the federal government, where through 'indirect public administration', local governments have the power to legislate on issues in a polycentric manner. This does not mean the Länder can disregard central government, with Article 28(1) embedding the theme of the 'federal loyalty' of each state. In addition, the Länder's role is also important administratively, with Article 30 providing the constitutional basis for local legislation without the federal government, which is predicated upon Articles 20(1) and 28(2). The core distinction between the competencies of the Länder and the federal government can be seen in Article 70(1), which states that the Länder has the right to legislate, unless Federation legislation is put into place. Article 70(2) further notes provisions on 'exclusive and concurrent' legislation, as seen in Articles 71 and 72, which govern the Länder and the Federation. Exclusive legislation refers to areas that the Federal government has full control over, and under Article 71, the Länder's competencies in these areas depend on "the extent they are explicitly empowered by federal law". By contrast, Articles 72(1), referring to 'concurrent' legislation as governed by federal law, and notes "[. . .] the Länder shall have the right to legislate as long as, and to the extent that the Federation does not exercise its legislative power". Yet, Article 72(2), mandating federal discretion, states:

> 'The Federation shall have the right to legislate where and in so far as the establishment of uniform living conditions throughout the territory of the Federation or the maintenance of legal and economic unity calls for federation legislation in the interest of the country as a whole'. [40]

Article 72(2) therefore mandates the Federal government to pursue interventions, and as a social state, the conception of "uniform living conditions" does not simply refer to minimum standards, but also to extensive funding. As Article 75 on areas of federal framework legislation highlights, the federal government has a clear role in structuring the direction of policy approaches, which in relation to Article 30, it is up to the Länder to enforce principles, as further seen in Article 83. As Article 84 stipulates, the federal government does have the power to issue rules. While both the Länder and the Federation have different roles, as seen in all the aforementioned articles, they are interdependent. While the Länder's function is in specific areas and implementation of policy, the federal government has greater general competency, although this is not a straightforward hierarchy, but rather, it can be seen as a strategic differentiation of policy approaches. This is illustrated by Article 76(1), which states that legislation may be either introduced in the Bundestag or the Bundesrat, with Article 77(1) stipulating conditions for the passage of laws. Overall, this provides a background to the provisions of the Basic Law for the processes of decentralised decision-making that are vital to framing of German energy governance.

4.2.2. Spatial Planning and Territorial Development

While these constitutional arrangements highlight a core focus on decentralised policy-making, Germany's planning context is important, as it frames innovation practices for the Energiewende. Germany operates a spatial planning system, with the core objectives being to promote sustainability

and equivalence, and strengthen the Länder. According to the Federal Office for Building and Regional Planning (FOBR) [41], the German approach to planning revolves around the interaction between different land uses: residential, employment-related and infrastructure, as defined through spatial and land-use configurations. Drawing on constitutional principles, which have helped to define the socio-legal relationship between the Länder and the German Federal Government, planning is mainly seen through the lens of German regionalism, although it is also affected through national, municipal and local scales.

Since reunification, Germany's planning system has been vital to the implementation of federal policy, and it has revolved around creating spatial manifestations of development. As Albrechts et al. [42] note, in exploring strategic spatial planning and regional governance in Europe, integration has helped to produce a 'rescaling' of planning agendas, with a greater focus on the state level, strengthening the role of the Länder in German spatial planning approaches. Drawing on a rich planning history that extends back to the early 20th century, southern German states, including Bavaria and Baden-Württemberg, have taken the lead in promoting innovation [43,44]. At the European level, German spatial planning approaches have also had critical impacts on the process of developing the common European Spatial Development Perspective (ESDP), aimed at creating a successful common framework for European planning [45]. As Dühr et al. [46] note, this understanding of multi-scalar processes within German planning frames the possibility of rescaling and transplanting different approaches.

The linkages between Germany's planning system and the Energiewende are extensive. As Lösch and Schneider [47] argue, a key element of Germany's approach is its focus on the socio-technical nature of energy systems. Controversially, this 'energy gamble' has focused on energy transitions being as much about users as about technology. According to Jacobsson and Lauber's [48] assessment, another critical theme has been a strong legislative and economic agenda. The creation of the Feed-In Tariff systems, political networks extending both within government and into the business sector, as well as a strong governance focus post-reunification, has fuelled the Energiewende thus far in promoting innovation. Further, as Becker et al. [49] argue, the changing nature of urban governance in German cities has been critical. The concept of 'Kommunalwirtschaft' (municipal economy) has been around since the 1980s, and it frames the 'municipal influence' over local affairs, rather than national governance. Gailing and Röhring [50] add that it has also led to an emphasis on 'spatial outcomes', rather than simply abstract concepts.

These planning concepts have connected the Energiewende to a wider focus on political and social legitimacy. As Beveridge and Kern [51] comment, discussions on the Energiewende have ranged from focusing on technological innovation in the wake of the Fukushima nuclear disaster, to debating the influence of the EU on Germany's policy-making process. This is why Burger and Weinmann [52] refer to the Energiewende as 'Germany's decentralised energy revolution', as choices are not made centrally, but rather through social consensus building. Concepts such as 'Stadtwerke' (municipal energy companies) and 'Energiegenossenschaften' (citizens' energy cooperatives) form the foundations for decentralised renewable energy systems, with features of political and social dynamism resulting from bottom-up actions alongside German federal goals [53]. This reveals how both planning approaches and constitutional arrangements have been critical to the formulation of the Energiewende.

4.3. From Policy to Practice: Three Selected German Cases of City Strategies

Although theoretically the Energiewende is a policy system that has been developed at the national level, the three case studies—Munich, Berlin and Freiburg—show how different municipalities and other actors at the local level have informed divergent approaches to energy policy. Moving from policy to practice therefore reveals how both planning systems and constitutional arrangements have advantaged forms of energy resource-use policy that are dependent on institutionalising policy-making processes. Below are summaries of each of the different cases and how they emerged.

