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Boundary Bridging Arrangements: A Boundary Work Approach to Local Energy Transitions

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Abstract: Local energy transitions involve various types of actors (e.g., politicians, businesses, public administrators, and citizens) that differ in their objectives, values, problem-related perspectives, and professional jargons: these differences risk deterring the collaboration that is needed to pursue energy transitions as encompassing socio-technological transformations. Based on a boundary work-approach, this contribution studies the interplay of actors in these transitions. The approach suggests that boundary bridging arrangements (e.g., boundary objects, boundary settings, and boundary organizations) evolve in local energy transitions, facilitating communication across the boundaries between the various types of actors. In applying the boundary work approach to the energy transitions in two German cities, the article explores the potentials and limitations of this approach.

Keywords: boundary work; energy transition; cities; collaboration; boundary objects; boundary organizations; governance; low carbon transition; interfaces

1. Introduction

Sustainability transitions are hard to govern. Their social complexity—involving different scales, temporalities, technologies, types of actors and social sectors—ultimately constrains their manageability: given the uncountable number of elements interacting in national transitions, controlling and steering these processes is challenging—if not impossible—and involves extensive uncertainties and surprises [1–4]. Local transitions, by contrast, are regarded as "more manageable than national transitions, given their proximity between actors, networks and place" ([5], p. 201). Based on dense social networks, new forms of governance may evolve in local spaces that draw on self-governed coordination rather than centralized authority, partially alleviating the aforementioned manageability concerns [6,7].

National governments increasingly rely on local action, sometimes by actively identifying the key roles of local authorities and designing policies to boost local action, and other times, more passively by redirecting the question of how to engender the pursued national goals to local authorities [8–11]. This is paralleled by rising activities on the level of cities and towns (cf. [6,12–20]). Here, municipalities, grass-roots movements, and local businesses often act as pioneering actors [7,8,10,21–23]: by encouraging transformations in their territories through experimentation, networking, bundling of interests, social learning, large investments in sustainable technologies, awareness-raising and other techniques, these local actors act as change agents and contribute through their micro-level activities to the national climate and energy goals.

However, governance problems of sustainability transitions do not disappear at the micro-scale of cities and towns. These can materialize, for instance, in the form of competing interests, lack of structures and resources, exclusive elite networks, reluctance of local communities, confusion

over responsibilities as well as problems aligning heterogeneous technological infrastructures and the divergent activities of different sectors and/or geographic entities [7,8,10,13,24,25]. A crucial governance problem concerns the collaboration of local actors from different sectoral backgrounds. Local transitions involve a variety of individual and collective actors such as politicians, entrepreneurs, businesses, researchers, public administrators, citizen activists, and consumers (cf. [6,14,26–30]). These actors are related to social worlds that differ in their overall objectives, incorporate dissimilar values, interpret their environment in a different manner, communicate in distinct professional jargons, and organize their activities along dissimilar structures [31,32]: in the end, the boundaries between the social worlds risk deterring the required collaboration. Frequently, it is assumed that collaboration requires consensus. However, consensus would imply tearing the boundaries between the social worlds down, abolishing their differences by establishing similar norms, jargons, and organizational principles. As this would undermine the functionality of these social worlds, alternative solutions are needed that maintain the differences between them.

This contribution suggests that consensus is not necessary for boundary crossing collaborations in local energy transitions. This raises the question of how collaboration, despite these boundaries, is achieved: how is cooperation possible without consensus in local transitions?

The article addresses this question by proposing a boundary work approach for the study of local energy transitions. Drawing upon research on boundary work in science-politics-interfaces, the approach shows that boundary bridging arrangements facilitate the collaboration of different types of actors [32]: standing in between social worlds, boundary bridging arrangements create common grounds and reference points for actors from different social worlds without requiring their consensus. Examples of such arrangements are boundary objects, boundary settings, and boundary organizations [33–35]. Understanding governance in sustainability transitions not just as an undertaking of political actors but also as a shared task of different social sectors [36], the approach perceives boundary bridging arrangements as governance structures that enable these sectors to exchange knowledge and coordinate their activities.

This article illustrates this framework by applying it to the energy transition processes in two German cities: Bottrop and Emden. Thereby, it explores the strengths and limitations of the boundary work approach for the study of local transitions.

The article is structured as follows: Section 2 portrays the boundary work approach and outlines its potential application to local energy transitions along several working hypotheses. Section 3 describes the methods as well as the national and local contexts of the two case studies while Section 4 illustrates the approach by applying it to the energy transitions in Bottrop and Emden. Section 5 explores the empirical insights from the case studies with regard to the working hypotheses and discusses the strengths and limitations of the approach. The article ends with a conclusion that summarizes the results and outlines potentials for further research.

2. A Boundary Work Approach to Local Energy Transitions

The notion of "boundary work" addresses the creation and transformation of boundaries between different social worlds that are inhabited by specific communities of actors [37–39]. Communities tend to generate boundaries between each other by, for instance, using specific vocabulary, striving for distinct objectives, and cultivating specific values and habits. These boundaries can differ in their character, the mechanisms that reproduce them, and their development over time [40–42].

While the notion of "boundary work" has been employed with varying foci to study different subjects in social sciences, resulting in vast conceptual and empirical disparateness in the literature on boundary work [40,43], in Science and Technology Studies, it has mostly been seen through the lens of efficiently managing boundaries between scientific researchers and policy makers [32]. Here, "boundary work" is mostly interpreted as an active effort of researchers to successfully disseminate knowledge across different social worlds and to inform policy-making through "practices of safeguarding, withdrawing and (re-)negotiating boundaries" ([44], p. 92). The challenge of this sort

of scientific boundary work consists in maintaining the credibility of scientific knowledge by drawing and upholding boundaries between science and other social worlds (cf. [37]), while at the same time facilitating an efficient exchange of knowledge with its social environment:

> "*the need to make boundaries more permeable is held in tension with the need to simultaneously reify boundaries to maintain the legitimacy of social activities within specific realms, most notably science and policy.*" ([32], p. 4198)

The evolution of specific interfaces helps to serve the need to stabilize boundaries while bridging them. As conceptual classifications of boundary work strongly vary between the different approaches and studies, this article introduces a specific terminology and subsequently calls these interfaces "boundary bridging arrangements" (see also [45]). These are defined as social arrangements that facilitate the communication between actors from different social worlds without endangering their boundaries.

There are different types of boundary bridging arrangements: studies on boundary work have determined several, often overlapping, arrangements that facilitate boundary crossing interaction, such as "boundary objects" [35], "boundary concepts", "boundary settings", "standardized packages" [46], "boundary spanners" [47], "boundary infrastructures" [48], and "boundary organizations" [33]. The overarching term boundary bridging arrangements bundles these types.

The following elaborations focus on the most important arrangements for the empirical study in this article: these are "boundary objects", "boundary organizations", and "boundary settings".

Boundary objects bridge the boundaries between different social worlds [35]: being positioned between these worlds, they constitute joint reference points that allow for communication across boundaries ([32], p. 4199). The concept was originally developed by Star and Griesemer [35] in a study about the boundary work at Berkeley's Museum of Vertebrate Zoology. The study shows how boundary objects, such as maps and field notes, enable the cooperation between actors from diverse social worlds (collectors, university administrators, curators, academic researchers, financial sponsors etc.). In order to allow for communication between different social worlds, boundary objects must be abstract enough to have—at least a vague—shared meaning for actors from both social worlds. However, at the same, the boundary objects will assume different and more specified meanings in each of the social worlds:

> "*Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use.*" ([35], p. 393)

Their interpretative flexibility allows for a dynamic switching between their more general boundary crossing meaning and the more thoroughly defined meanings in the specific social worlds [49]. As such, boundary objects are "a sort of arrangement that allow different groups to work together without consensus" ([49], p. 602). Boundary objects can be physical artifacts as well as terms, concepts, and tools. They usually constitute collaborative products of actors from different social worlds who create them in the course of their collaboration [31,35]. However, this does not imply that boundary objects are necessarily the product of purposive efforts to create them: they can be designed on purpose by specific groups of actors and agents (e.g., boundary organizations) with the goal to advance boundary bridging interactions or simply evolve out of recurring interactions between agents from different communities. In both cases, they facilitate collaboration by creating shared reference points with sufficient interpretative flexibility.

A challenge in the use of the concept is its own "interpretative flexibility" which makes it difficult to delineate the conceptual and empirical boundaries of "boundary objects" (cf. [49,50]): many concepts, terms and artifacts can theoretically constitute boundary objects, making it challenging to define what is not a boundary object per se. In the end, whether an "object" serves as a "boundary object" or not

will depend on the way in which actors from different backgrounds employ it. Only when serving a boundary bridging function, can we speak of a boundary object.

Clarifying the characteristics of boundary objects, Star outlines in a review that two of their aspects have often been neglected in the literature: "(1) the material/organizational structure of different types of boundary objects and (2) the question of scale/granularity" ([49], p. 602). Boundary objects vary in their organizational structure and scale. Therefore, this article distinguishes between broad and specified boundary objects. Broad boundary objects are ill-defined, lack an organizational structure, and are of a wide scale, as they draw no clear boundaries in terms of who might participate in their production. Specified boundary objects, by contrast, are more clearly defined, depend upon some sort of organizational structure that implies regularized participation, and are, therefore, more exclusive. This second type of boundary object is usually the outcome of boundary processes in organizationally more complex boundary bridging arrangements such as boundary settings and/or boundary objects. The notion of boundary objects has been applied in manifold ways in research related to sustainability. For instance, Abson et al. [51] assume that ecosystem services constitute a boundary object that brings together various disciplines researching sustainability. Molligna ([34], p. 6) points out that also protocols, frameworks, or research results that have been jointly produced by researchers and policy makers in activities related to sustainability can constitute boundary objects.

