smart cities

MDPI

Article

Planning Principles for Integrating Community Empowerment into Zero-Net Carbon Transformation

Liwen Li [1,2,*] and Klaus W. Lange [1]

[1] Faculty of Human Sciences, University of Regensburg, 93053 Regensburg, Germany
[2] Regensburg Center for Energy and Resources, Regensburg University of Applied Sciences (OTH), 93053 Regensburg, Germany
* Correspondence: liwen.li@ur.de or liwen.li@oth-regensburg.de; Tel.: +49-(0)941-943-3848

Abstract: The adoption of the UN 2030 Agenda and the Sustainable Development Goals is a landmark in international sustainability politics. For example, Europe has set ambitious targets to achieve 100 climate-neutral and smart cities by 2030. However, numerous case studies from different countries have found that accelerating the transition to net-zero carbon emissions is easily hampered by the lack of a coherent systems framework, and that implementation gaps remain at the community level. These barriers are often due to a lack of an adequate end-user (i.e., household) input and early planning participation. This work therefore aims to improve on conventional planning methods that do not reflect innovative technologies with uncertainty and may not be applicable due to the lack of community empowerment, which is a dynamic learning and intervention opportunity for end-users at different planning stages (i.e., outreach, survey, planning, implementation, management, and maintenance). Using the lessons learned from participatory action research, whereby the author was involved as a project director throughout the planning and design process, we identified a six-step cycle principle. The steps are (1) collective action commitments, (2) local values and resource identification, (3) carbon footprint inventory, (4) optimized integration of environment, economy, and energy action plans, (5) Flexible strategic energy system plans, and (6) digital performance monitoring. Ultimately, the outcomes provide application support for policymakers and planners and stimulate community engagement to contribute to the achievement of zero net carbon emissions.

Keywords: low-carbon communities; public–private partnerships; collective actions; participatory action research; responsible research innovation; environmental planning; social science

Citation: Li, L.; Lange, K.W. Planning Principles for Integrating Community Empowerment into Zero-Net Carbon Transformation. *Smart Cities* **2023**, *6*, 100–122. https://doi.org/10.3390/smartcities6010006

Academic Editors: Aapo Huovila, Adriano Bisello and Guarino Francesco

Received: 8 November 2022
Revised: 19 December 2022
Accepted: 22 December 2022
Published: 26 December 2022

1. Introduction

The adoption of the UN 2030 Agenda and the Sustainable Development Goals is a hallmark in international sustainable development politics. To accelerate progress toward the goals, countries have committed to setting relevant policy-driven plans [1–4]. Europe, for example, has pledged to take a leadership role in climate action and has set an ambitious target of 100 climate-neutral and smart cities by 2030. Similarly, three batches of low-carbon city pilot projects were launched in China from 2010 to 2017, expanding low-carbon pilot projects to 100 cities and approximately 1000 communities [5]. However, whether it is a cross-national region or a single country, the rapid increase in numbers to accelerate the transition to net-zero carbon emissions is easily hindered by the lack of a coherent systemic framework to support it [3]. This is because the transition to net-zero emissions involves many innovative developments in technology, economy, and society. Innovation is an overturning of traditional consumer behavior, policy decisions, technology development, energy and land use, and spatial planning models [6]. Hence, seeking local acceptance and support to achieve energy efficiency (EE) and sustainability goals is necessary and important to empower community users to participate in sustainable development management during the initial operational mechanisms and planning process [7], in addition to enhancing innovative community energy planning and design approaches.

Community-scale development projects with very low fossil fuel use and greenhouse gas (GHG) emissions have been promoted in many countries. These projects are known by names such as 'carbon neutral communities' [8], 'low-carbon communities' (LCCs) [9–11], 'renewable energy communities' [12,13], and 'net-zero energy communities' [14,15]. Different projects take different forms, but all play a significant role in showing how place-based communities can exist with far less dependence on fossil fuels and far fewer greenhouse gas emissions. Yet, getting such projects designed, approved, financed, constructed, maintained, and monitored is far from easy. In addition to the lack of a coherent planning system framework as mentioned above, the main reason is the lack of sufficient input from end users (i.e., households) to participate in early planning and build their capacity through the planning process, and ultimately through their own actions that can contribute to net zero communities in the long term. For this reason, recent studies have begun to focus on community empowerment [16–18] and highlighted the importance of social factors in influencing long-term local energy and climate change [19]. The transformation of community residents into the energy system can be facilitated through an empowering process of providing information and choice, further supporting them to self-manage demand and supply with a flexibility of their own energy system. Furthermore, with respect to community-based approaches, research indicates that the recognition and incorporation of local values, capacity, and knowledge is increasingly considered an essential part [1,20].

Yet, the question remains as to how and what mechanisms are available to integrate community empowerment into the planning process, especially in countries where historically no energy community exists [21,22]. Finding this answer is opportunistic, and it has proven successful in implementing empowerment through project-level energy planning practices, such as Canada [20] and even achieving gender inclusion in the past [23]. To adjust its feasibility and clarify which mechanisms can incorporate community empowerment into the planning process, our study adopted a participatory research approach using the first LCC in Taiwan as a case study, where the researcher was the project director of a government-commissioned planning and design project. To elucidate, the key issues are as follows: What drives community empowerment, and how can it be influenced? What drives the feasibility of RE development and EE deployment in the specific case study area? Finally, what drives effective work on integrated energy, environmental, and economic (3E) assessment into the planning process?

To answer these questions, in Section 2, we review the literature to identify the driving facilitators that influence community empowerment to embed zero net carbon. We then tested these planning models in an actual hands-on project, the first LCC in Taiwan, a tea-making and tourism district in Pinglin, New Taipei City (NTC). For this purpose, we evaluated the proposed planning model through participatory action research (PAR). These methods are described in Section 4. We discuss the results of the application of the drivers in Section 5. In the final section, we summarize the key principles of the planning process based on the experience gained in the case study and then draw a conclusion.