4.3.1. Munich: The Solar Energy Revolution

Munich is one of most well-known cases that are associated with the Energiewende approach setting itself the goal of producing 100% renewable energy by 2025. According to Zimmerman et al. [54] Munich's energy journey has had four main periods of development: the first was in the 1980s, when it established an Energy Commission consisting of a range of local stakeholder institutions providing local knowledge, and helping to enshrine the principles of decentralised task allocation and network building at the local level. From 1989 to 1998, the Förderprogramm Energieeinsparung (Energy Conservation Support Programme) regularly monitored CO_2 emissions, and reported to the City Council through the Local Agenda 21 process.

Between 1998 up until 2008, there was a process of strategic urban development, leading to the Perspektive München (PM) concept [55]. This started the shift in energy thinking in Munich, and was based on a constant development review process to build robust institutional adaptability to deal with energy and planning issues. The final period started in 2008, when Munich aimed to supply all municipal facilities and private households with 100% renewable energy by 2025. This resulted in the Integrated Action Program on Climate Protection (IHKM) which embedded climate change and energy policies within local governance structures. Since then, as Hall et al. [56] note, the 2011 decision to phase out nuclear energy has meant that local municipalities have had to play a leading role in securing sufficient capacity to protect against the adverse effects of problematic short-term energy market changes.

According to Bulkeley and Kern [57] Munich has done much in terms of innovation and governance: using the energy commission as a springboard for discussions, including the Solarstadt München (Solar City Munich). These institutional frameworks for local administration, companies and citizens are critical to developing policy ideas, and also for exchanging knowledge and experience across sectors in-order to implement innovative energy concepts. Further, Jurca ([27], p. 175) notes that, "Munich already produces 47% of its electricity needs from renewable sources, which is sufficient to provide electricity to its 800,000 households, the subway, and the tram system". Yet, questions still exist about the shift to a decentralised, small-scale, on-site production of renewable energy, which can only be seen in certain types of renewables, due to the current focus on expanding national and European power grids to ensure the security of supply in larger cities.

Munich's approach is based on the Stadtwerke München (state utility company), which owns and operates various forms of renewable energy plants: hydropower, biogas power and geothermal plants, wind turbines and photovoltaic installations, which are evidence of the qualities of resilience and adaptability. Byrne et al. [58] while focusing on Munich's solar city strategy (and the integration of market, finance, and policy factors for photovoltaic development) argue that in comparison to other cases in Europe, Munich and Germany have a more fundamentally reformed system to support renewable energy development, and are now in the 'market penetration' phase of renewable energy deployment, and are fast becoming competitive. Thus, this approach shows how the Energiewende possibly could be achieved.

4.3.2. Berlin: Re-Unification and Energy in the City

Berlin's energy approach has been markedly different from other cities, due to its unique history, which has presented its own challenges. Unlike other examples within Germany, Berlin is both a city as well as Länder, and thus its powers extend beyond most municipalities [59]. According to Blanchet [60], exploring the struggle over the energy transition in Berlin, the agenda of 'remunicipalisation' of energy networks and creation of municipal utility companies, seen as a prerequisite to enable local energy transition, has been a political sticking point. Beyond the rhetoric of energy-related issues, criticism has been aimed at the Berlin Senate for the lack of development of renewable energy policies, as Berlin's electricity is mainly produced by using fossil fuels.

Diekmann et al. [61] also notes that Berlin ranked last for the development of renewable energies Germany-wide, according to the German Institute for Economics, due to its lack of free rural space to

develop sites for renewable energy, and the lack of political support for renewable energy investment. Despite the Energiekonzept 2020, the Berlin senate has been lagging behind other states, although as Morlet and Keirstead [59] note, and due to the significant energy demand in Berlin, there is much potential for transformation if the Energiewende approach is successfully implemented. Berlin's situation means that 'combined heat and power' (CHP) electricity production is a much-discussed option, especially due to the government's goal of doubling the current electricity production by 2020. This level of municipal investment in renewable energy sources could be part of its socio-technical shift towards distributed generation.

Questions of governance are also pertinent in the case of Berlin. Monstadt [62], focusing on the transition of Berlin's energy system, notes that until the 1990s, there were close corporative arrangements between the city and regional government, alongside energy infrastructure subsidies. Yet, extensive privatisation, restructuring towards European energy markets and reduced regulation led to shifts away from state-dominance. The assumption in the 1990s was that reunification would result in economic and demographic growth [63]. Conversely, structural changes resulted in a 58% loss in the industrial workforce while reduced federal subsidies resulted in a decline in public revenue. Privatisation was seen as the solution with the state energy and gas companies, Bewag and GASAG, becoming international energy consortiums in 1997 and 1998, respectively. Although contractually bound by promises related to investment, public service provision and environmental protection, these were only partially fulfilled [64]. Consequentially, there has been a continued debate over the role of the state government.

As Becker et al. [49] note, situations in Berlin have been fast changing. Campaigning by the Berliner Energietisch (Berlin Energy Roundtable) and BürgerEnergie Berlin (Citizens' Energy Berlin) to establish remunicipalisation of the electricity grid led to a petition of over 220,000 signatures, forcing a referendum on the issue in 2013. Despite its failure, falling 21,000 votes short of reaching the required minimum of 625,000 votes, it was a moral victory, with 83% voting in favour of remunicipalisation [65]. Still as Cumbers [66] argues, there is no consensus over what remunicipalisation means, with some focusing on ownership, finance or energy security, though energy transition is clearly on the agenda. As a result, Berlin's energy experiment through the Energiewende has been at a standstill.