Similar to boundary objects, boundary organizations stand in between different social worlds. Guston [33] developed the notion of "boundary organizations" by studying collaborative participation of scientists and non-scientists in technology transfer. It refers to organizations that manage boundaries between social worlds, helping to stabilize their boundaries, while at the same time enabling higher permeability between the involved social worlds. Thereby, these organizations allow for translation, coordination, and joint knowledge production between actors from different social worlds [33,52–54]. Unlike boundary objects, boundary organizations constitute actors that are vested with management capacities to structure boundary bridging knowledge flows. As such, they can exert a high degree of control over boundary bridging knowledge exchanges. Constituting enduring organizational agents, boundary organizations are, at the same time, accountable for their actions towards diverse social worlds. In this regard, they differ from intermediary organizations that represent a specific social world and seek to lobby its interests towards another social world [53]. As they are delegated from different social worlds, boundary organizations, in contrast, have to balance the expectations and worldviews of the involved social worlds. As such, they are accountable towards these worlds which are likely to define dissimilar standards for measuring the success of the given boundary organization. Moreover, boundary organizations can become subject to conflicting demands, causing serious tensions and potentially leading to open conflict (cf. [55]). To prevent conflicts, boundary organizations must carefully balance these differing standards. To this end, they can convene representatives and information from the participating social worlds, involve them in their decision-making processes, and create mixed working teams, commissions, or consultation groups. The participation of different stakeholders facilitates the production of specified boundary objects that create shared reference points between them.

Clark et al. [31] provide a helpful heuristic for describing the main boundary bridging characteristics of boundary organizations. In an empirical study of a boundary organization, they show that the successful boundary work involves three elements: accountability, participation, and boundary objects. Drawing upon these three elements, the boundary bridging of boundary organizations can be described as consisting of: (a) creating durable organizational structures that respond to the needs of different social worlds (accountability); (b) building-up constant relationships by bringing specific actors from different social spheres on a regularized basis together (participation); and (c) creating joint reference points that further facilitate boundary bridging interaction (specified boundary objects).

Boundary organizations are usually designed on purpose to enable and/or assist boundary bridging interactions. Whether such an organization will be created in a given context will depend on the availability of resources to run it and the perceived need for a structured and purposefully governed

knowledge exchange between specific actors from different social worlds (e.g., in the case of complex environmental challenges such as water scarcity; cf. [55]). Its presence will have implications for the given boundary bridging exchanges, as it will centralize and strongly structure them according to the configuration of the given organization (e.g., organizational structures, norms, and fixed meetings).

White and coworkers' [56] study on water management in Phoenix illustrates the creation of boundary objects within a boundary organization. Being confronted with potential water supply shortages in Phoenix, White and coworkers' [56] develop a prescriptive model of a boundary organization (*Decision Center for a Desert City*), which envisages bringing together representatives from the policy sphere (e.g., political officials, and managers from regional water providers) and researchers from different scientific disciplines. This organization involves stakeholder meetings and the joint production of a conceptual model of water supply and demand. As the variables for this model are jointly agreed upon, the model can be used by both communities. Moreover, when working locally with the model, it can be adapted to the needs of each community. For this article, a third form of boundary bridging arrangement is important: boundary settings. Sometimes settings are regarded as the environments in which boundary work takes place (cf. [34], pp. 6–7). As such, they may consist of specific environments, "safe spaces" or "niches", in which actors from different backgrounds can experiment with each other (e.g., field trips of social and natural scientists; see ([31], p. 2)) Drawing upon these insights and seeking to relate boundary settings to the other two types of boundary bridging arrangements, this article defines them as standing in terms of organizational complexity in between boundary objects and boundary organizations. Unlike broad boundary objects, boundary settings are based on an organizational structure that brings specific actors from different social worlds together, drawing boundaries between members and non-members. Operating along temporally more limited structures, they differ from boundary organizations in terms of their temporality and accountability. Rather than forming a constantly operating organization, boundary settings mostly assume their boundary bridging functions in the specific moments in which actors from different backgrounds come together. Due to these characteristics, boundary settings constitute intermediate forms between boundary objects and boundary organizations that are more organizationally complex than boundary objects but less than boundary organizations. Boundary settings can stand for them alone or can be embedded in boundary organizations. Their main boundary bridging characteristics are that they bring actors from different social worlds on a regularized basis together and create shared reference points in the form of specified boundary objects. Regular tables, working groups, or joint projects with actors from different social worlds are examples for such boundary settings. In the course of their meetings, the involved actors are likely to create specified boundary objects that facilitate their interaction. Sharing the basic boundary bridging function, "boundary objects", "boundary organizations", and "boundary settings" belong to the same family of boundary bridging arrangements. Nevertheless, they differ in their individual attributes. These can be classified along: (a) their boundary bridging characteristics; (b) their level of organizational complexity; and (c) their inclusiveness. Table 1 presents an overview over the three types of boundary bridging arrangements and their specific characteristics.

Table 1. Boundary Bridging Arrangement and their attributes.

	Boundary Object	**Boundary Setting**	**Boundary Organization**
Boundary bridging characteristics	Shared reference points with interpretative flexibility	Participation, Shared reference points	Participation, Shared reference points, Accountability
Level of organizational complexity	None or low	Medium	High
Inclusiveness	Broad: inclusive; Specified: exclusive	Exclusive	Exclusive

The three arrangements vary in their boundary bridging characteristics: while they all share the basic characteristic of providing shared reference points for actors from different backgrounds, boundary settings and boundary organizations involve regularized participation in the form of adherence. Adherence secures regular come-togethers and facilitates building relationships between the relevant actors from different social worlds. Finally, boundary organizations differ from the other two arrangements by involving accountability in the form of durable organizational structures that respond to the needs of different social worlds.

Regularized participation has consequences for the inclusiveness of the arrangements: enforcing some type of membership standards, boundary settings and organizations tend to be exclusive groups of actors, drawing boundaries in terms of who participates in the given boundary bridging process.

Boundary bridging arrangements differ in their level of organizational complexity. As such, more intricate boundary bridging arrangements entail less complex ones: boundary settings produce specified boundary objects, whereas boundary organizations create boundary settings (e.g., mixed consultative groups) and specified boundary objects (e.g., shared methods). When being produced in the other two boundary bridging arrangements, boundary objects will be more specified and exclusive, as they are based on the regularized participation in these arrangements.

While the boundary work of science, specifically between science and politics, is relatively well studied, we know less about the boundary strategies that facilitate interactions between other social worlds. In addition, in the context of sustainability, research thus far has been mostly restricted to science-politics-interfaces [31] and ([32], p. 4196). As local energy transition processes involve an array of social worlds (cf. [14,57–59]), this article pursues a broader employment of this notion, exploring boundary processes between politicians, researchers, businesses, municipal administration, and engaged citizens.

The involvement of an extensive array of social worlds creates high demands on the coordination between them. Localities have to find ways of integrating the different social worlds in order to successfully reorganize their energy consumption, production, and supply in a more sustainable way and improve their CO_2 footprint. Therefore, local energy transitions require boundary bridging arrangements: when engaging in these transitions, actors from different social worlds need social arrangements that enable them to coordinate and broker their knowledge across their boundaries.

Though not explicitly employing a boundary work approach, existing research on urban transitions points towards the importance of boundary bridging arrangements by highlighting the role that shared guiding visions and intermediary organizations play in bringing together actors from different sectors (cf. [13,19,30,58,60–62]). For instance, Späth and Rohracher ([30], p. 103) describe that, in the cities of Graz and Freiburg, aligning and encouraging different types of actors was made possible through "remarkably stable visions of a sustainable energy future in the cities". In terms of a boundary work approach, shared visions constitute boundary objects that provide joint reference for different communities of actors. Moreover, in the case of local energy transitions, concepts such as "sustainability", "energy transitions", and "energy efficiency" can also constitute boundary objects: they enable communication between different groups of actors while their understanding of and approach to these terms may vary significantly (cf. [63,64]). Local intermediary organizations, in contrast, may serve as boundary organizations. To what extent, they fulfill this role will depend on their ability to balance between different social worlds (instead of lobbying for specific worlds) [53].

Based on the theoretical elaborations in this section, working hypotheses can be raised regarding the occurrence of boundary bridging arrangements in local energy transitions.

(1) *Local energy transitions involve the emergence of boundary bridging arrangements*: Given that there is a need for facilitating interaction across sectoral boundaries in local energy transitions, boundary bridging arrangements will evolve in the course of these processes.
(2) *Collaboration takes place without consensus*: Boundary bridging arrangements will allow for collaboration without consensus. Decreasing the boundaries between the involved social worlds becomes obsolete.

(3) *Different contexts lead to different boundary bridging arrangements*: The emergence of specific boundary bridging arrangements will depend upon the particular contexts. Boundary organizations are likely to be founded in contexts where sufficient resources are available and there is a perceived need for purposefully governed knowledge exchanges between specific actors from different social worlds. Where this not the case, localities may rely on boundary objects and/or boundary settings.

(4) *Boundary bridging arrangements shape local energy transitions*: Given their individual characteristics, the presence of specific arrangements will have implications for the local transition processes by shaping its boundary bridging collaborations. Where boundary organizations emerge, there will be tendencies to centralize boundary bridging collaborations and the transition process in this organization.

(5) *Boundary organizations are probable places of tension*: Given their high level of centralization, tensions over the divergent demands of different social worlds regarding the transition are likely to manifest in or around boundary organizations.

The following application of the framework to the local energy transitions in Bottrop and Emden illustrates the approach and helps to identify its potentials and limitations.