2. Literature Review

Here, we construct hypotheses supported by two theories. Both collective action theory and coevolutionary theory are proposed as unique perspectives to contribute to the empowerment of communities in regulatory planning practices. Promoting collective action by building links between the private and public sectors and the community is not a new idea in community practice projects [24,25]. The external facilitators that collaborate with community action for renewable energy (RE) development can be identified from the definition of a sustainable community: "governors, politicians, project developers, technology market actors, professionals and citizens actively cooperate to develop high degrees of intelligent energy supply, facilitating sustainable energy sources" [26]. Facilitating mixed sector participation in community collective action as a way of empowering the community has been proposed to provide a number of key benefits [16,17,21]. The first benefit is pragmatic, as convincing individuals to shift to innovative technology is a barrier to sustainability; however, through ongoing experience, knowledge and information exchange can increase acceptance and trust [27]. Second, the empowerment process enhances the capacity of the community and facilitates the internal building of transformational capacity in accordance with a sense of ownership [17]. Thus, these benefits may be more significant than the results of the actual implementation of the projects.

Second, coevolutionary theory emphasizes the importance of non-economic factors (e.g., institutions and social norms) as a means of balancing energy technology with economic development [28,29]. Cherp and his colleagues best interpreted and applied Elinor Ostrom's approach [30] to national energy transitions [31], which conceptualizes coevolution as three types of systems: energy flows and markets, energy technologies, and energy-related policies [6]. We adopted three perspectives, political governance, social–technology, and technology–economy, and identified their related priorities, variables, and implementation key factors.

2.1. Political Governance Facilitators

The political governance-related facilitators are undertaken within the context of a network that is strongly linked by financial, knowledge, and governance frameworks. The linked public sectors vertically assume the policymaking, promoting, and budgeting responsibilities that are central to a sustained green niche of carbon reduction competitiveness and the promotion of collective action worldwide from communities and regions. For example, in many cases in the United Kingdom [31,32] and China [3,33], central government financial support for profit-based RE schemes is an essential framework for facilitating development. In addition to government initiatives, matching local economic conditions can be effective for organizing EE and technology deployment [34]. However, local governments or local authorities mostly play a role in responding to local conditions and, more significantly, encouraging and bridging government Initiatives into local actions [35,36]. Therefore, the role of local government in this initiative is to facilitate effective community engagement through the deliberative communication of legislative instruments and policy statements [37,38]. For example, in the United Kingdom, local authorities play a strategic role in influencing policy making and flexible engagement initiatives among diverse government sectors [35,39]. The three key drivers related to political governance thus, in agreement with [40], include well-structured planning processes, intensive collaboration with formal networks seeking knowledge and information exchange, and diverse financial resources.

2.2. Sociotechnical Facilitators

The sociotechnical facilitators allow private sectors such as NGOs, academic institutions, and professionals (planners) as well as public sectors to exchange knowledge, information and technical, financial and professionals' services. These groups of facilitators assist the community in sustaining a sense of local identity and green energy ownership. As the researcher stated, this is a long-term framing process and strongly relies on the building of social capital, social learning, and social norms [37]. Thus, these facilitators play an important role in communicating, coordinating, and transforming the process of community empowerment [17]. They create a logical facilitation of decision making through a systematic process that results in the best actions by coordinating information and activities with different sectors. For sustainable rural development, such as in Hungary and China, these actors facilitated the initiation of an international or national funded proposal, building partnerships among local institutions, community, and residents, enhancing local knowledge and capabilities, and forming actionable strategies [33,41].

2.3. Techno-Economic Facilitators

Recent studies in community energy planning have focused on the integration of flexible and diverse technologies involving three components: EE, RE, and energy storage. Although technologies such as wind and solar are maturing, there are still geographic, climate, and physical restrictions. However, current practices also face the problem of spare capacity to supplement storage technologies such as batteries or hydropower [42]. On the other hand, the driving forces for technical-economic actors are still more market considerations of renewable energies, as described by Balachandra et al., which include the structure of domestic production, advantages in market competition, opportunities for trade, and improved standards of living [43], as well as finical feasibility. One of the many lessons learned from the past decade in German communities is that bringing financial tools, such as Feed-in Tariffs (FIT), into policies is a major incentive factor for the successful development of green energy. Such tools provide investors and users a guaranteed price for power generated from a RE source and can reduce the public opposition against environmental impacts [44] and can even more bring positive public acceptance and participant projects [16,45] if a planning process is openly discussed through community involvement and acted upon with multiple actors.

Furthermore, to incentivize community engagement in multi-energy systems, in addition to the green energy price market mentioned above, infrastructure development, such as grid stability support, energy service, and product differentiation, is also critical [42]. Thus, policymakers are required to monitor the progress of the rapid diffusion of innovations and stimulate the development of complementary innovations such as infrastructure to prevent the emergence of critical bottlenecks. Moreover, it is also important to facilitate a feasibility study of detailed techno-economic and environmental comparisons of different options [46].

Participatory processes have been identified by empirical studies as more effective planning methods, providing citizens and stakeholders with information and empowerment tools, as in the case of local energy transformation in Germany [40] and Sweden [47]. As Gustafsson et al. noted, participation is a way to improve learning and can create trust relationships, insights, coordinated action, and social change through the collective engagement of communities and external stakeholders [47]. All participants are to be considered as having equal legislative rights to express their opinions. Thorough knowledge exchange and quality communication are considered valuable tools for meeting public perceptions and active public participation. A summary of the literature here illustrated the importance of communication and learning among internal and external participants involved in community energy projects, and the opportunities to drive innovative socio-technical–economic transformations.

2.4. Planning Process Assumptions

Recently, there has been a growing research interest in this practical approach to energy community planning, such as from an urban planning perspective [48], urban hybrid RE planning [49], and simulation smart energy planning [50,51]. So far, however, scholars have mostly focused on more single-solution-oriented research. Amado [52] from a techno-economic facilitation perspective suggested that the integration of urban planning is an opportunity to reduce energy consumption and to support the integration of solar systems and smart grid technologies in an urban context. Akrofi et al. [48] reviewed 15 current articles on solar urban planning and found that the interrelationship between solar energy and urban planning remains largely unintegrated. A common feature of the above studies related to planning projects is that they all lack a holistic planning framework and focus more on the operative process of energy planning. To meet the net-zero carbon emission transition of the empowered communities, the three main facilitators mentioned above covering the socio-technical and economic conditions are fundamental in the planning development process. In the following, we illustrate how we apply literature-based drivers in our model for planning hypothesis.