4.3.3. Freiburg: Creating SETs through an Eco-City

As with other cities in Germany at the end of the Second War World in Freiburg, in southwest Germany, planning was geared towards remaking cities that were destroyed by the war. However, unlike other examples, Freiburg rejected modernist trajectories of the post-war era [67]. Instead it pioneered the concept of the 'eco-city' or 'Green City', emphasising sustainable urban development principles. As the Lord Mayor, Dieter Salomon, noted: "Freiburg has taken a leadership role in this area that has garnered it international recognition. The city is globally seen as an example of ecological politics and urban development" ([68], p. 965). As Rohracher and Späth [69] note, looking retrospectively at the development of Freiburg, the city's energy agenda started to develop in the mid-1970s, with growing opposition to nuclear and coal as unsustainable energy resources, which since the 1980s, helped to build momentum for local energy transitions.

In 1986, Freiburg City Council created its own 'energy supply concept': prioritising and increasing its share of renewable energy, alongside commitments to eliminate nuclear energy. This led to the creation of district 'combined heat and power' (CHP) systems [70]. Späth [71] also notes that as the city has grown, regulatory standards have meant greater efficiency, and a reduced energy consumption level per household. Rohracher and Späth [69] also comment on renewable investment in Freiburg, noting that notwithstanding strong local support, resistance from provincial authorities has meant that investment has been largely based on residents' private financing, which has helped to realise the potential of local solar and wind alongside other renewable forms, ultimately making it a leading German eco-city.

Kronsell [68] argues that the notion of 'citizen's control' and engagement has been pivotal to Freiburg's energy transition. Unlike most cities, Freiburg has worked hard to create engagement with its residential population, and to facilitate legitimacy. This has two elements: procedural or input legitimacy, and outcome or output legitimacy [72]. Arguably Freiburg's approach has been successful because it both engages local citizens in urban processes alongside practices of decision-making, most notably in relation to energy policy, and then works to deliver on these promises rather than make promises that cannot be kept. Joss [73] realises this in analysing the drivers of the eco-city concept, where understanding environmental challenges, dealing with socio-economic pressures, facilitating business development, creating cultural branding, embedding political leadership and creating international co-operation has been critical.

Joss et al. [74] also note that a feature of Freiburg's success has been its ability to consolidate and expand its horizons, building a sense of ambition, even though narratives and objectives may change. Hamiduddin [75], focusing on neighbourhood-planning strategies in Freiburg, adds that concepts such as 'sustainability of community' and 'social equity' have enhanced the way in which the socio-technical experiment has been conducted in the city. This can be extended to energy policy in Freiburg, which stems from grass-roots notions of development practice. In addition, the socio-spatial relationship with demographics in Freiburg is notable, with neighbourhood planning strategies transforming the composition and acceptance of certain agendas, which unlike Berlin, tend to be more progressive, marking Freiburg as a unique example [75].

4.4. A View of the Case Studies through the Lens of the ACF

Using the ACF as a prism through which to view the cases of Munich, Berlin and Freiburg reveals similarities and differences. While all these cases occurred in the same national policy context, their approaches have been radically and differently shaped by differing local debates, political priorities and approaches to renewable energy resource-use policy. In addition, the coalitions that have supported sustainable energy resource-use policy and the constraints facing local policy systems are quite varied. These findings of this analysis are presented below (see Table 1).

Overall, this ACF analysis shows that while Berlin has taken a more detached approach to energy resource-use policies, Freiburg has worked hard to a more bottom-up approach based to local conceptions of the 'eco-city'. Munich's approach has involved local government as a critical intermediary in facilitating the policy agenda. Thus, together, these examples frame the following discussion on lessons from the Energiewende in relation to the UK post-Brexit.

Table 1. A view of the case studies, Munich, Berlin and Freiburg, through the lens of the Advocacy Coalition Framework (author's own work).

Case Study	Munich, Bavaria	Berlin	Freiburg, Baden-Württemberg
Policy sub-system interaction	Municipal energy company and strategies, but widely consultative since 1980s, current solar city agenda; 2025 vision. Municipal strategy as part of the Bavarian approach—focus on the solar city agenda.	Berlin as its own Länder, and with lots of power to determine policy, but problems of control related to privatisation. Referendum in 2013, but no real policy engagement; pressure on the 2020 energy concept.	Freiburg's policy approaches the result on trial and error emerging from its historic post-war agenda ongoing; focus on 'eco-city concept' and co-evolution of institutional and technical arrangements and coalition building.
External Systems Events	(1) Focus on public-sector ownership since the 1980s, and investment policy. (2) Public opinion in favour of renewables. (3) Solar City Munich approach to governing coalition: technical and other consultancy. (4) General agreement on policy subsystems.	(1) Privatisation of the energy company in the 1990s, and debate on remunicipalisation. (2) Some support, but no general consensus on energy policy and renewable investment. (3) Role of external pressure groups. (4) Impact of the 2013 referendum on choices.	(1) Strong investment and economic strategy, and emphasis on planning agenda. (2) Public opinion strongly in favour of renewable energy systems investment. (3) Partnership between mayor/planners (4) 'Eco-city vision' as a critical element.
Relatively Stable Parameters	(1) City in Southern Germany; renewables produced by state-owned energy company. (2) Strong solar energy power potential. (3) Strong technical and professional community and inter-stakeholder relations. (4) Local municipality within Bavaria.	(1) Most powerful Länder in Germany, and capital, but economic issues; reunification. (2) Lack of space for renewables, need for more integrated/engaged approaches. (3) Strong external groups for renewables. (4) Senate-based governance system.	(1) Strong planning/social involvement framing outcomes of policy approaches. (2) Strong renewable resources potential. (3) Integrated approach to planning outcomes and non-governmental approach. (4) Local municipality in Baden–Württemberg.
Long Term Coalition Opportunity Structures	(1) Professional and government consensus needed for policy shifts to occur overall. (2) Some openness, but government as the main stakeholder in framing outcomes.	(1) Need for political consensus for any change to occur in terms of energy policy. (2) System as closed to outside groups, except for referendums on policy approaches.	(1) Some consensus needed, but based on engagement with public and other actors. (2) Radically open system of decision-making based on constant experimenting.
Short Term Constraints and Resources of subsystem Actors	Possible constraints are municipal arrangements and investment levels, but large resources and ability to implement a vision in the given period. Need for meeting short-term targets and pro-active engagement to achieve outcomes.	Huge constraints with no political leadership or investment. Large social capital but underutilised, no clarity over achieving the 2020 energy vision announced. Questions over energy policy externally, though 2013 referendum a missed opportunity.	Constraints may include complacency and stalling of projects, but limited problems, though further on-going investment in renewables is needed for outcomes. Need for examination of processes and failures to understand decision-making outcomes.