3. Methodology and Context

This section describes the methodology and introduces the reader to the empirical context of the cases. Adopting the boundary-work approach in the empirical analysis of local energy transitions in these two case studies both illustrates the application of the approach and explores its potentials and limitations. For this purpose, it draws upon two case studies that were conducted in the context of a broader research project on local energy transitions. The methodology for this research was based on an exploratory case study approach [65] in which the main units of analysis are local energy transition processes. The goal of this project was to provide a comprehensive perspective on local energy transition processes in different regions, tackling the question of how local energy transitions unfold in the interaction of different types of actors. While studies on local transitions often focus on specific sets of actors (e.g., political or business actors), this research explored different social worlds that are involved in the given transitions in order to gain a more holistic perspective. Starting from the assumption of sectoral divisions in modern societies, it aimed to identify the main actors from different social worlds, their contributions to the given transition and how they collaborate with each other. The study sought for a comparison of transition processes between a more rural and a more urban German context. The densely populated and highly urbanized region of the Ruhr in the mdwest of Germany and the more sparsely populated northwestern coast region offered a sound context for this undertaking. The cities Bottrop and Emden were selected within these regions due to their outstanding engagement in energy transition processes. Thus, while both cases are located in the same European Union and German context, the configurations of the regions in which the cases are embedded, differ.

Most of the field research was undertaken in the year 2012 and was later complemented by additional interviews and online research (e.g., five further interviews were undertaken in 2014 in Emden). Empirical data were gathered through document research and interviews. Document research consisted of collecting information about the two cities and their energy transition activities from webpages, reports, press releases etc. In the first step of data gathering, the collection of information allowed for the creation of an overview of the cities' structural contexts (e.g., potentials for specific types of renewables) and their transition activities. This overview helped in drafting a preliminary list of interview partners with those actors from each social world that appeared to be important for the local transitions. Based on this list, first interview partners were selected and contacted. During the field research in the cities further documents relating to the transition process—such as flyer material of local projects, press articles, reports on the local transition—were collected.

In total, 68 semi-structured, in-depth interviews (31 interviews in Bottrop and 37 interviews in Emden) were conducted with actors engaged in the local energy transitions who are related to different social worlds: politics, economy, civil service, city administration, research and education.

The sampling strategy aimed to choose those actors (individual actors and organizations) from each social world who appeared to be the most important to the transition. Information gathered in the first interviews helped to identify further interview partners and to adapt the preliminary list of potential interviewees. Interviews particularly addressed the activities of the interviewees and/or their organizations in the given transition as well as their relationship with other local actors and joint projects. Audio recordings of the interviews were sent in for transcription.

The data were analyzed with the help of the qualitative data analysis software MAXQDA based on codes that had been partly created in advance (e.g., codes for different social worlds) and others that developed during the analysis process (e.g., codes related to specific challenges and conflicts). Based on these codes, the material was analyzed with regard to the activities of the individual social worlds and their interaction. Insights from the analysis were compiled into two 60–100 pages long case study reports on the cities' transition processes. These describe the evolution of the transition processes, the activities of each of the social worlds, and the interaction of different actors. The following illustration of the boundary work approach draws upon these case studies. In order to explore the strengths and limitations of the approach, the data are studied according to the aforementioned theoretical criteria (e.g., types of arrangements, and their boundary bridging characteristics) and working hypotheses. Before applying the theoretical framework to the two cases, the following paragraphs will familiarize the reader with the cases and their empirical context.

Germany's national politics has set an ambitious agenda to become "one of the most environmentally friendly and energy efficient economies" [66]. Its objectives include a nuclear phase-out by 2022, 55%–60% of renewables in electricity production by 2035, and by 2050, a 50% reduction of energy consumption, as compared to 2008. While the national government shows a general commitment to the *German Energiewende*, it is a contested and ill-defined transformation project: detailed frameworks to achieve these objectives are missing and power conflicts about the design of the transition steadily flare up, leaving stakeholders of this process—among them municipalities—in uncertainty (([9], p. 4), [11,67]). In the context of an increasingly decentralized energy production and local energy efficiency measures, municipalities become important stakeholders of the German "Energiewende", often designing their own ambitious transition agendas, as in the case of Bottrop and Emden.

Both of the cities featured in this research have been facing a challenging industrial transformation. In Emden, the ship-building sector, once a crucial economic sector of the city, has been declining in the last decades. In Bottrop, coal mining marked the economic history of the city, but, given its ever-shrinking competitiveness, will be closing its last coal mine in 2018. Struggling with their industrial background, both cities started to experiment with new activities in the energy field in the 1980s.

Bottrop's city administration established an environmental subdivision in the 1980s and launched a municipal energy management for public buildings in the early 1990s. In 1997, the city drafted its first climate concept, which was substituted by a more encompassing climate protection concept in 2011. A pivotal event for the recent developments was the city's success in the competitive call *Innovation City Ruhr* in 2010. The competition was launched by *Initiativkreis Ruhr*, a non-profit organization of 70 large industry companies, seeking to advance structural transformations in the Ruhr region. In its application, Bottrop envisages the energetic transformation of a city area of approximately 70,000 inhabitants, cutting its CO_2 emissions by 50% by 2020 (based on 2010 levels). A specific organization, *Innovation City GmbH*, has been founded to undertake this endeavor. This organization brings together actors from various sectors of the city, planning and coordinating the local activities. Until now, approximately 350 individual transition projects have been planned and/or undertaken under the direction of this intermediary organization.

In Emden, local politicians, the city administration, the public utility (Stadtwerke Emden), and a business entrepreneur promoted the first activities. From the late 1980s onwards, the city experimented with wind energy. In the early 1990s, the city's public utility was reoriented to become a sustainable

energy service provider. It subsequently constructed its first wind farm and launched energy efficiency programs for its clients. With improved feed-in tariffs for renewable energy and rising environmental awareness, an increasing number of local actors from different social worlds started to engage in the local transition and launched their own projects from the late 1990s onwards. Given an active policy to attract businesses in renewables to the city, Emden's ship-building sectors has been increasingly substituted by a flourishing wind energy sector, undertaking the production of components for onshore and offshore wind mills and the construction of wind farms. The municipality has set the goal to reduce its CO_2 emission by 50% by 2030, as compared to 1990 levels.

Given their strong engagement, the two cities are today considered to be pioneering transition cities in their regions. Despite the striking similarities between the two cities, there are some significant differences in their transitions. Emden's transition process emphasizes renewables, particularly wind energy, whereas Bottrop's transition is marked by a focus on energy efficiency, mainly in transportation, the building sector, and industry. Moreover, Emden's transition is not centrally coordinated and takes place in the form of mostly unconnected projects while, in Bottrop, a central coordinating body for the local transition has evolved with the foundation of the *Innovation City GmbH* (IC). Finally, Emden has a public utility that produces renewable energy and assumes a crucial role for the local transition, whereas Bottrop lacks such a local energy provider.

4. Boundary Work in Bottrop's and Emden's Energy Transitions

The boundary work approach starts from the premise of different social worlds and their boundaries. Being embedded in particular social worlds, local actors tend to have specific perspectives on the energy transitions. Politicians in the two cities have a strong interest in the economic prosperity of their cities: they regard the transitions as an opportunity to attract investments and reduce unemployment. Often they act as rather passive supporters and enablers of the transition processes, whereas business actors and employees of the city administrations assume a more pro-active stance. Businesses also tend to perceive the transitions as an economic opportunity. Their engagement often constitutes a strategy to improve their image and advertise products and/or to tap new business fields. Some bigger companies perceive the urban transitions as test-fields for new technologies, other companies also see the cost-saving potential through energy efficiency measures, as illustrated by the Bottrop's NRW Bank's slogan "efficiency pays off". Scientists perceive opportunities of conducting research. Specifically, actors related to applied sciences regard the urban transitions as living laboratories, implementing and testing innovative solutions. The city administrations of both cities are concerned about the planning and future of their cities. Besides following political decisions from the city council and mayor, they fix their own agendas and some departments act as drivers of the transition processes. Finally, citizens and NGOs are marginally integrated in the "official" transition projects of the two cities, mostly acting as moral watchdogs of the processes. In comparing the two cities, the involved social worlds draw, in general terms, similar boundaries when it comes to the transition. Nevertheless, given Bottrop's living laboratory character, its transition appears to be more interesting for research and also for industrial experimentation than Emden. Thus, within the business and research sectors there is a high shared interest in knowledge production.

Between the involved social worlds, there are similarities in the perspectives on the transitions (e.g., politicians and business actors see economic opportunities) as well as differences. While the similarities will simplify collaboration, the discrepancies are likely to hamper cooperation between actors from different social worlds. The boundary work approach assumes that boundary bridging arrangements allow for cooperation despite these discrepancies. These become manifest in the energy transitions of both cities.

The following descriptions provide examples for boundary bridging arrangements in the two local transitions. Focusing on specific examples for each type of boundary bridging arrangement, the descriptions illustrate how these become manifest and relate to each other. Table 2 summarizes these boundary bridging arrangements in the two cities.

In both cities, broad boundary objects become manifest in ill-defined shared visions and concepts that are available to all actors involved in the local transitions. More specified boundary objects (e.g., shared methods and plans), in contrast, are bound to more exclusive groups of actors, and are the product of the other two types of boundary bridging arrangements. The first subsection of the following descriptions discusses broad boundary objects, while specified boundary objects will be addressed in the context of the other boundary bridging arrangements.

Boundary settings can also be found in both cities. While Bottrop's most important boundary settings are embedded and organized within its boundary organization, Emden's boundary settings are organizationally unconnected. Emden's engagement in the European Energy Award and a joint power-to-gas project are examples of its boundary settings and will be addressed in the second subsection of the descriptions. Bottrop's boundary settings, in contrast, will be tackled in the third subsection in the context of its boundary bridging organization.

Finally, in Bottrop, a central boundary organization emerged in the form of the *Innovation City GmbH*; none were identified in Emden. This organization brings together relevant actors from different social worlds, enabling knowledge exchange between them and coordinating their activities. The third subsection addresses this boundary organization.

Table 2. Boundary bridging arrangements in the two cities.