2.4.1. Environmental and Socioeconomic Context-Based

Planning for community level energy transitions is site-specific, and the three facilitators mentioned above play a location-independent role in their emergence, such as appropriate policy plans and support for participatory learning processes. One review study [53] noted that geographic context and cognitive cultural factors are also critical in influencing community participation and empowerment, although these were rarely mentioned in past case studies. A site-specific alternative reflects the resources and strategies that are most suitable for the application. Furthermore, the different site-specific concerns for RE are all strongly connected to the geographical location, which can impact economy-of-scale benefits and are also influenced by population factors, such as density and distribution. When community-owned projects are based on a particular sense of place and the specific site is designed with maximized benefits from the local climatic conditions and landscape structures, while blending into them, the projects have been shown to make unique contributions to socioeconomic improvement [54]. A different range of impacts on communities, habitats, and landscapes are an inevitable result of infrastructure installation for energy supply. Therefore, a vital principle of planning involves the examination of the macro climate and landscape conditions for effective local energy use and supply [55,56].

2.4.2. Integrating 3E Assessments into Planning Processes

3E developments are often intertwined in the community-level planning process and influence decision-making. These interrelated problems and benefits of 3E changes pose immense challenges for the future identification and quantification of community resource potential and gaining access to a wide range of knowledge at a practical community level [50,57]. Moreover, research has shown that traditional planning, with its technology-focused short-term problem-solving approach, often fails to consider or predict the impact of actor or user behavior [58]. Therefore, it is recommended to integrate various analytical tools early in the decision-making process [15,50,59] to aide in the planning of action schemes.

A Carbon Footprint Inventory (CFI) or Greenhouse Gas Inventory is measured in terms of carbon dioxide equivalents associated with the production and consumption of goods, services, and personal activities within a certain boundary [60,61] and varies depending on the available data and the scope of the consideration [62]. It is considered an important assessment tool to quantify and analyze a community's energy production and consumption and its environmental impact in order to understand local lifestyles and what types of socio-economic activities affect energy use. To achieve efficiency, most authors agree that it is critical to measure initial household energy demand on a macro scale over time and between countries and sectors [63,64]. Therefore, the baseline setting from quantifying CFI is expected to be a useful communication tool for energy performance management for the correct selection of green technologies [65] and the consequent reduction of the release of carbon emissions from RE sources [64]. The community-level CFI includes energy consumption by households and private vehicles, water use, and domestic waste management by community residents. In some cases, it also includes energy consumption by local products and visitors, depending on their industry.

Assessing and locating current potential RE models—solar/wind/hydro/biomass—of local resources within the context of environmental, technological, economic, and practical criteria have been widely developed to apply RE resources in a planning system for a renewable future [35,50,59]. The multicriteria RE assessment proposed by Nigim et al. [24] is a comprehensive measurement tool that supports decision making in consideration of both human/environmental impact and project feasibility. The criteria established for human/environmental impact are ecological impact, social and economic benefits, and education potential. Additional categories of project feasibility criteria include resource availability, technical feasibility, and financial viability [50,66]. The challenges of RESs are to balance the costs and benefits within a practical project and the technological improvement and its influence, which cannot be predicted [50].

2.4.3. Flexible Strategic Energy System Planning

A rich body of research is interested in constructing a decision support framework for assessing the feasibility of existing renewable energy technologies [15,59,67,68]. Most of them [15,69] suggested that energy planning needs to be flexible enough to moderate the optimal integration of niche-technologies, business models, and regulation addition to stakeholder perspectives and judgments about priorities [29,70]. Hybrid energy resource design can take many different approaches and objectives, from obtaining a low environmental impact to assessing the geographic and climatic potential of a community to obtain a 3E optimized installed system that implements sustainable energy in the right location. Energy design methods and tools can therefore support this decision-making process with accurate and timely modeling of energy performance. A review work [71] outlines nearly 200 solar design tools, covering accuracy, complexity, scale, computational speed, and 2D/3D environment performance characteristics. Furthermore, incorporating flexible responses to change and feedback in dynamically adjusted energy planning and investment management has preserved the benefits of improved customer energy use behavior in the empowerment process. Three suggestions for having a holistic view of 3E interactions based on continuous evaluation of information and reflecting flexible decision making are as follows:

(1) a strategic position for promoting lifestyle changes related to the actual relationship between the community and its environmental and socioeconomic context at a specific point in time;
(2) Strategic green technology applications, which refer to an intended relationship and consist of a set of integrated energy systems. The integration of EE and RE systems is designed to maximize the benefits of reducing costs, land usage, and environmental impacts; and
(3) energy performance monitoring, which is applied in the overall steps to evaluate the progress of achievements. The review of the effects and benefits that can be achieved becomes a starting point for the community to take action on sustainable behavior change and energy conservation.

2.4.4. Identifying 3E Performance Indicators

A process of community empowerment to create baseline information on 3E conditions is used to monitor the impact of new and improved energy management. Establishing long-term actionable indicators to verify feedback from the information system is a useful tool for mobilizing community participation [72,73]. The useful indicators are ideally simple, effective, and clearly defined and are also associated with an action plan through a collaborative learning process for a sustainable community [72]. Therefore, the process of establishing indicators to enable the local community to improve its own living standard must be based on a long-term adopted learning process [72,74]. In a theoretical review, Innes and Booher (2000) suggested that establishing indicators through a collaborative decision-making process requires three considerations [75]:

(1) Participants: key stakeholders, agency players, experts, and local people to select a set of system indicators to avoid information overload;
(2) Leadership discussion: addressing difficulties and controversial issues to increase opportunities for learning and change; and
(3) Prioritizing indicators: the potential action for selecting the forthcoming indicators should meet the actual policy proposed.

3. Methods and Materials

Considering the effectiveness and efforts of participatory planning in a LCC, the initial objectives of PAR are expected to be practice-based observations [76,77] because project evaluation and the evaluation of an intervention involving program-relevant actors can have different influences on the outcome, based on context, mechanisms of actions and interactions [78] and practicable exchange tools for knowledge sharing and for transferring knowledge into practice and maximizing community involvement [77,79]. As we emphasized in the introduction, the transition to net zero emissions involves many innovative technological, economic, and social developments, and barriers arise when stakeholders are unfamiliar with these developments.

Thus, the enabling process enhances capacity and, as a result, the actual planning project may be more important than the actual implementation outcome, PAR is envisioned as an effective method for understanding the planning process by shifting the power dynamics between researchers and community participants, leading to a perspective in which residents recognize the benefits of innovative technologies and influence decision-making. Grounded in a project-based and community-engaged learning approach and democratizing innovation in the planning process [80,81], reflection on change and participation-based hybrid approaches were used to explain how stakeholders collectively represented the scope and boundaries of the project. A case study in Germany also took this approach to diagnose how different actors succeeded in transforming previously poor agriculture to locally owned RE industries through collective action [82]. On the other hand, the collective action analysis approach of participatory planning allows researchers to adapt assumptions and methods in such a way that more details of the local situation can be discovered through the community RE projects [83].