5. Discussion

5.1. Comparing Examples from Germany and the UK

Drawing lessons from the Energiewende for the UK in relation to energy and reosurce-use policy raises several distinct challenges. Renewable energy and resource-use policy and outcomes are often determined by a complex combination of factors that may include the following: (1) local and national institutions, (2) relative natural resource capacity, (3) socio-cultural values, and (4) socio-legal frameworks. For example, institutional factors—such as constitional arrangements, government control, and decentralisation—and external factors that include public opinion, can affect and influence outcomes. In comparing and contrasting the approaches of Germany and the UK, the main question(s) raised relate to how to assess differences between the two countries and furthermore, how applicable lessons from Germany might be for the UK. To address these concerns, the ACF approach helped to present five emergant themes from the case studies of Munich, Freiburg and Berlin, that were of relevence to the UK. First, shifts from 'government' to 'governance' highlights how multi-scalar, multi-stakeholder approaches are increasingly critical for policy-making, with the results of greater policy decentralisation. Second, the case studies highlight the need to break 'carbon lock-in' and tensions that are raised by current approaches. Third, renewable energy innovation is an underutilised resource in relation to energy transitions. Fourth, this means the fostering sustainable outcomes, depends on creating new governance arragments for managing renewable energy resources. Finally, there is also need for shifts from policy to practice.

The example of the Energiewende reveals critical challenges for UK cities, post-Brexit. As Wolsink [76–78] and Wüstenhagen et al. [79] both discuss, creating sustainable energy resource-use policies involves dealing with issues of innovation, governance, socio-legal frameworks, economic policy-making, public and professional engagement and technical knowledge. Balancing different stakeholders and perspectives especially across scales and sectors requires paying attention to different aspects of energy and resource-use debates. While initally facilitating energy transitions may seem primarily about the physical adoption and implementation of renewable energy technologies to replace fossil fuels, it is also about socio-technical frameworks, through which transitions are developed. In the context of Brexit, general ideas emerging from the analysis of Germany's Energiewende are critical. Biesbroek et al.'s [80] analysis of different National Adaption Strategies (NASs) in Europe highlights fundamental differences between the scope and development of British and German approaches to energy policy.

Although broadly similar, the UK's Climate Change Act 2008, which introduced a national energy policy approach, is much less comprehensive than Germany's Energiewende [80,81]. Among critical areas that it ignores, is energy infrastructure, which has been vital in Germany's case. Lockwood's [82] prognosis is that although the UK's Climate Change Act 2008 failed to deliver sustainable and innovative energy policy, it may be vital to cities, post-Brexit. However, it has managed to enshrine in UK law post-Brexit critical environmental targets [83]. The emergence of devolution has also helped to reshape UK attitudes towards governance [84]. While in Germany, reunification and regional development discourses have focused on municipalities and the Länder [49], in the UK, the devolved administrations of Scotland, Wales and Northern Ireland, and local authorities in England continue to play a critical part in dealing with energy policy concerns. This has been despite the decision of the then-UK government in 2010 to abolished regional planning, leaving a vacuum between national-level planning, local authorities and devolution administrations as part of the austerity agenda, changing the resources that were available to deliver on th ewider aims of the UK planning system [85,86].

5.1.1. The Shift from Government to Governance

Analysis of the Energiewende highlights the impact of the shift from 'government' to 'governance', in relation to renewable energy and sustainable resource-use policy-making processes. While in the mid- to late 20th century, it was common to simply refer to government interventions, by the late 1990s,

all three case studies reveal how complex networks of actors have had to work together to achieve (or not achieve) their respective visions [17]. In Germany, this movement towards governance was fostered by both constitutional arrangements and planning systems—which yielded greater control at the municipal level, and allowed for the fostering of dialogue between different actors with a variety of perspectives. This is clear in both Munich and Freiburg, where respective local governments could be seen as stakeholders working in partnership with a variety of other actors to deliver on visions. In the case of Munich, although the role of the municipality has been significant, it is hard to ignore other actors and stakeholders in the development of the solar city vision. In Berlin, the local government has made little progress in achieving sustainable energy resource-use because of its lack of engagement with different perspectives, while in Freiburg, the governance agenda has been more fully embraced, helping embed the eco-city vision into the ethos of the city.