	Boundary Objects	Boundary Settings	Boundary Organization
Bottrop	**Broad**: positive outlook, "energy transition" **Specified**: goals, shared methods, plans and working areas (embedded in boundary settings and/or organizations).	Friday round table, IC's steering committee (embedded in boundary organization)	Innovation City GmbH: central organization with specified entry points and advisory boards
Emden		European Energy Award, joint power-to gas Project	**None**

4.1. Boundary Objects

Boundary objects can assume multiple forms [49]. In the case of the two cities, they become manifest in ill-defined shared visions, terms, and concepts as well as to some extent in methods, plans, and material facilities. Following the theoretical elaborations on boundary objects, these can be distinguished into broad and specified boundary objects. Ill-defined shared visions, terms, and concepts are broad boundary objects. Research highlights the role of guiding visions for local energy transitions (cf. [30]). These should not be confused with politically established visions, such as the climate goals of cities. As they are usually fixed by actors from a specific social world, these are not necessarily shared by all involved actors. In the two cities studied here, shared visions are unstructured, barely defined, and hard to grasp.

Nevertheless, engaged actors in the two cities appear to share a general vision of their local transitions. In this vision, the transformation of the energy system is not necessarily conceived of as ultimately leading to a "greener" and more sustainable city, but, more generally, as creating a positive outlook. As in other urban low carbon transitions, the transformations are strongly coupled with positive prospects for the individual cities (cf. [9,13]). Taking up the opportunities offered by the transition implies becoming a pioneering city in these transformation processes: a city that distinguishes itself from others through its strong engagement. A politician from Emden describes his city as a "forward-looking regenerative city" (Interview E-24), whereas a local business more ambitiously labeled the city as "Europe's renewable energy capital". Other actors related to the business sector envisage developing the whole region towards "Energy Excellence Region" (Interview E-29). In addition, in Bottrop, the vision of becoming a pioneering city is prevalent, as local actors credit the city, for instance, with the potential of becoming a global "show-case model" for urban low carbon transitions (Interview B-16).

The shared visions create a joint reference point: local actors agreeing on the positive outlook of an urban energy transition have a common perspective on the future of their city and therefore may engage together for creating a prosperous and pioneering transition city. Given the very abstract nature of the shared vision, it is not clear to what extent it facilitates boundary crossing collaborations. Nevertheless, its ill-defined character allows for a high adaptability to specific social worlds and actors. As such, the concrete readings of the vision differ along the social worlds, as actors define the positive outlook for their city in heterogeneous ways: engaged citizens and NGOs envisage a "greener", more sustainable future for their city, whereas local businesses and most politicians place an emphasis on strengthening the economic outlook. As in many other transitions, the positive prospects are frequently perceived in terms of economic benefit and follow a narrative of the "green economy" (cf. [13,68]).

A second type of broad boundary object becomes manifest in the terms "Energiewende" and "Energiewandel". As in any collaboration between actors from different social worlds, there are some terms and concepts that are frequently used and create a common ground. A specified term that is often mentioned in this context is the German term "Energiewende." Constituting a joint reference point, it enables local actors to situate their activities in a bigger context. "Energiewende" is mostly perceived as a national transformation project of the energy system. Although sometimes criticizing its implementation, interviewees usually approve the project. They regard the political decision for the "Energiewende" and the structural decisions related to it (e.g., feed-in tariffs, and reconstruction of national power grids) as the context in which their local activities are embedded. Local actors conceive of their cities as having to contribute to this wide-reaching national transformation project: "We have a national task to which we have to contribute [. . .]" (Interview E-28). However, given the national connotation of "Energiewende", actors sometimes use other terminologies to frame the local activities with reference to an energy transformation (e.g., "Energiewandel", and "Transformation"). Commonly used terms and concepts create joint reference points and facilitate communication among actors from different social worlds. Again, given their ill-defined character, social worlds are able to develop specific understandings and approaches to them: being only vaguely defined, each social world can specify these boundary objects in compliance with its own perspective. For instance, business actors perceive the local energy transformation mostly through the prism of economic gain and loss, weighing its potential costs (e.g., rising energy prices) against its potential gains (e.g., business opportunities, savings through energy efficiency). Local NGOs, by contrast, regard it through its positive and negative impacts on nature and humans: from their perspective, the transformation should reduce the society's negative impact on nature and human wellbeing. Researchers regard it as a technological and scientific challenge which they have to confront with new insights and technological innovation. Leading politicians' perceptions strongly parallel those of the economy: they regard the transformation as a means to improve the city's economic outlook and additionally highlight its potential for creating employment. As such, in each social world the transformation receives a specified connotation. However, referring to the transformation in its more general, abstract sense allows actors from these different social worlds to create a positively connoted reference point: agreeing on the importance of "the" transformation and its positive outlook, local actors from different social worlds are willing to contribute to this endeavor.

Broad boundary objects, in the form of ill-defined shared visions and sufficiently abstract concepts such as "energy transition", constitute joint reference points in the two transitions. Given their ill-defined nature, each of the involved social worlds can specify them along its own perspective. As such, these ill-defined boundary objects enable actors to collaborate on the basis of common understandings without requiring consensus. However, being highly abstract they barely provide shared orientation for actors from different worlds. Specified boundary objects, conveying more clearly defined concepts, by contrast, can offer more orientation. These are produced in the context of boundary settings and boundary organizations which will be discussed in the following subsections. Examples of specified boundary objects in the two transitions are fixed goals, working plans, shared methods, and specified working areas.

4.2. Boundary Settings

Boundary settings are organizationally more complex boundary bridging arrangements than boundary objects. Apart from their ability to produce shared reference points, they involve regularized participation, creating a more exclusive group and leading to the production of more specified boundary objects. In the two transitions, boundary settings become, for instance, manifest in the form of committees, round tables, working groups, and joint projects, comprising actors from different social worlds. As the most important boundary settings of Bottrop's energy transition are embedded within its boundary organization, these will be addressed in the following subsection together with its boundary organization. This subsection instead focuses on two boundary settings from Emden: the European Energy Award and a power-to-gas project. The *European Energy Award* (EEA) is simultaneously a management tool and an award for municipalities engaged in energy transitions. Depending on the extent to which municipalities implement the predefined measures of the EEA, they receive points which determine their EEA-status as undefined, silver, or gold. The points are attributed in six different working areas: urban development, municipal buildings, supply/removal, mobility, internal organization, and communication/cooperation. In each of the working areas, the EEA suggests specific measures. Providing a tool-kit with standardized procedures and working steps, the EEA conveys a set of predefined and specified boundary objects that are accessible for actors from different social worlds. Regularized participation allows for employing these in an exclusive group of actors from divergent backgrounds. As such, there is a central committee responsible for the EEA in Emden. This committee comprises representatives from various departments of the city administration, the public utility, the local waste management company, the municipal facility management, a local wind energy business, and a consultancy accompanying the EEA certification process. Politicians, engaged citizens, and researchers are not included in this group. Meetings of its members take place on a regular basis. In these meetings, the committee identifies EEA measures that are relevant and feasible for Emden, thereby creating a working plan that assigns responsibilities for the chosen measures. The regular meetings between these actors improved their mutual understanding, as the following quote indicates: "[. . .] dealing with the topics of other colleagues has not necessarily produced more detailed knowledge, but has improved the capacity to integrate individual activities into the general concept, to classify and evaluate them and has enormously increased the comprehension of the restrictions that one brings into this field and the ability to develop these [. . .]" (Interview E-2) Similarly to the broad boundary objects discussed above, the creation of more specified boundary objects does not lead to the dissolution of boundaries between the involved social worlds, as the detailed knowledge remains in each of involved social worlds. For those participating in the central committee, the EEA-framework enabled the creation of a joint concept of the local transition as consisting of specific working areas and measures. Thereby, it involves more specified boundary objects, different from the ill-defined visions and concepts discussed in the previous subsection. These specified boundary objects are, however, restricted to the specific actors participating in this group. As such, this boundary setting does not create broad and inclusive boundary objects accessible to all actors involved in Emden's energy transition processes.

Besides the EEA, there are numerous joint projects that involve actors from different social worlds and, as such, constitute boundary settings. An example of this is Emden's power-to-gas project. Emden's university of applied sciences and the public utility collaborate on this project, which envisages constructing a pilot plant for power-to-gas conversion. The plant will store wind power by converting it into methane gas. Representatives from each of the two organizations participate in regular board meetings. Their collaboration has led to specified boundary objects that facilitate their interaction in the form of the shared vision of a power-to-gas facility and collaboratively designed working plans. At the same time, the clear separation of tasks and responsibility maintains the boundaries between the two social worlds. Each project partner participates in this project according to its specialization: the public utility handles the material implementation, funding, and legal feasibility, whereas Emden's university of applied sciences provides scientific and technical knowledge to this

project, assembling data about existing technologies and evaluating the feasibility within the given local context.To sum up, boundary settings enable actors from particular social worlds to generate more specified boundary objects (e.g., working plans). Given the exclusive nature of these settings, the production and use of these more specified boundary objects is restricted to those participating in them.

4.3. Boundary Organizations

In Emden's energy transition, a central boundary organization does not exist. Instead, several intermediaries help to facilitate communication and coordination between certain actors from particular social worlds. For instance, the intermediary *Centers of Competence* seeks to foster knowledge exchange among local businesses regarding energy efficiency; another intermediary, the *Harbor Society*, brings together businesses related to the harbor, advocating offshore-wind energy in the city. A balancing between different social worlds, such as that described by Guston [33,53], does not take place within these organizations. In contrast, the local intermediaries are focused on specific worlds and sometimes lobby the interests of this world towards other worlds (e.g., local chamber of commerce towards local politics).