In addition, in studies of participatory approaches to developing recommendations for sustainable energy development in a carbon-intensive jurisdiction, the analysis of the direct output and input of all relevant stakeholders was designed to explore the changes in institutional arrangements, financial incentives, and technological options [76]. As an illustration of the possible roles and principles adopted by public and private sectors in an LCC project, PAR is not valuable from a participation viewpoint but rather because it influences the processes through which the new planning method is established. PAR was combined with the collective action model of participatory planning to empower community self-sustaining energy management in the Pinglin communities, the first Taiwanese LCC project.

A PAR process was initiated as an attempt to understand how RE development and EE deployment can be achieved or obstructed on a community scale in Taiwan, as well as to assist the establishment of networks across the community and diverse sectors with common visions for knowledge production and collective actions. The approach of PAR used in this case study was based on practice-based observations and interactions [77] and practical exchange tools for knowledge sharing and transferring knowledge into practice to maximize community involvement [22], trust building, local value identifying, and a list of key stakeholders compiling [77]. The researchers who were engaged as the Pinglin LCC project director. With this role could be directed and obtained various qualitative and quantitative data by project participation and interaction components. The data were obtained by 3 different phases: first, participatory planning project including intensive meetings, workshops, and site surveys from 2009 to 2010. The project was packaged across three major steps in a binding contract. The first step was a model community selection from Pinglin's 78 communities. The second step was integrated assessment and planning. The third step was the presentation of a detailed design and budget. The second phase—implementation and construction during 2011–2012, and the third phase—community management and maintenance (starting once the construction was completed)—were conducted through site surveys and analysis, government reports from NTC and EPD, and interviews with officials.

The five methods were used to conduct the investigation in a deliberate process with different sectors.

(1) Coordination of meeting minutes from the Pinglin district office and community member meetings (4 times), community representative meetings (2 times), meetings with government staff (monthly), report reviewing committee and local authority meetings (3 times) were collected and analyzed for elements of community participation.

(2) Participant observations were observed at coordination meetings, public presentations, and workshops presented by members of the Pinglin LCC project to identify the key elements of community participation in research.
(3) In-depth individual interviews were conducted with key informants in different process steps during the planning work, including the head representatives of seven villages, community actors, university scholars, and municipal and central government officials involved in the LCC project. The purpose of the individual interviews was to gain a deeper understanding of the experience of participating in a research project in which community involvement was both valued and a necessary requirement.
(4) A semi-structured guide was developed based on the following factors: CFI, perception of RE technology, acceptance of developing Pinglin LCC, and resident and landowner stakeholders. The assessment and planning of the PV, wind turbine, and hydro-energy system were provided by 3 RE technology companies.
(5) Focus group workshops were conducted with key working groups, which have been shown to be effective for the dynamic exploration of differing experiences and perceptions and were therefore a valuable inclusion in this research project. In this manner, differences in some perceptions and consensuses on others were investigated.

4. Case Study

4.1. LCC Development in Taiwan

4.1.1. Policy and Initiatives

Taiwan's ambitions with respect to energy policy were encapsulated in the 2008 Sustainable Energy Policy Principles, which committed Taiwan to a 50% reduction in carbon emissions by the year 2025 through technological advances and supporting measures [84]. To reach this target, a two-year initiative for promoting LCC was initiated in 2011 by the Eco Community Implementation Office, which was established by the Environmental Protection Administration (EPA) in 2009 and closed in 2020. The initiative's goals included establishing two demonstration LCCs in each of 25 cities within two years and six low-carbon cities within five years. As of 2016, 114 demonstration LCCs have been selected, emphasizing that practicing energy conservation and carbon reduction were grassroots efforts and that reducing energy and resource consumption were primary goals.

The 52 low-carbon demonstration communities were selected by two key characteristics: recommended by the city government with community mobilization and voluntary participation and evaluated by experts for potential carbon reduction opportunities. In 2014–2016, a similar promotion initiative called "Low-carbon and Sustainable Communities" was announced. The purposes were to analyze the carbon reduction performance of the 52 existing LCC pilot projects, to establish a certification system for pilot projects, and to expand 42 LCC demonstration communities. The last initiative related to Taiwanese LCC was initiated in 2016 with six main goals. They are reviewing the carbon reduction measure planning of the 91 existing LCCs, constructing 22 new low-carbon and sustainable demonstration communities, guiding at least 10 low-carbon and sustainable demonstration communities in achieving the silver level of certification, selecting one low-carbon and sustainable demonstration community for upgrading to include an environmental education promotion function, instilling businesses and property management services to jointly participate in community building, and guiding at least five low-carbon and sustainable communities to work with adjacent communities in extending implementations.

4.1.2. City Government Response and Actions

Prior to the central government plan, in 2007, as part of the mayor's vision, the powerful NTC government announced the ambition to build the first low-carbon city in Taiwan. The intention was to enhance the social welfare of citizens and, as announced by the government in its budget, to reduce carbon emissions by 20% over a 20-year period [39]. NTC was also the first municipality to establish an official carbon-reducing organization, the Low-Carbon Community Development Centre (LCCDC), which is regulated by the Department of Environmental Protection (DEP). Since 2008, the LCCDC has initiated the first low-carbon tour event in Pinglin, called "The Pinglin Low-Carbon Eco Tour", in cooperation with the local Pinglin District Office (PDO). The tour program was initiated and promoted by the local government, and the private sector has thus far been responsible for implementing the events. The major aim of this program was to reduce carbon dioxide emissions through a traffic control system, including controls on car access and the provision of free public transportation. Free transportation and a tour guide service are used to attract tourists.

4.2. Pinglin LCC Project Advocacy Stage

Aiming to develop Taiwan's first LCC in Pinglin, the NTC municipality, with the assistance of a research team of one of the authors, applied to the central government in 2009 for regular annual program funding called the "Experimental Eco-Community Grant initiative". The initiative, which has been in place since 2004, was designed to encourage broad community participation in the local planning process, allowing experts to apply creative ideas and utilize local resources to build a vibrant community and develop appropriate industries while maintaining local character. Additionally, the local government has proposed the following three goals for this project.