Partially all three case studies reveal the extent to which modes of partnership are needed to deal with energy resources challenges. As Lefèvre [87] notes, shifts from top-down institutionalised processes to bottom-up approaches to decision-making, where policies emerge and develop from the grassroots, are critical to understanding how metropolitan regions in European countries are continuing to deal with complex local challenges. Increasingly, traditional options of either full-state intervention or private management seem not to be able to meet the demands of decentralised governance systems [88,89]. In the case of energy resources, while the state may have a fixed role, i.e., through a state-run energy company, policy shifts can depend on changing public attitudes and opinions. Borrás [90] comments, that this is not simply a German phenomenon, but it can be seen across the EU, as the result of multi-scalar policy-making and different decentralised arrangements across regions. In Germany, constitutional arrangements highlight both pragmatic and aspirational agendas: reunification of East and West in the 1990s, and broader relationships between EU, national and sub-national scales that are critical to framing the Energiewende. Scharpf [91] argues that in the context of the emergence of the EU through the Common Market and West Germany pre-reunification, the framing of the new European experiment in-terms of governance was extremely similar to West Germany: both started with a sense of 'Politikverflechtung' (joint decision making) towards respective visions of integration.

Despite this, the shift from government to governance also makes it clear that a change in governing attitudes towards energy and resource-use policy is needed. As Rydin [92] notes, the Foucauldian conception of 'governmentality' is vital, since in order to achieve sustainable outcomes, and better utilise energy resources policy agendas need institutionalisation. De Roo and Porter [93] argue that the result of shifts from government to governance has been the rise of 'fuzzy planning', where the various boundaries between different types of decision-making process become unclear. Clearing this 'fuzziness' requires actors at various scales to interact and build not only top-down or bottom-up management systems, but also to engage in meaningful debate over policy—as is seen in the cases of Berlin, Munich and Freiburg. For the UK, the Energiewende has clear lessons about the importance of city-scale energy governance, especially in the context of devolution. While in Germany reunification and regional development, discourses have focused on the role of municipalities and the Länder [49], so far in the UK, there has only been a focus on devolution to constituent parts of the UK. Post-Brexit, sub-national governance raises the need for stronger discussions about how various local actors, i.e., England's new Metro-Mayors, can transform policy debates [94,95].

5.1.2. Breaking Carbon Lock-In

Further, breaking carbon lock-in was also an emergent theme from the case studies. In the analysis of Wüstenhagen et al. [79], implementing renewable energy systems requires a focus on planning and socio-legal perspectives such as procedural and distributive justice, with implementation, alongside an emphasis on efficiency and cost-effectiveness. This was clearly evidenced by the cases of Munich, Berlin and Freiburg, where the politics of renewable resource-use were driven as much by public opinion, as by public policy. The agenda of grassroots mobilisation has meant that challenging the

embeddedness of fossil fuels within Germany's energy system has become a priority. A critical part of shifts towards breaking carbon lock-in has been both the degree to which emphasis has been placed on the 'openness' of policy-making, as well as the visioning of policy outcomes. For example, in Freiburg, the 'eco-city' vision has been combined with a strong attention to community participation and co-operatives. This has favoured a decentralised municipal approach, steering the agenda, depending on legitimacy. In contrast, Munich shows how greater state control over resources allows for greater ambition, as with the solar city vision, but this risks backlash if developments do not respond to citizen's concerns. This was clear in Berlin, where notwithstanding significant support for remunicipalisation, existing policy agendas were heavily embedded.

Röttgen [96] contends that a key challenge for Germany's energy policy agenda has been balancing technical capability with economic concerns and public participation; for example, in relation to questions surrounding the financial viability of replacing carbon-based energy resource regimes without using nuclear energy sources. As Quitzow et al. [26] notes, the situation has become more difficult since the U-turn on nuclear energy in 2011, with implications for sustainability and acceptability of renewable energy. Beveridge and Kern [51] thinks that it was a 'politics of exceptionalism' that drove the 2011 decision, radically transforming the road map for German energy systems. Gawel et al. [97], writing in the aftermath of the nuclear decision, note the critique of the Energiewende as the 'irrational sonderweg' (special path) where current government expenditure on energy is too high, with consequences for its consumers. Therefore, Joas et al. [98] argues that there is a need to question the objectives driving Germany's energy transition, since with a range of policy motivations, its future may be uncertain [99]. As successive versions of the German Renewable Energy Sources Act (the Erneuerbare-Energien-Gesetz, EEG), first introduced in 2000, and heavily revised in recent years, reveal: the cost of energy and innovation is a major concern in the application and development of the Energiewende [100,101]. Thus, tensions have emerged between community-based models and large corporations involved in energy provision [102], with different approaches taken, depending on the context.

As a result, any discussion about post-Brexit energy and resource-use policy needs to consider the costs of shifting towards renewable resources. As Wolsink [76] notes, the challenge is not simply to produce renewables, but also to build resilience and acceptance, to create sustainable outcomes. Such approaches require a reprioritisation of financial and other resources. Breaking carbon lock-in therefore depends on reconfiguring interconnections between actors, institutions, networks, technology and regional governance, which together formulate the basis of SETs and socio-spatial transformations [103]. Grubler's [1] work highlights that there needs to be a focus on end-users, recognition that historically, rates of change in relation to energy resources have been slow, and that scaling-up new energy systems successfully requires substantial, rapid and systemic adoption of renewable technologies. Several models describe how complex energy transitions can be: the energy ladder, used by Leach [104], which focuses on socio-economic factors affecting energy technology adoption; national historical approaches, seen in Fouquet's [105,106] work, referring specifically to national energy policy trends; and evolutionary economics approaches, which, as van den Bergh et al. [107] emphasise, explore innovation within socio-technical systems in relation to energy policy.