While in Emden a boundary organization has so far not emerged, Bottrop's energy transition is strongly shaped by such an organization. After the successful application for the *Innovation City Ruhr*, the *Innovation City GmbH* (IC), an organization with the purpose of steering and coordinating the transformation process was created. This organization involves regularized participation in the form of memberships. Constituting a network organization, IC members are organizations from different social worlds: craft businesses, big industry companies, the city administration, banks, research institutes, and the political sphere. By contrast, the local civil society (e.g., NGOs, energy consumers) is only marginally integrated into its boundary bridging activities. Thereby, the boundary bridging activities create new boundaries: these run between those participating and those not participating in the boundary bridging of this central organization and its energy transition activities.

Funding for running IC comes from the Land North-Rhine Westphalia, the *Initiativkreis Ruhr*, and its member companies as well as the city, whereas specific projects that are undertaken in the context of IC are funded on an individual basis (e.g., financial contributions of specific companies, EU funding). As a private-public company, IC recruits its staff from the city administration, the *Initiativkreis Ruhr*, and some of the member companies of the *Initiativkreis*. The main purpose of IC is to achieve the goal formulated in the application for the *Innovation City Ruhr*: a 50% reduction of CO_2 emissions by 2020, on the basis of 2010 levels, in a city area of approximately 70,000 inhabitants. Around 350 individual projects are run or planned within IC to achieve this goal. Against the background of this ambitious goal, IC assumes several—partly overlapping—functions: (a) steering the transformation process and acting as an interface between actors from different social worlds; (b) initiation, implementation, monitoring of individual projects; and (c) creating a positive public reputation of the IC project from which the participating organizations benefit.

In particular, its interface-role is crucial: by integrating and connecting large companies, Bottrop's city administration, small craft businesses, research institutes, and politicians, IC helps to coordinate their activities and bundle their competences. Thus, one interviewee states that IC has "the role [. . .] of the mediator, the moderator, yes, it has the task to collect the other actors, pick them up, pick up their ideas, and to develop together adequate projects. Thus, actors from the economy, science, and other actors [. . .]" (Interview B-21).

The three abovementioned characteristics of boundary organizations enable IC to fulfill this task: (a) accountability towards different social worlds (specific entry points and boards for particular types of actors); (b) internal boundary settings (round tables and steering committee); and (c) specified boundary objects (shared methods and plans).

In terms of its accountability towards different social worlds, IC has evolved organizational structures that allow it to respond to the particular needs of its heterogeneous stakeholders. Each social

world has specific entry points to IC and advisory boards within IC: the intermediary has (a.1) assigned particular staff members as contact persons for specific stakeholder-groups and (a.2) created several advisory boards, each of them composed of external actors from a particular stakeholder group (e.g., craft-businesses, banks, science partners etc.). The contact persons at IC are internal experts who have know-how in the area of the given stakeholders and can, therefore, address their concerns. The mixed composition of IC's staff contributes to its ability to respond to the concerns of different social worlds. The advisory boards, by contrast, integrate actors from specific social worlds more directly into the work of the organization. These boards bring together partners from one particular social world with experts from the IC GmbH (e.g., Science Advisory Board, Industry Advisory Board). Meetings of the boards take place between four and six times a year. The purpose of these meetings is to guarantee a constant flow of knowledge between IC and these specific social worlds. Furthermore, the meetings help to foster the commitment of partners and often lead to new project ideas. In total, assembling several unique contact points adapted to specific social worlds and thus responding to the particular needs of each, enables IC to be accountable to its different stakeholders.

Whereas each of the aforementioned contact points centers on one social world, internal boundary settings bring together different social worlds on a regularized basis. This is undertaken by (b.1) IC's Friday project roundtable and (b.2) IC's steering committee. The Friday project roundtable is a weekly meeting of all responsible project leaders, heads of departments as well as representatives from the external partner companies. The main purpose of this meeting is to discuss ongoing projects. This guarantees that all relevant actors are aware of ongoing projects and their progress. As all relevant actors are present, they can support each other with know-how, generate new ideas, and take instant decisions. The steering committee, by contrast, brings together representatives from IC, the city administration, and the city council. By prominently integrating the city council, it connects IC with the political sphere and serves as a preparatory committee for decision-making processes in the city council. Political decision-makers discuss specific topics related to the overall project (e.g., development plans for specific city areas) together with executives from IC and the city administration. The necessary political decisions are prepared in this committee and then feed into the political process within the city council. An interviewee illustrates the importance of settings that bridge sectoral boundaries as follows: "We have realized in many small working groups that [. . .] when seeking for some solutions [. . .] the competences or possibilities of those present were not sufficient. Thus, if we now have only public administrators at our desk, then we can only decide on things [. . .] that really have to do with the administration. But if we have a desk here at which we have also representatives from the industry and people from the GmbH [IC], [. . .] also representatives from science, that are on this desk, then one can more easily produce solutions as if when everyone only works only for him/herself in his/her own small area" (Interview B-20).

A third boundary bridging characteristic of IC is its production of specified boundary objects in the form of (c.1) shared quality standards and (c.2) a general masterplan. Together with its member organizations, IC has developed quality-standards for energy-efficient refurbishment measures. Members of the IC-network have to commit themselves to these standards, which are conveyed in specific training workshops carried out by the chamber of commerce, the chamber of crafts, and equipment producers. These standards concern, in particular, organizations related to the refurbishment sector such as architects, craft businesses, and energy advisers. However, as these standards refer only to particular actors from the business world and exclude other social worlds, they constitute a highly specified boundary object. A wider, but still specified, boundary object is the general masterplan which has been developed for the transformation process. The 1300 page document that was presented in 2014 arranges the activities and individual projects along six main fields of action ([69]): (1) living: reduction of energy consumption in residential districts; (2) working: reduction of energy consumption in public buildings and businesses; (3) energy: production and supply of energy; (4) mobility: reduction of traffic and development of climate-friendly transportation; (5) city: climate-friendly use and greening of city areas; and (6) activation of consumers and other

stakeholders. The masterplan provides a general road-map of the transition, guiding the involved actors and committing them to the same working schedule and milestones.

As a boundary organization, IC facilitates the collaboration of actors from different social worlds. This is undertaken by: (a) creating structures that allow the organization to respond to the needs of different social worlds; (b) establishing internal boundary settings; and (c) generating specified boundary objects. By bringing crucial actors together and managing their boundary bridging interaction, IC has established itself a central actor of Bottrop's energy transition. Therefore, the vast majority of transition activities involve IC which concentrates the boundary bridging exchanges within its organization and structures them according to its particular configuration (e.g., Friday round table, particular boards, and masterplan). This leads to a steered and centralized transition, governed by a strong agent along the needs of its stakeholders and leaving little space for alternative transition pathways.

Nevertheless, given its central role, IC is also confronted with conflicting demands regarding the shape of the transition activities, leading to tensions within the organization. While big business actors tend to favor impressive showcase projects that help to test and promote innovative technologies, smaller businesses and end-users are interested in less costly and more pragmatic solutions. Additionally, regarding the type of energy transition there are conflicting demands and visions: while many businesses share a technological vision of the transition, relying on the implementation of greener technologies, other actors prefer a more comprehensive urban planning perspective that regards technological change as part of wider social transformations and highlights the need to integrate the new technologies in the life world of local users. These tensions are not only related to the conflicting standards of different social worlds, but also to the size, operational foci, interests, and paradigmatic visions of the involved stakeholders. Although boundary organizations are supposed to balance conflicting perspectives without prioritizing a specific social world, some stakeholders—such as big industrial companies and the city administration—will have effectively greater power to enforce their visions within the boundary organization and thereby shape the transition process. Often assuming a harmonious and equal balancing of the conflicting needs of different social worlds, boundary work approaches tend to neglect these tensions and the role of power [55,70].

5. Discussion

Local energy transitions involve a heterogeneous variety of actors such as politicians, entrepreneurs, researchers, public administrators, citizen activists, and consumers [6,14,26–30]. As these actors differ in their overall objectives, incorporate unlike values, interpret their environment in a dissimilar manner, communicate in distinct professional jargons, and organize their activities along different structures, they may face problems in collaboration and coordination (cf. [31,32]). Boundary bridging arrangements respond to this governance-problem: evolving governance structures in the form of shared grounds and/or reference points, they help local actors from heterogeneous backgrounds exchange knowledge and coordinate their activities. Drawing upon the boundary work approach, the article has raised five working hypotheses regarding the occurrence of boundary bridging arrangements in local energy transitions. Based on the empirical findings, the following paragraphs will summarize the main results regarding these hypotheses. After addressing the hypotheses, this section discusses the general strengths and limitations of the boundary work approach.

Local energy transitions involve the emergence of boundary bridging arrangements: In both of the two energy transitions, different boundary bridging arrangements have evolved. In both cities, boundary objects in the form of shared visions, terms, and concepts as well as boundary settings enable for boundary crossing collaboration. Additionally, a boundary bridging organization has emerged in Bottrop's transition, serving as an interface between businesses, city administration, politicians, and researchers. Some of these arrangements have been purposefully established with the goal to facilitate cross-sectoral collaboration (e.g., IC). Others, though not established with this particular

goal, have partly evolved in response to the high demands of cross-sectoral interaction in local energy transitions (e.g., joining the EEA).