(1) Address local problems associated with potential soil erosion and water pollution in tea plantation areas, high energy costs associated with tea making, and poor living standards in community buildings;
(2) contribute to wider local and national government policies for achieving 50 LCCs by 2012; and
(3) act as an example for other rural, remote, and protected areas willing to establish self-supporting and sustainable RE systems.

Pinglin is a predominantly forested district with an area of 170.83 km^2 that incorporates seven villages within the Taipei water protection area in northern Taiwan. Within the Taipei Water Special Area (TWSA), Pinglin, along with three other districts, has, since 1987, experienced conflict between economic growth and interest groups oriented toward environmental conservation. The TWSA was tasked with protecting the Feitsui Reservoir from siltation and pollution and guaranteeing a stable drinking water supply for the five million residents in Taipei City and a portion of the NTC. Since the establishment of the TWSA, it has been extremely difficult to cultivate agricultural land in Pinglin and construct more buildings. Strict land use controls have caused difficulty for local residents in the restoration of land use development rights. To improve this situation, the local government has actively promoted the local infrastructure for tourism development, including tea-culture tourism, as part of the cultural identity, and, since 1996, eco-tourism, by planning hiking and biking trails. To understand Pinglin's socioeconomic context, Figure 1 presents the history of economic development and community mobilization in the region on issues related to the environment.

Thus, the initiative of achieving Pinglin LCCs has been viewed recently by governments as an effort to reduce local conflicts, seen, for example, in a 50% decline in tourism since 2006 following the opening of the Taipei-Ilan Expressway No. 5. This nonstop transportation system has recently brought competitive advantages and enhanced the attractiveness of the neighboring city of Ilan but has negatively impacted tourism development in Pinglin. Pinglin used to be a very important midsize town with a well-developed tourism industry, serving as a gateway for passengers of the maintain-highway between Taipei and northeastern Taiwan. However, after the opening of Expressway 5, the number of car-driving tourists declined dramatically, and fewer tourists stopped shopping for local products. In view of this local economic impact, the PDO and municipal NTC government invited environmental scholars to analyze the possibilities for tourism transformation and development options.

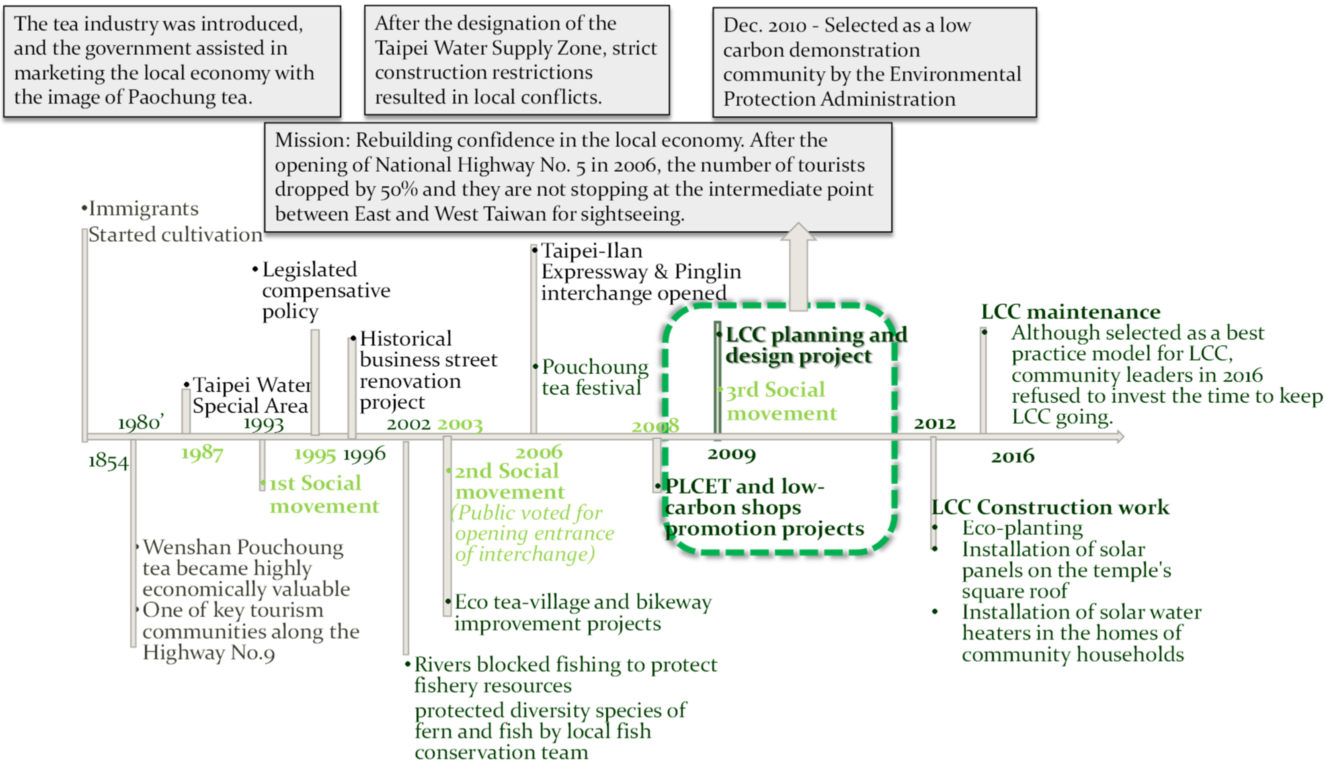

Figure 1. Timeline of Pinglin's socioeconomic context.

4.3. Planning and Design Stage

The Pinglin planning and design of LCC project was more complicit than traditionally practiced, due to more consideration of the economic aspects of energy technologies. As mentioned in the literature, the acceptance of this innovative technology by stakeholders and residents, as well as the limitations and risks associated with its application, made it more complex than traditional planning, and required more communication and integration efforts. The actual tasks framework of the Pinglin LCC project is shown in Figure 2 and is grouped into three main categories: energy planning considering economic technology, traditional planning considering social technology, and empowering participation considering political governance. The list of data requirements for each phase of task framework is shown in Table 1. For more details on the process and results, refer to the Supplementary Material.

Figure 3 shows an ideal planning concept for net-zero carbon emissions in the Pinglin LCC, seeking a balanced relationship between household and industrial energy demand and the supply of renewable energy within the boundary, without relying on external fossil energy sources and without polluting emissions.

Table 1. LCC's data use inventory for each phase of energy planning, spatial planning and community engagement.