5.1.3. Renewable Energy Innovation as an Underutilised Resource in European Cities

The case studies also show that energy innovation is an underutilised resource within European cities. A critical challenge for Berlin, Munich and Freiburg has been creating radical change and innovation to disrupt the current energy paradigm. While in Berlin, privatisation has effectively locked-out renewable energy innovation, in Munich, much more thought has been given to how socio-technical shifts may occur to achieve the 'solar city' vision. Though, as the case of Freiburg shows, innovation also requires localised community ownership, to help to foster both sustainable investment, and to promote desirable resource-use. Markard et al. [108], reviewing the literature

on energy transitions, identifies four main schools of thought in relation to innovation approaches. Transition Management is focused on creating open-ended management processes; Strategic Niche Management refers specifically to localised innovation that is scaled-up; the Multi-level Perspective revolves around taking holistic approaches to energy transitions; Technological Innovation Systems refers to technological innovation and acceptance processes. Together, these perspectives emphasise an integrated approach to renewable energy resource innovation, recognising complex interconnections between innovation, technology, multi-scalar and multi-stakeholder engagement, and management and policy approaches. Jacobsson and Johnson's [109] analysis of renewable energy technology and its diffusion also reveals how 'prime movers' can facilitate innovative practices, developing networks through which information, knowledge, technology and institutions spread, enabling high connectivity.

As Coenen et al. [110] notes, spatial perspectives are integral to understanding SETs. Socio-spatial frameworks, using multi-level and technological innovation perspectives help to contextualise the co-evolution and variation of socio-technical systems. Fouquet [111] argues that reconciling global targets with local strategies and approaches, where energy demands are increasing despite capacity constraints, is a key challenge. For Goh et al. [112], taking a project management perspective, holistic understandings of economic processes behind current systems are essential to deconstructing them and creating distributed generation. This highlights that in order for SETs to succeed, awareness of how policy processes can improve innovation is critical. Dolata's [113] analytical framework describes the co-evolution of technological and institutional factors via concepts of transformative capacity, sectoral adaptability and policy agendas, collectively revealing modes of sectoral transformation. Without this, the ability to understand how SETs function, and how the underutilised capacity of renewables can be harnessed, is limited. Farla et al.'s [114] argument is that multi-level perspectives can help to analyse complex relationships between actors, resources and strategies. Where actors refers to social movements, policy-makers and firms are embedded in visioning processes; resources are both tangible and intangible, and strategies include targets, standards and regulations.

In relation to UK cities, post-Brexit, more needs to be done to embed innovation into contemporary discussions on renewable energy resources. Beyond targets and objectives, SETs are only possible if there is a significant buy-in to ideas about renewable energy and sustainable resource-use. As Ernst et al. [115] argue, taking advantage of change can create empowerment, radical reform and reconstellation of energy systems, but also risks backlash, collapse or lock-in. Current approaches highlight how governments and the private sector have worked to reduce immediate costs in energy provision, though the effective lack of other actors to undertake innovation has meant that different models of energy distribution have fail to emerge. Only by making innovation part of discussions within investment and business circles, within communities and governments, can change occur. This does not necessarily mean that the role of the government disappears. According to Azevedo et al. [116], there are three main mechanisms through which local governance can facilitate energy policy shifts: tambourines, carrots and sticks. The first are 'soft' awareness-based policies, while the second refers to incentive-based policies and regulations and the third can be taxes and other penalties for non-compliance.

5.1.4. Governance Strategies for Renewable Energy Solutions

Governance strategies at the local level are a critical facet of the shift towards renewable energy resource-use. As Kiser and Ostrom [117] discuss, there are 'three worlds of action' that can be considered in relation to the functioning of policy transformations: constitutional, collective choice and operational. While the first refers to the overall agenda, the second relates to its perception and the third its implementation. The cases of Munich, Berlin and Freiburg all highlight these 'worlds of action' within the Energiewende—and the different approaches taken by cities to governance issues. On one hand, Munich indicates that building strong institutional partnerships across the public–private sector divide requires visioning processes that involve changing public opinion, and creating a governing coalition to embed the use of renewable resources [27]. On the other hand, Freiburg reveals how strong

investment, municipal leadership and radically open approaches that recognise the possibility of failure are important to the growth of renewable resource-based energy systems [67]. Berlin emphasises how the politics of energy governance can influence the implementation of distributed energy [60].

For UK cities, post-Brexit, the challenge remains as to how governance patterns can reorient resource-use away from carbon-based sources to renewables. Though part of the challenge lies in fostering innovation and investment, an equally important aspect is upscaling, referring to processes through which local projects become universalised, thereby mainstreaming and institutionalising renewable energy provision, which are vital to building momentum [118,119]. There are two main types of upscaling: vertical or horizontal, the former occurring through the institutionalisation of policies at higher scales, i.e., regional, national or international, while the latter occurs when projects either grow in spatial scale, or are replicated in copycat initiatives. The result is that decentralised governance arrangements can act as a potential catalyst for transforming energy resource-use. This is clear in Germany, and in examples like Munich and Freiburg, which have taken different approaches in this regard. In UK cities the potential for city-level governance regimes to institutionalise such approaches has been undervalued.

Changing the approach to energy governance is therefore critical for UK cities. As de Vries and Chigbu ([120], p. 69) note, a contemporary normative leitmotiv is the term responsible, which has gained increasing space in land and natural resource management literature, because it highlights the need for a focus on structures, processes and outcomes. Such an approach therefore emphasises shifts from top-down government intervention to integrated governance approaches, which are seen as being essential to understanding the logic embedded within energy governance. For example, 'Regional Innovation Systems' (RIS) perspectives in Germany highlight how multi-scalar, multi-stakeholder processes are integral to policy transformations [121]. Wüstenhagen et al. [79] and Wolsink [76–78] argue that socio-political, community and market acceptance is essential for facilitating and embedding SETs.