Collaboration takes place without consensus: The boundary bridging arrangements in the two cities allow for a type of collaboration that does not require consensus. As actors from different social worlds jointly engage for the energy transition processes in their cities, boundaries between the different social worlds are not vanishing. Actors continue to operate along the specific working principles of their social worlds while the boundary bridging arrangements facilitate their collaboration across these boundaries. This is, for instance, illustrated by Emden's power to gas project in which researchers and employees of the municipal utility company collaborate. Both actors engage in this project based on their specific knowledge area and competences while the production of joint working plans and visions affords them shared reference points. *Different contexts lead to different boundary bridging arrangements:* The differences in the particular arrangements of Bottrop and Emden are related to the specific contexts of each of the transition processes. Local energy transition processes are embedded in institutional and geographical settings influencing their shape [14,25,27,60]: the given local rules, cultural habits and values, infrastructures, and geographical landscape are likely to have an impact on the way in which boundaries are bridged and may even shape how the boundaries are designed and reproduced in the first place. Accordingly, cities develop distinctive boundary bridging patterns that go hand in hand with their unique transition pathways (cf. [60,71]). Apart from the local context, the embeddedness in specific national and regional spaces may likewise have an impact on the boundary processes (cf. [6,24,30,59,72]). As such, the presence or absence of national political support, funding schemes (e.g., feed-in tariff for renewables) or programs (e.g., EEA) will influence the localities' activities and spur or hinder collaborations between different social worlds (cf. [30,73]). In the case of Bottrop, the regional context with the *Innovation City Ruhr* competition has strongly shaped the urban transition process and its boundary bridging arrangements. The winning of the competition has led to the creation of the boundary organization IC. By contrast, Emden's leading actors have not considered the creation of a central boundary organization that brings together different social worlds: given the small size of the city, the existence of dense social networks between key actors, and the lack of funding opportunities, the creation of a boundary organization is out of the scope of Emden's leading actors.

Boundary bridging arrangements shape local energy transitions: The presence (or absence) of a central boundary organization appears to have implications for local energy transition processes. Bottrop's IC creates a strongly steered and centralized transition dynamic. The most important boundary settings and objects are embedded in IC, leading to a high standardization of the transition and leaving little space for alternative transition pathways. The centralization of boundary bridging activities within an organization with formalized membership implies the exclusion of some actors and their stances on the transition. By contrast, in Emden, the energy transition is based on a plurality of heterogeneous boundary settings with specified boundary objects. As such, Emden's transition is more loosely structured, lacking central coordination, but providing more space for different approaches to the transition.

Boundary organizations are probable places of tensions: Forming the central agent that is accountable to different social worlds, IC is also the scene for their conflicting demands regarding the energy transition. Conflicting demands concern the type of energy transition and form of projects that should be undertaken. These tensions are, however, not only related to the dissimilar operational logics of the social worlds, but also to the individual interests and paradigmatic visions of actors.

The empirical results from the case studies allow for discussing the strengths and limitations of the boundary work approach. Its particular strengths concern: (a) its awareness for the importance of cross-sectoral collaboration in energy transitions; (b) the ability to explain collaborations across sectoral boundaries; (c) the provision of a heuristic for studying different arrangements that facilitate collaboration; and (d) its potential to explain different types of local transitions.

In the most general terms, employing a boundary work perspective helps, on the one hand, to consider the importance of collaboration between different types of actors in local energy transitions

and, on the other, to bear in mind that carrying out collaborations is a complex undertaking in the face of sectoral boundaries. Social differentiation processes have led to the evolution of distinct social worlds that are based on disparate perspectives, goals, professional jargons, and operational logics [74,75]. However, energy transitions are encompassing transformation processes that span different social worlds and, therefore, require the collaboration between them. Accordingly, local energy transitions must involve arrangements that enable cross-sectoral collaboration. From the perspective of a boundary work approach, boundary bridging arrangements appear as a necessary prerequisite: collaboration will only thrive when actors from different backgrounds have social arrangements at their disposal that facilitate their interaction.

The boundary work approach helps us to grasp these arrangements. Thereby, it enables us to understand how collaboration is possible in these transitions against the backdrop of sectoral boundaries. Boundary objects, for instance, facilitate the communication between actors from different social worlds without endangering their boundaries through providing shared reference points with sufficient interpretative flexibility (e.g., ill-defined concepts and terms). From this perspective, the often criticized vagueness of the "Energiewende" affords local actors from different social worlds with a common reference point that facilitates exchange across boundaries and simultaneously allows them to individually adapt this notion to their specific social worlds. Apart from broad boundary objects, other more specified and complex arrangements, such as specified boundary objects, boundary settings, and boundary organizations, can equally contribute through their particular boundary bridging characteristics to the cross-sectoral collaboration in energy transitions.

Existing research on boundary work provides a heuristic of boundary bridging arrangements to analyze collaboration at the local level. Through distinguishing types of boundary bridging arrangements according to their dissimilar boundary bridging characteristics, the boundary work approach provides a framework that can help researchers to identify and explore different patterns of boundary bridging in local energy transitions.

As the heuristic allows for relating different types of energy transition to types of boundary bridging arrangements, the boundary work approach can contribute to the study of the heterogeneous transition patterns in localities. The presence of specific boundary bridging arrangements has implications for the local transition processes. As such, boundary organizations seem to lead to more centralized and steered transitions than transitions based on heterogeneous boundary settings and boundary objects.

In total, the notion of boundary work can be a helpful device to study local energy transitions. Nevertheless, the boundary work approach in its current shape also faces several limitations and challenges. These concern: (a) its focus on the social dimension; (b) the employment of a pre-fabricated heuristic of boundary bridging arrangements to the specific context of local energy transitions; (c) the assumption of sectoral divisions; (d) the role of power, interest, and conflict; and (e) methodological challenges.

As the approach's main focus is on the social dimension, it discounts other dimensions that may also assume an important role for the local transition dynamics, such as the role of materiality and the geographic space (cf. [20,76–79]). However, to not become overly complex and remain applicable, analytical frameworks studying the multifaceted dynamics of sustainability transition will necessarily have to focus on some dimensions while making less allowance for others.

In addition, the applicability of the heuristic of boundary bridging arrangements raises critical questions. Given that the existent knowledge about boundary bridging arrangements is particularly based on research about science-politics-interfaces, the approach suggests a specific range of boundary bridging arrangements that may not be fully suitable for local energy transitions. Slightly different or even new boundary bridging arrangements may evolve in local energy transitions. An example for this is Bottrop's IC. Most studied boundary organizations bridge only two social worlds, whereas IC responds to the more extensive demands on collaboration in low urban carbon transitions by

integrating several social worlds. More empirical research may provide insights about the specific types of boundary bridging arrangements in these transitions.

Similarly, the implicit assumption of strict sectoral division in modern societies is often critically regarded. While many sociologists start their reflections and observations from the premises of these divisions (cf. [74,75,80]), other scholars believe that overlaps and interferences between different social worlds lead to hybrid spaces in which boundary bridging arrangements are created and employed [55,81]. In particular in small and medium size cities, the assumption of strict boundaries between social worlds may face its limitations: actors on the ground may experience them only to a minor extent or totally ignore them. Boundaries based on interests and personal antagonism are sometimes more important for these actors than those based on social worlds. Thus, in Emden, local actors highlight the role of social ties and proximity for their collaborations. Diverging interests and personal antipathy, by contrast, can create solid boundaries even between actors from the same social world, jeopardizing their collaboration and leading to conflict (cf. [29,82–84]). This relates to the role of power.

Power is barely integrated into the approach [70]. The construction of boundary objects mostly appears as a largely non-hierarchic process, in which power plays no significant role. Local energy transitions are, however, saturated with power, individual interests, and conflicts: actors compete over shaping these transitions to serve their interests (cf. [13,21,79,85]). In these struggles, some actors will usually exercise more power than others, thereby having a stronger impact on the design of boundary objects and boundary organizations. Bottrop's IC and the companies prominently represented in it are powerful actors shaping the most important local boundary bridging arrangements. As these arrangements are not necessarily accepted by all actors, conflicts about the structure and content of the boundary bridging arrangements can arise. Thus, Bottrop's IC has received criticism for its lack of citizen involvement and distance from the more pragmatic needs of everyday energy consumers.

Finally, applying the boundary work approach to local energy transitions, researchers may experience methodological difficulties: given their ill-defined nature, it is hard to identify and define boundary objects that are shared by actors from different social worlds (see also [49]). This problem becomes particularly puzzling when not only two but various social worlds participate in the creation of boundary objects.

In order to further adapt the boundary work approach to the study of local energy transitions, future applications will have to find solutions for these problems. Particularly power, interest, conflict and personal ties are important features of transitions: even when placing an emphasis on the social dimension of transitions and neglecting other dimensions, taking these features into account is crucial for grasping the complex social dynamics of local transitions.

6. Conclusions

Local energy transitions involve various types of actors such as politicians, entrepreneurs, researchers, citizen activists, and public administrators. These actors are related to heterogeneous social worlds which differ in their objectives, structures, professional standards, and jargons. As energy transitions are transformations that span these social worlds, the differences raise the question of how collaboration is possible in local energy transitions despite the boundaries between the social worlds.

This article has outlined a boundary work approach for tackling this problem. The approach suggests that boundary bridging arrangements evolve in local energy transitions. These arrangements facilitate the communication between different social worlds without endangering their boundaries. Existing research on boundary work suggests various types of boundary bridging arrangements which differ in their boundary bridging capacities. For this article, three types of boundary bridging arrangements have been proposed: boundary objects (broad and specified), boundary settings, and boundary organizations.

Applying the approach to the energy transitions of the German cities Bottrop and Emden, the article has identified different boundary bridging arrangements in each of the cities. While broad

and specified boundary objects and boundary settings can be found in both cities, a boundary organization has only emerged in Bottrop. The emergence of a central boundary organization is related to the specific context of Bottrop. The winning of the IC Ruhr competition that involved the commitment to an ambitious local energy transition combined with funding opportunities has led to the foundation of IC as a central boundary bridging actor. At the same time, its emergence has consequences for the transition process, leading to a centralized, strongly steered energy transition that involves a specific group of actors while excluding others. In contrast to Bottrop's centralized transition, Emden's energy transition is based on a variety of boundary settings and objects and evolves in a mostly uncoordinated form. The comparison of the two cases indicates a twofold relevance of contexts: on the one hand, the evolution of specific boundary bridging arrangements is an outcome of the given local context, and, on the other hand, boundary bridging arrangements shape how actors from different social worlds relate to each other and thereby have an impact on the transition in the given locality.