Planning Tasks	Spatial Planning Data	Energy Planning Data	Community Engagement
Local social, economic, environmental issues and values identification (see Figure 1)	- Population and number of households - Land area and land use and coverage - Topography and climate - Public transportation system - Economic: income sources, local business	- Building types and materials - Industries and major products - Living style patterns	- Interview with local leaders, agencies and government - Organizing regular local forums - Collection of local voices on current environmental issues and local values)

Table 1. *Cont.*

Planning Tasks	Spatial Planning Data	Energy Planning Data	Community Engagement
Carbon footprint inventory (See Figure 3)	- Energy demand and supply - Water resources - Public and private transportations - Industrial Structure	- Number of people in the household - Household type: Home-based tea making, home-based restaurant, B&B operation, campground - Number of cars and usage, public transportation system - Electricity usage: Electricity and barrel gas - Water consumption: Groundwater cannot be estimated - Cooking and cooling facilities	- Households and business visits and survey - Power and gas company data collection - Consumption patterns of food and living on households * - Local business **: number of visitors, peak period, energy, water and gas demand and supply
Pilot community selection	Criterion 1. The best accessible and visible for public Criterion 2. Effective combination of local attractions for tourism concerns	Criterion 3. Energy efficiency living style Criterion 4. Potential feasibility of mixed renewable energy resources	Criterion 5. Residents mobilities Criterion 6. Cooperation and action willingness (Political relationship and preferences)
Renewable energy resource feasibility assessment	Criterion 1. Area of public Land Properties Criterion 2. Traffic and construction site accessibility	Criterion 3. Local geographic microclimatic environment, i.e., wind direction and speed Criterion 4. Amount of organic waste Criterion 5. Roof type/slop and shaded area of the buildings and maximum area of unused open space	Criterion 7. Residents' willingness to take action to conserve energy use Criterion 8. Residents' willingness to install energy saving and RE equipment ****
Community spatial planning	- Public and private land ownership and zoning map - Analysis of land use and building use - Analysis of the improvement of the existing spatial landscape environment	- Analysis of building styles and floor heights - Transportation routes and spatial distribution of settlements	- Community wastewater connection plan - Tea farm irrigation system configuration ***
Energy scenarios planning *****	Scenario 1. The multi-functional land use model. - Multi-functional land use planning - Visual impact assessment - Environmental impact assessment	- Scenario 2. 100% community RE mixed with small wind, solar and hydro system, i.e., combining GIS data and solar analysis software tools to evaluate solar radiation incident on open space or roof and facade areas over a one-year period	- Building partnership with different energy companies - Seeking for land or roof usage agreement form owners
Detailed Design	Priority design projects for implemented immediately and have visible results	- Priority design for lowest cost maximum benefit projects	- Communication with residents around the construction area - Coordination with governmental authorities related to the construction of the project
Benefits and cost analysis	Overall community development benefits, such as improving the environment and increasing tourism development opportunities	- Carbon emission reduction scenarios analysis - cost and risk assessment analysis	- Community common, individual, stakeholder cost-benefit analysis

* Comparison of the other regions and living patterns were required. ** Family tea manufactory required high energy demands. *** Local Industries, ecological and living environment, such as forest and river surroundings, tea plantations and small family vegetable farms. **** The wait-and-see attitude was dependent on government financing. ***** Small scale wind and hydro energy technologies were still rare in Taiwan.

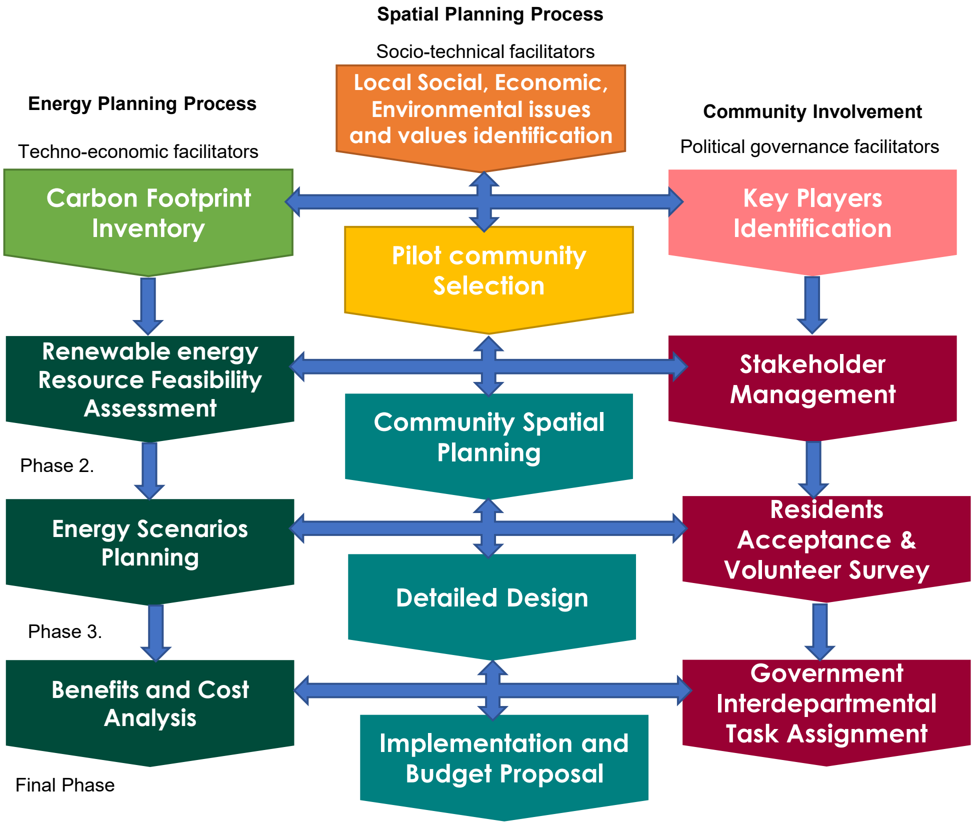

Figure 2. The task framework of Pinglin LCC Planning and Design Project.