Several authors including, Wolsink [77] and Goldthau [122], also argue that renewables need to be considered as 'common pool resources' (CPRs). As Dietz et al. [123] advocate from a CPRs perspective, a polycentric decentralised governance can help to prevent a 'tragedy of the commons', first highlighted in the work of Garrett Hardin [124]. What differentiates 'polycentricity' is its focus on 'robust governance principles': devising common rules, clear boundaries, accountability and conflict resolution mechanisms, sanctions for violations, institutional variety, multi-level approaches and forms of community deliberation. These principles form the basis of an engaged policy approach that allows for sustainable resource-use and management that puts local actors at the forefront of decision-making. Further, Ostrom's [125] general framework on socio-ecological systems focuses on inter-relationships between users, governance systems, resource systems and resource units. These ideas help in considering the governance of renewable energy resources, reframing energy as a local resource to be managed, in contrast to current energy resource-use approaches. Post-Brexit, such approaches could help to increase the local ownership of renewable energy resources, as in the Energiewende [126,127].

5.1.5. From Policy to Practice: Implementing New Renewable Energy Systems

A final theme from the case study analysis of the Energiewende has been the shift from policy-level discussions to practice. In all three cases, different change agents have implemented renewable energy policy in varying ways. For example, in Munich, public sector ownership has helped to operationalise the solar city vision, and to manage the costs that are involved in shifting from carbon-based resource-use to renewable resources. Investment in solar power therefore was built on a tariff system through municipal resources. Valorisation has therefore been easier, since renewable energy resource-use was embedded within local systems. By contrast, Freiburg shows how communities of local residents themselves can be seen as change agents—with co-operative based investment being critical to the realisation of the eco-city vision. Yet, differences in practice were much larger between Munich and Freiburg. While the former vision primarily has been about energy resources, the latter

example has been linked to a wider socio-cultural transformation—which can also be seen in terms of transport and housing investment. The result has been a greater focus on embedding change in resource-use over the long-term, rather than short-term. In contradistinction, Berlin shows the inter-dependence between visions and outcomes. While it was believed that privatisation would solve issues post-reunification, this choice cemented carbon-based resource-use.

A much larger concern is about local ownership and control over the visioning and implementation processes. As Goldthau [122] notes, a tension within the shift from policy to practice in relation to renewable energy has been the highly localised nature of impacts and transformations vis-à-vis national and international agreements on decarbonisation. The consequence of divergence between local and national scales has produced a dichotomous reality, disenfranchising local resident communities that are most affected by the spatial transformation in energy resource use. The highly visible nature of certain types of renewable infrastructure, i.e., solar panels and wind turbines, means that local resident communities notice transformations more acutely. For Wolsink [78], this means that approaches such as procedural and distributive justice—focusing on both the process and outcome of decision-making locally—are vital to building trust. This was seen in all three cases, where bottom-up approaches accounting for public opinion were vital for embedding transformations and building trust between actors. Still, recognising how public opinion is shaped and understood can also be critical to understanding the shift from policy to practice. For example, as Pidgeon et al.'s [128] study of public opinion and risk framing in the UK highlights, perceptions of policy and its consequences can vary, depending on context. While in the abstract, shifts in resource-use have been framed as a solution, public opinion can be fickler when linked to trade-offs with energy costs, lifestyle changes, and societal transformations.

When connected to wider political events such as Brexit, where future uncertainty problematises energy resource-use policy, awareness about aspects in the shift to renewable energy resources is key. For much of the recent past since the late 1980s, European institutions have focused on socio-economic and political convergence. As Jeffery [129] writes, shifts occurring from centralised state-led decision-making towards multi-scalar understandings based on German and Dutch approaches have yielded heavy influences across Europe. In the context of the EU Renewable Energy Directive (2009/28/EC), national approaches to renewable energy policy have emerged, building on decades of common ideals. Post-Brexit, the challenge for the UK includes finding its own language regarding SETs, distinct from that of the European project [130–132]. Brexit may not necessarily lead to a replacement of the current energy approaches, but it does raise questions about how systems can respond to local needs. As Germany's example highlights, legislative and policy agendas alone cannot replace local considerations, which is why ideas like Lefebvre's [133] 'right to the city' (discussed by Harvey) [134] and Soja's [135] conception of 'spatial justice', which deals with wider issues of exclusion and inequality within the urban environment, are critical to further understanding socio-economic, political, and cultural dynamics. Thus, this facilitates a shift from top-down to bottom-up approaches to renewable energy governance.

6. Conclusions and Recommendations for an Integrated Energy Governance Framework, Post-Brexit

Returning to the four main research questions posed in this article, renewable energy is an increasingly critical resource for cities in dealing with modern socio-economic, environmental and political challenges. As seen in this article, reconceptualising renewable energy as an underutilised resource has the potential to add to the functionality, efficiency and sustainability of urban environments, providing UK cities with a 'challenge to innovate' and an 'incentive to expand' renewable resource-use—creating sustainable growth and development. Exploiting renewable energy resources requires a fundamental rethinking of strategies, understandings and approaches towards renewable energy production and distribution across Europe. By reconceptualising the role occupied

by renewable energy in debates about sustainability and efficiency, this article has aimed to redress the imbalances between technical and social perspectives in relation to energy policy.

Taking inspiration from the Energiewende, as an example of a policy system in which renewable resource-use has been promoted, this article reviewed three case studies—Munich, Berlin and Freiburg—to analyse (and explain) the German approach to SETs. The results of this initial study highlighted the role of German constitutional arrangements for local decision-making, and spatial planning in fostering decentralised policy outcomes. Both of these factors, among others, have been vital to the Energiewende's focus on decarbonisation, despite issues of regional disparity. Thus, in-order to embed renewable energy resource-use within cities recognition is needed for wider socio-economic and political systems to which the energy resources are connected. Using Brexit as a starting point, although seemingly unconnected, allowed for a reappraisal of the UK's approach to energy, which since the Climate Change Act 2008 has continued to focus on decarbonisation and sustainable energy resource use.