This relates to the strengths of the approach which concern: (a) its awareness for the importance of cross-sectoral collaboration in energy transitions; (b) the ability to explain collaborations across sectoral boundaries; (c) the provision of a heuristic for studying different arrangements that facilitate collaboration; and (d) its potential to explain different types of local transitions. However, at the same time, the boundary work approach has certain limitations which are related to: (a) its focus on the social dimension, potentially neglecting other important dimensions of transitions; (b) the employment of a pre-fabricated heuristic of boundary bridging arrangements to the specific context of local energy transitions; (c) the assumption of sectoral divisions; (d) its insufficient consideration of power, interest, and conflict; and (e) methodological challenges.

Applying the approach in additional research will provide more knowledge about the boundary bridging arrangements in local energy transitions and may help to further develop the approach. Comparative research in different local, regional, and national contexts could generate insights about the conditions that lead to the evolution of particular boundary bridging arrangements and the impact of specific arrangements on local transitions. Moreover, as local, regional, and national policies can support the creation of specific arrangements, analyzing the advantages and pitfalls of different arrangements under specific local and national conditions could provide important insights for designing policies that match the particular requirements of local energy transitions.

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References

1. Loorbach, D.; van der Brugge, R.; Taanman, M. Governance in the energy transition: Practice of transition management in the Netherlands. *Int. J. Eng. Technol. Manag.* **2008**, *9*, 294. [CrossRef]
2. Kemp, R.; Parto, S.; Gibson, R.B. Governance for sustainable development: Moving from theory to practice. *Int. J. Sustain. Dev.* **2005**, *8*, 12–30. [CrossRef]
3. Meadowcroft, J. What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy Sci.* **2009**, *42*, 323–340. [CrossRef]
4. Rotmans, J.; Loorbach, D. Complexity and Transition Management. *J. Ind. Ecol.* **2009**, *13*, 184–196. [CrossRef]
5. Hodson, M.; Marvin, S.; Bulkeley, H.; Broto, V.C. Conclusion. In *Cities and Low Carbon Transitions*; Bulkeley, H., Castán Broto, V., Hodson, M., Marvin, S., Eds.; Routledge: London, UK, 2013; Volume 35, pp. 198–202.
6. Bulkeley, H.; Kern, K. Local Government and the Governing of Climate Change in Germany and the UK. *Urban Stud.* **2006**, *43*, 2237–2259. [CrossRef]

7. Khan, J. What role for network governance in urban low carbon transitions? *J. Clean. Prod.* **2013**, *50*, 133–139. [CrossRef]
8. Peters, M.; Fudge, S.; Sinclair, P. Mobilising community action towards a low-carbon future: Opportunities and challenges for local government in the UK. *Energy Policy* **2010**, *38*, 7596–7603. [CrossRef]
9. Fuchs, G.; Hinderer, N. Situative governance and energy transitions in a spatial context: Case studies from Germany. *Energy Sustain. Soc.* **2014**, *4*, 16. [CrossRef]
10. Fudge, S.; Peters, M.; Woodman, B. Local authorities as niche actors: The case of energy governance in the UK. *Environ. Innov. Soc. Transit.* **2016**, *18*, 1–17. [CrossRef]
11. Gailing, L.; Röhring, A. Germany's Energiewende and the Spatial Reconfiguration of an Energy System. In *Conceptualizing Germany's Energy Transition: Institutions, Materiality, Power, Space*; Gailing, L., Moss, T., Eds.; Palgrave Macmillan UK; Palgrave Pivot: London, UK, 2016; pp. 11–20.
12. Bulkeley, H.; Castán Broto, V.; Edwards, G.A. *An Urban Politics of Climate Change: Experimentation and the Governing of Social-Technical Transitions*; Taylor et Francis: London, UK, 2014.
13. Hodson, M.; Marvin, S. Mediating Low-Carbon Urban Transitions? Forms of Organization, Knowledge and Action. *Eur. Plan. Stud.* **2012**, *20*, 421–439. [CrossRef]
14. Mattes, J.; Huber, A.; Koehrsen, J. Energy transitions in small-scale regions—What we can learn from a regional innovation systems perspective. *Energy Policy* **2015**, *78*, 255–264. [CrossRef]
15. Maassen, A. Heterogeneity of lock-in and the role of strategic technological interventions in urban infrastructural transformations. *Eur. Plan. Stud.* **2012**, *20*, 441–460. [CrossRef]
16. McCauley, S.M.; Stephens, J.C. Green energy clusters and socio-technical transitions: analysis of a sustainable energy cluster for regional economic development in Central Massachusetts, USA. *Sustain. Sci.* **2012**, *7*, 213–225. [CrossRef]
17. Moloney, S.; Horne, R. Low Carbon Urban Transitioning: From Local Experimentation to Urban Transformation? *Sustainability* **2015**, *7*, 2437–2453. [CrossRef]
18. Schönberger, P. Municipalities as Key Actors of German Renewable Energy Governance, an Analysis of Opportunities, Obstacles, and Multi-Level Influences. Available online: http://wupperinst.org/en/publications/details/wi/a/s/ad/2056/ (accessed on 31 September 2013).
19. Späth, P.; Rohracher, H. 'Energy regions': The transformative power of regional discourses on socio-technical futures. *Res. Policy* **2010**, *39*, 449–458. [CrossRef]
20. Truffer, B.; Coenen, L. Environmental innovation and sustainability transitions in Regional Studies. *Reg. Stud.* **2012**, *46*, 1–21. [CrossRef]
21. Bulkeley, H.; Castan Broto, V.; Maassen, A. Low-carbon Transitions and the Reconfiguration of Urban Infrastructure. *Urban Stud.* **2014**, *51*, 1471–1486. [CrossRef]
22. Darby, S. Social learning and public policy: Lessons from an energy-conscious village. *Energy Policy* **2006**, *34*, 2929–2940. [CrossRef]
23. Hisschemöller, M.; Sioziou, I. Boundary organisations for resource mobilisation: Enhancing citizens' involvement in the Dutch energy transition. *Environ. Politics* **2013**, *22*, 792–810. [CrossRef]
24. Hoppe, T.; van Bueren, E. Guest editorial: Governing the challenges of climate change and energy transition in cities. *Energy Sustain. Soc.* **2015**, *5*, 88. [CrossRef]
25. Monstadt, J. Urban governance and the transition of energy systems: Institutional change and shifting energy and climate policies in Berlin. *Int. J. Urban Reg. Res.* **2007**, *31*, 326–343. [CrossRef]
26. Busch, H.; McCormick, K. Local power: Exploring the motivations of mayors and key success factors for local municipalities to go 100% renewable energy. *Energy Sustain. Soc.* **2014**, *4*, 1–15. [CrossRef]
27. Blanchet, T. Struggle over energy transition in Berlin: How do grassroots initiatives affect local energy policy-making? *Energy Policy* **2015**, *78*, 246–254. [CrossRef]
28. Dowling, R.; McGuirk, P.; Bulkeley, H. Retrofitting cities: Local governance in Sydney, Australia. *Cities* **2014**, *38*, 18–24. [CrossRef]
29. Gabillet, P. Energy supply and urban planning projects: Analysing tensions around district heating provision in a French eco-district. *Energy Policy* **2015**, *78*, 189–197. [CrossRef]
30. Späth, P.; Rohracher, H. The 'eco-cities' Freiburg and Graz: The social dynamics of pioneering urban energy and climate governance. In *Cities and Low Carbon Transitions*; Bulkeley, H., Castán Broto, V., Hodson, M., Marvin, S., Eds.; Routledge: London, UK, 2013; Volume 35, pp. 88–106.