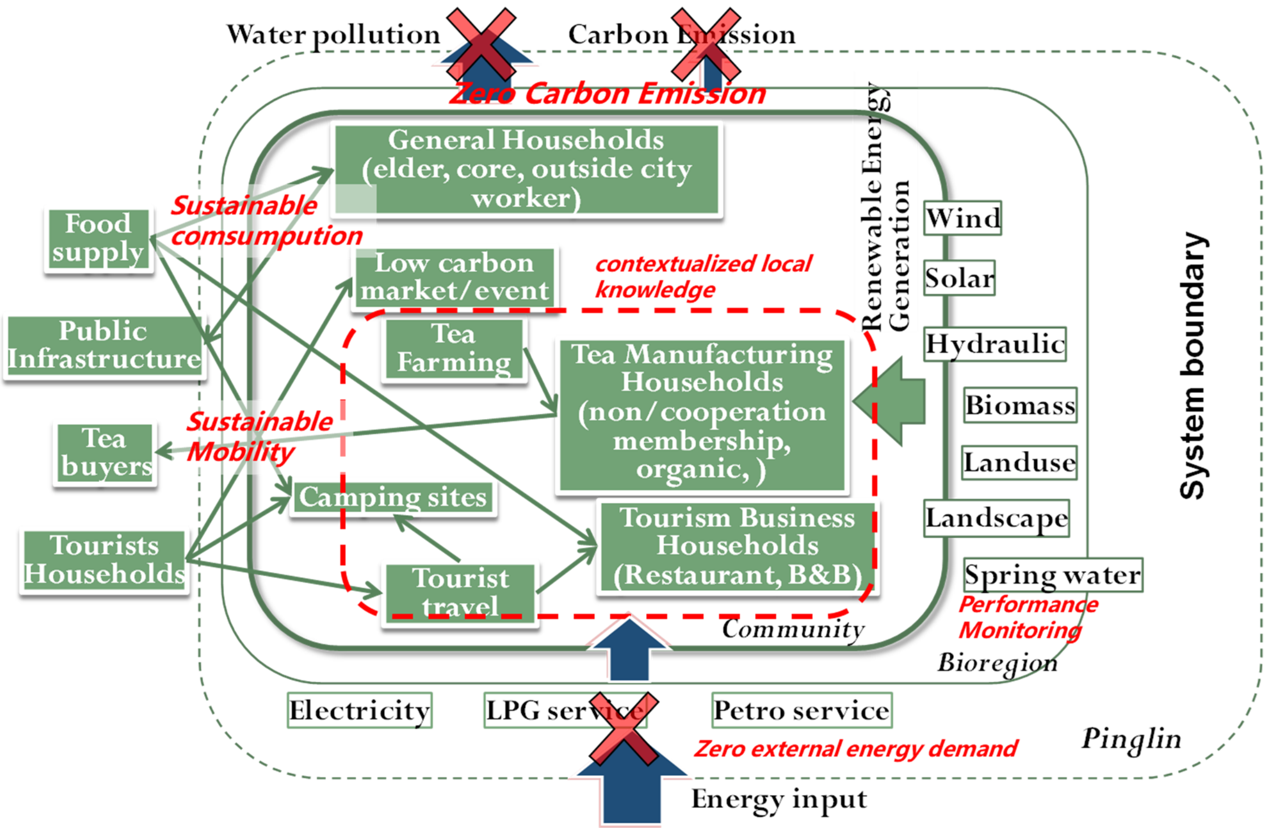

Figure 3. A systematic conception of the relationship between carbon footprint inventories and renewable energy assessments within a system boundary of the Pinglin LCC.

4.4. Implementation Stage

After the completion of the planning and design project, the author was not further involved in the implementation of the construction phase. After the planning and design project was completed, the author was not further involved in the implementation of the construction phase. But the result of the project was evaluated as the first model community by the Central LCC Project and was granted a construction grant. The construction was completed in 2014 with NT$193,200 raised by the city. However, many of the contents of the plan and design were removed due to funding and construction period considerations, and were also modified in order to respond to the six low-carbon assessment directions set by the central government. The final construction contents are listed in Table 2 according to the EPA's six major carbon reduction initiatives.

Table 2. List of contents of the final construction.

Low Carbon Directions	Implementation Contents
Eco-planting	Planting native plants Rooftop greening Subsistence farming Impervious pavement improvement
Low carbon building energy saving	Energy saving street light replacement Reuse of unused space in historic buildings
Renewable Energy	Installation of solar panels on the temple's square roof Installation of solar water heaters in the homes of community households
Low Carbon Transportation	Bicycle charging station and small photovoltaic system time display Connection of electric shuttle bus
Resource Recycling	Installation of rainwater recycling Water saving improvement of household toilets and faucets
Low carbon living	Counseling B&B operators to conserve resources

Management stage: In 2016, this community was also awarded the certification from "Low-carbon and Sustainable Homeland Promotion initiative". This central initiative established an Evaluation and Certification System. The implementation agencies are short-term (most two years) contractors that support the EPA in implementing the certification system. The certification for low carbon and sustainability measures are divided into five main areas: "Eco-Greening"—by increasing green cover and protecting habitats; "RE and EE"—by establishing RE sources and using energy efficient facilities; "Green Transportation"—by promoting the use of public transportation or bicycles; "Low Carbon Living"—by using low carbon products; and "Resource Recovery"—by recycling and reusing waste and water resources.

However, in the recent development status, during 2015–2016, the EPD's external implementation agency has tried to assist the model community in Pinglin to participate in the upgrade of low-carbon home certification, but the results of the visit were not optimistic, as stated below:

> " … *The current community leader has focused on the economic development of the community and has devoted less attention to low-carbon homes, and due to the limited number of volunteers, it is not easy to promote the community* … "

5. Results and Discussion

The findings below illustrate the ramifications and challenges associated with the use of collaborative strategies based on the Pinglin LCC experience. In contrast to traditional planning methods, collective action was expected to increase multi-actor involvement in community empowerment in countries working toward building and piloting community-based energy. Most of the impact factors/principles are strongly interconnected. The effects cannot be explained by a single phenomenon, but a fundamental understanding will enable comprehensive achievement.