There are five main lessons for UK post-Brexit, emerging from the discussion of the Energiewende and its approach to SETs, which can be listed as follows:

1. There is need to reconsider the role of governments and the private sector in achieving SETs, recognising decision-making can be non-linear and complex, and depend on power-balance, the nature of policy processes and community engagement.
2. Breaking 'carbon lock-in' requires a clear focus on end-users, policy implementation and outcomes that area aimed at creating longer-term socio-cultural shifts in relation to renewable energy resources as much as physical investment in renewables.
3. Reconceptualising renewables as underutilised resources in cities allows for a focus on modes of sectoral transformation across scales, to reconcile different policy approaches that focus on different aspects on renewable energy resource-use.
4. In-order to govern SETs post-Brexit, a focus on responsible energy governance is needed, building on robust governance principles and multi-scalar, multi-stakeholder processes that are vital to the management of renewable energy resources.
5. To implement SETs, renewable energy resource-use policy needs to account for trade-offs between different policy objectives, but also embed forms of procedural and distributive justice to build trust in policy-making processes.

These policy lessons drawn through the case studies, using the ACF as an analytical framework, highlight the need for a new policy framework that reflects on the peculiarities, tensions and uncertainties that are associated with the shift towards renewable energy resource-use, and evidenced by the case of the Energiewende. As seen in this study—the limitations of using the ACF approach is that it does not distinguish between the different roles of different actors, and the tensions between different scales and modes of policy governance. UK cities have the potential to embed renewable energy usage into their policy-making processes. However, to examine such processes, reflection is needed on the use of resources (both material and immaterial) that until now have been underutilised. The multi-scalar, multi-stakeholder integrated energy governance framework (see Figure 2) is an attempt to think beyond current paradigms and to reconsider the way in which renewable energy resources are seen, in governance terms.

The proposed integrated energy governance framework attempts to synthesise various perspectives, using Kiser and Ostrom's [117] conception of the 'three worlds of action', to distinguish between constitutional, collective choice and operational levels of renewable energy policy. It further makes distinction between resource-use in relation to 'production', with a focus on the supply-side of industries and firms, and 'distribution' focused on the demand and consumption of energy resources within regions, cities and communities. Together, this framework can be deployed to re-evaluate renewable energy resource-use policy, through a coherent and structured approach.

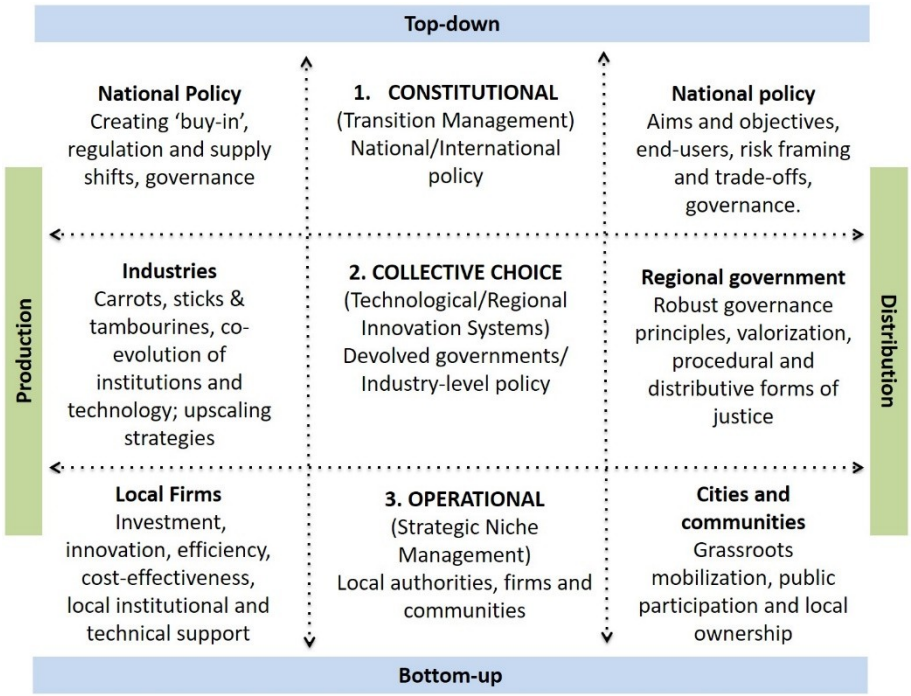

Figure 2. Proposed integrated energy governance framework (author's own work).

To conclude, this approach to renewable energy resource-use policy aims to promote approaches to energy that embrace innovation, responsible governance and inclusive processes, alongside thinking beyond simply technical solutions, to considering the socio-economic impacts of policy decisions. Taking advantage of emerging technical knowledge requires a realignment of political and social priorities, to redress the current disconnection between energy production and consumption—with major consequences in-terms of rising GHG emissions and its environment impacts. Critically, this shows that in cases like the UK, where the potential for transforming energy resource-use exists, undertaking SETs is possible.

Lessons from the Energiewende for post-Brexit UK cities therefore focus not only simply on energy policy, but also on the continuing complexity of regional dynamics, social concerns and economic transformations. Thus, regardless of ultimate outcomes of Brexit, including the event that the UK may decide to remain in the EU rather than leave—that is, a situation of no Brexit—the recommendations of this study may remain relevant for the future, both for the UK within Europe and apart from it. The future of renewable energy resource-use depends on only upon political decisions and their implications, but also on the ability of governance systems to enable SETs, rather than to simply perpetuate 'lock-in' and take advantage of new opportunities that may emerge, harnessing the potential of underutilised resources in cities.

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