31. Clark, W.C.; Tomich, T.P.; van Noordwijk, M.; Guston, D.; Catacutan, D.; Dickson, N.M.; McNie, E. Boundary work for sustainable development: Natural resource management at the Consultative Group on International Agricultural Research (CGIAR). *Proc. Natl. Acad. Sci. USA* **2011**, *113*, 4615–4622. [CrossRef] [PubMed]
32. McGreavy, B.; Hutchins, K.; Smith, H.; Lindenfeld, L.; Silka, L. Addressing the Complexities of Boundary Work in Sustainability Science through Communication. *Sustainability* **2013**, *5*, 4195–4221. [CrossRef]
33. Guston, D.H. Stabilizing the Boundary between US Politics and Science: The Role of the Office of Technology Transfer as a Boundary Organization. *Soc. Stud. Sci.* **1999**, *29*, 87–111. [CrossRef] [PubMed]
34. Mollinga, P.P. Boundary Work and the Complexity of Natural Resources Management. *Crop Sci.* **2010**, *50*, S-1–S-9. [CrossRef]
35. Star, S.L.; Griesemer, J.R. Institutional ecology, translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–39. *Soc. Stud. Sci.* **1989**, *19*, 387–420. [CrossRef]
36. Lange, P.; Driessen, P.P.; Sauer, A.; Bornemann, B.; Burger, P. Governing towards Sustainability—Conceptualizing Modes of Governance. *J. Environ. Policy Plan.* **2013**, *15*, 403–425. [CrossRef]
37. Gieryn, T.F. Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists. *Am. Sociol. Rev.* **1983**, *48*, 781–795. [CrossRef]
38. Lamont, M. *Money, Morals & Manners: The Culture of the French and the American Upper-Middle Class*; University of Chicago Press: Chicago, IL, USA, 1992.
39. Lamont, M.; Fournier, M. Introduction. In *Cultivating Differences: Symbolic Boundaries and the Making of Inequality*; Lamont, M., Fournier, M., Eds.; University of Chicago Press: Chicago, IL, USA, 1992; pp. 1–17.
40. Pachucki, M.A.; Pendergrass, S.; Lamont, M. Boundary processes: Recent theoretical developments and new contributions. *Poetics* **2007**, *35*, 331–351. [CrossRef]
41. Wimmer, A. The Making and Unmaking of Ethnic Boundaries: A Multilevel Process Theory. *Am. J. Sociol.* **2008**, *113*, 970–1022. [CrossRef]
42. Wimmer, A. Elementary strategies of ethnic boundary making. *Ethn. Racial Stud.* **2008**, *31*, 1025–1055. [CrossRef]
43. Lamont, M.; Molnár, V. The Study of Boundaries in the Social Sciences. *Annu. Rev. Sociol.* **2002**, *28*, 167–195. [CrossRef]
44. Schut, M.; van Paassen, A.; Leeuwis, C. Beyond the research–policy interface. Boundary arrangements at research–stakeholder interfaces in the policy debate on biofuel sustainability in Mozambique. *Environ. Sci. Policy* **2013**, *27*, 91–102. [CrossRef]
45. Hoppe, R. Rethinking the science-policy nexus: From knowledge utilization and science technology studies to types of boundary arrangements. *Poiesis Prax.* **2005**, *3*, 199–215. [CrossRef]
46. Fujimura, J.H. Crafting science: Standardized packages, boundary objects, and "translation". *Sci. Pract. Cult.* **1992**, *168*, 168–169.
47. Tushman, M.L.; Scanlan, T.J. Boundary Spanning Individuals: Their Role in Information Transfer and Their Antecedents. *Acad. Manag. J.* **1981**, *24*, 289–305. [CrossRef]
48. Bowker, G.C.; Star, S.L. *Sorting Things Out: Classification and Its Consequences*; MIT Press: Cambridge, MA, USA, 2000.
49. Leigh Star, S. This is Not a Boundary Object: Reflections on the Origin of a Concept. *Sci. Technol. Hum. Values* **2010**, *35*, 601–617. [CrossRef]
50. Trompette, P.; Vinck, D. Revisiting the notion of Boundary Object. *Rev. D'anthropol. Connaiss.* **2009**, *3*, 1. [CrossRef]
51. Abson, D.J.; von Wehrden, H.; Baumgärtner, S.; Fischer, J.; Hanspach, J.; Härdtle, W.; Heinrichs, H.; Klein, A.M.; Lang, D.J.; Martens, P.; et al. Ecosystem services as a boundary object for sustainability. *Ecol. Econ.* **2014**, *103*, 29–37. [CrossRef]
52. Carr, A.; Wilkinson, R. Beyond Participation: Boundary Organizations as a New Space for Farmers and Scientists to Interact. *Soc. Nat. Resour.* **2005**, *18*, 255–265. [CrossRef]
53. Guston, D.H. Boundary Organizations in Environmental Policy and Science: An Introduction. *Sci. Technol. Hum. Values* **2001**, *26*, 399–408. [CrossRef]
54. Pesch, U.; Huitema, D.; Hisschemöller, M. A boundary organization and its changing environment: The Netherlands Environmental Assessment Agency, the MNP. *Environ. Plan. C* **2012**, *30*, 487–503. [CrossRef]
55. Parker, J.; Crona, B. On being all things to all people: Boundary organizations and the contemporary research university. *Soc. Stud. Sci.* **2012**, *42*, 262–289. [CrossRef]

56. White, D.D.; Corley, E.A.; White, M.S. Water Managers' Perceptions of the Science–Policy Interface in Phoenix, Arizona: Implications for an Emerging Boundary Organization. *Soc. Nat. Resour.* **2008**, *21*, 230–243. [CrossRef]
57. Geels, F. The role of cities in technological transitions: Analytical clarifications and historical examples. In *Cities and Low Carbon Transitions*; Bulkeley, H., Castán Broto, V., Hodson, M., Marvin, S., Eds.; Routledge: London, UK, 2013; Volume 35, pp. 13–28.
58. Hodson, M.; Marvin, S. Cities mediating technological transitions: understanding visions, intermediation and consequences. *Technol. Anal. Strateg. Manag.* **2009**, *21*, 515–534. [CrossRef]
59. Späth, P.; Rohracher, H. Local demonstrations for global transitions: Dynamics across governance levels fostering socio-technical regime change towards sustainability. *Eur. Plan. Stud.* **2012**, *20*, 461–479. [CrossRef]
60. Hodson, M.; Marvin, S. Can cities shape socio-technical transitions and how would we know if they were? *Res. Policy* **2010**, *39*, 477–485. [CrossRef]
61. Hoppe, T.; Graf, A.; Warbroek, B.; Lammers, I.; Lepping, I. Local Governments Supporting Local Energy Initiatives: Lessons from the Best Practices of Saerbeck (Germany) and Lochem (The Netherlands). *Sustainability* **2015**, *7*, 1900–1931. [CrossRef]
62. Hoffman, S.; Fudge, S.; Pawlisch, L.; High-Pippert, A.; Peters, M.; Haskard, J. Public Values and Community Energy: Lessons from the US and UK. *Sustainability* **2013**, *5*, 1747–1763. [CrossRef]
63. Scoones, I. Sustainability. *Dev. Pract.* **2007**, *17*, 589–596. [CrossRef]
64. Walker, G.; Shove, E. Ambivalence, Sustainability and the Governance of Socio-Technical Transitions. *J. Environ. Policy Plan.* **2007**, *9*, 213–225. [CrossRef]
65. Yin, R.K. *Case Study Research: Design and Methods*, 4th ed.; Sage Publications: Los Angeles, CA, USA, 2009.
66. The Federal Government. Energiewende: Maßnahmen im Überblick. Available online: http://www.bundesregierung.de/Content/DE/StatischeSeiten/Breg/Energiekonzept/0-Buehne/ma%C3%9Fnahmen-im-ueberblick.html;jsessionid=384458BD8066B80D628516114515E39C.s4t1 (accessed on 18 September 2015).
67. Beveridge, R.; Kern, K. The 'Energiewende' in Germany: Background, Developments and Future Challenges. *Renew. Energy Law Policy Rev.* **2013**, *4*, 3–12.
68. Luederitz, C.; Abson, D.J.; Audet, R.; Lang, D.J. Many pathways toward sustainability: Not conflict but co-learning between transition narratives. *Sustain. Sci.* **2016**. [CrossRef]
69. Innovation City Ruhr. Master Plan. 2014. Available online: http://www.icruhr.de/index.php?id=276&L=1 (accessed on 5 December 2016).
70. Oswick, C.; Robertson, M. Boundary Objects Reconsidered: From Bridges and Anchors to Barricades and Mazes. *J. Chang. Manag.* **2009**, *9*, 179–193. [CrossRef]
71. Woolthuis, R.K.; Hooimeijer, F.; Bossink, B.; Mulder, G.; Brouwer, J. Institutional entrepreneurship in sustainable urban development: Dutch successes as inspiration for transformation. *J. Clean. Prod.* **2013**, *50*, 91–100. [CrossRef]
72. Bulkeley, H.; Broto, V.C.; Hodson, M.; Marvin, S. Introduction. In *Cities and Low Carbon Transitions*; Bulkeley, H., Castán Broto, V., Hodson, M., Marvin, S., Eds.; Routledge: London, UK, 2013; Volume 35, pp. 1–10.
73. Rohracher, H.; Spath, P. The Interplay of Urban Energy Policy and Socio-technical Transitions: The Eco-cities of Graz and Freiburg in Retrospect. *Urban Stud.* **2014**, *51*, 1415–1431. [CrossRef]
74. Luhmann, N. Differentiation of Society. *Can. J. Sociol.* **1977**, *2*, 29. [CrossRef]
75. Luhmann, N. *Die Gesellschaft der Gesellschaft*, 1st ed.; Suhrkamp: Frankfurt, Germany, 1997.
76. Becker, S.; Moss, T.; Neumann, M. The Importance of Space: Towards a Socio-Material and Political Geography of Energy Transitions. In *Conceptualizing Germany's Energy Transition: Institutions, Materiality, Power, Space*; Gailing, L., Moss, T., Eds.; Palgrave Macmillan UK; Palgrave Pivot: London, UK, 2016; pp. 93–108.
77. Coenen, L.; Benneworth, P.; Truffer, B. Toward a spatial perspective on sustainability transitions: Special Section on Sustainability Transitions. *Res. Policy* **2012**, *41*, 968–979. [CrossRef]
78. Coenen, L.; Truffer, B. Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field. *Eur. Plan. Stud.* **2012**, *20*, 367–374. [CrossRef]
79. Rutherford, J.; Coutard, O. Urban Energy Transitions: Places, Processes and Politics of Socio-technical Change. *Urban Stud.* **2014**, *51*, 1353–1377. [CrossRef]
80. Bourdieu, P. *Les Règles de L'art: Genèse et Structure du Champ Littéraire*; Éd. du Seuil: Paris, France, 1992.

81. Miller, C. Hybrid Management: Boundary Organizations, Science Policy, and Environmental Governance in the Climate Regime. *Sci. Technol. Hum. Values* **2001**, *26*, 478–500. [CrossRef]
82. Rutherford, J. The Vicissitudes of Energy and Climate Policy in Stockholm: Politics, Materiality and Transition. *Urban Stud.* **2014**, *51*, 1449–1470. [CrossRef]
83. Rutherford, J.; Jaglin, S. Introduction to the special issue—Urban energy governance: Local actions, capacities and politics. *Energy Policy* **2015**, *78*, 173–178. [CrossRef]
84. Späth, P.; Rohracher, H. Conflicting strategies towards sustainable heating at an urban junction of heat infrastructure and building standards. *Energy Policy* **2015**, *78*, 273–280. [CrossRef]
85. Shove, E.; Walker, G. CAUTION! Transitions ahead: Politics, practice, and sustainable transition management. *Environ. Plan. A* **2007**, *39*, 763–770. [CrossRef]