5.1. What Drives Community Empowerment, and How Can it Be Influenced?

(1) Managing local social capital by increasing accumulated social capital for empowerment

In examining how participatory planning works in practice, the Pinglin LCC demonstrates how the engagement of external actors who are intensively involved in a project deeply influences the attitudes of residents. Both positive and negative attitudes were simultaneously held by residents of the Pinglin community and were expressed via active and passive support or opposition. The degree of perceived personal benefit and concerns about risking existing community profits strongly influenced residents' attitudes toward the LCC during the preliminary implementation stage. The interest of residents changed from passive participation, possibly because at first, most residents had a wait-and-see attitude with respect to government actions and expected information on the specific economic incentives. The residents were more interested in what direct benefits could be gained through this project than in participating in the decision-making process for improving the public area. Second, given that family tea making is a time- and energy-intensive industry and a major source of livelihood for local households, residents' willingness to participate in public participation may be reduced based on this consideration. In support of this conclusion, government-organized workshops have historically featured low attendance by Pinglin residents. Evidence was also provided by the report of the community leader who reported that the community refused to undertake the LCC certificate upgrade program planned by the central government. This was because the busy tea-making business also lacked community volunteers. As researchers mentioned, the valuing of identity and recognition by leaders can promote local democracy among residents through local collective action [83,85].

(2) Building trust and capacity through partnership to ownership

First, it is not futile to explain the inherent benefits of RE when public involvement in achieving LCC development cannot be enhanced because identifying niche benefits takes time and trust as many researchers have mentioned [86,87]. The time when LCC development was at the initial stage in 2010, favorable RE technology impacts at the community level in Taiwan were not readily evident. As many resource and energy management approaches imply, the long-term net-zero carbon emission transition is not promising without the understanding and engagement of end-users or residents to take action [88–91]. Introducing community empowerment in the planning process can been as an important approach for building long-term actions through public and private partnerships [45], in this case community leaders also have the opportunity to participate. Then, trust can be built during the planning process to gradually form a partnership [86,92]. However, trust was not the main driving force in creating a collective action in Pinglin. The model of economic development in the tourism and tea industry communities may provide an example of interest incentives and how feedback from personal interests affects the development of public construction. Here, residents have become accustomed to giving greater priority to the cost-effectiveness of individual economic benefits. In fact, the external and internal relationships in which the value chain operates can positively or negatively affect the community's ability and motivation to acquire knowledge and translate that knowledge into actionable decisions. It is expected that the community, because of its greater awareness of the ownership of the energy system, will participate in its management, thus improving energy sustainability.

Second, a well-organized coordinating group within the Pinglin community can more easily obtain institutional support from external actors to facilitate the direction of the project and encourage local resident participation [74]. Similarly, in a rural village of Cumbria, local organization was shown to be a key success factor for aiding effective community involvement, building trust and empowering local knowledge and support for REC projects [93]. However, the establishment of local organizations requires active involvement with other actors and the generation of direct profits for local residents [94]. Otherwise, as occurred in Pinglin during the project period, the planner team can encourage the head of the village and residents to establish a local organization that can make community development more systematic and organized and act as an official channel to receive continued funding for supporting community development. However, this local organization has not yet been incorporated into the action. Therefore, the evidence mentioned above demonstrates that Pinglin residents were often reluctant to assume responsibility and looked to external support for leadership. Self-motivation is critical for sustained change, but it requires the empowering process: awareness, education, and incentives from external actors for support at the initial phase.

(3) Comprehensive and long-term resource integration and initial funding is necessary to kickstart community empowerment

Collective power and the establishment of public–private partnerships have replaced traditional, inflexible contract-based relationships; this is the first step toward a collective movement for sustainable energy. As the Pinglin project entered its final stages, although it received attention from various fields as well as government funding, the project outcomes were merely the installation of a simple solar roof and an energy-efficient toilet facility. Then, we could conclude that the reasons why some of the results of the planning and design project were not used in the construction phase are due to the following limitations of different actors.

- Planners and designs: they lacked basic long-term participation in assisting locals and government in project implementation, owing to contract, time, funding, and resource constraints.
- Organizers: they were unfamiliar with the operations of green energy technology and was averse to responsibility and risks, which caused a shutdown.
- Government decision makers: government was periodically restructured, leaders were changed, the principal focus shifted, and political incentives were lacking.
- Community residents: they lacked confidence and capability; although they felt helpless toward the current situation, they were also afraid of the risk of loss vested in the benefits promised by changes.

5.2. What Drives the Feasibility of RE Development and EE Deployment in Pinglin

(1) Energy price, maturity of community-scale RE technologies and financial systems

The maturity of RE technology development and the high cost of the current budget in Taiwan affect the tariff imbalance. The energy-related financial policy has been affected by the current price of energy. The cost of generating electricity with RE technologies is higher than that associated with nonrenewable energies in many Asian countries [95], including Taiwan. Since 2003, the Taiwan Power Company has issued interim measures for purchasing electricity from RE sources. Even the FIT established in March 2011 is designed to encourage the generation of RE in Taiwan, which has decreased from NT$ 2–2.6/kWh to 2.28/kWh in wind power. However, the diffusion of RE technologies has stagnated due to insufficient economic impetus at the current time for individual to take action [51], because of unattractive cost-benefit ratios and uncertainty around the capacity of installed RE techologies [96]. For this reason, in Taiwan, the development of RE is still limited to cases in which there is strong backing and supportive funds from the government, particularly at the initial level. Therefore, achieving coordination among the government sectors and between the public and private sectors requires the development of new mechanisms and processes for incorporating the diverse elements of the RE community system. Furthermore, the cross-sector linkage system (development investors, developers, manufacturers, generators, suppliers, banks and insurers) is expected to share the financial barrier to RE development with the government. Therefore, the government must play a leading role in fostering the broad application and acceptance of local RE technologies by reducing the risks associated with investments in RETs and addressing concerns about low-cost efficiency. Similar to the Italian and Brazilian cases, the challenges of adopting and developing their own RE resources and connecting to the grid by exploring voluntary behavior change in communities are demonstrated [21]. It is due to the fact that among the tech-economic factors involved in place-based community RE projects are many innovative and uncertain conditions that are beyond the knowledge and capacity of community residents.

(2) The transformative capacity of new green technologies as a project initiator

A significant barrier to an appropriate response from the contracting agency, which is driven by bureaucratic imperatives and parochialism, is that the relevant education and implementation of RETs is important but already beyond the scope of their responsibilities. The lack of coordination and cohesion within fragmented government sectors is a well-known problem in planning approaches, particularly at the practical community level. The three major sectors of NTC involved in the Pinglin LCC project were the commissioned contractor (URDD), parallel sector (LCCDC), and Pinglin administrative office (PDO). URDD was more mission oriented than the other sectors. Decision making was deeply influenced by their relevant legislative mandates with respect to the planning system and constrained budgets. We found that these constraints limited feasibility and influenced decision making. One way of translating the results of technical assessments and planning into a social reality can be, as Seyfang notes, in the form of networks based on top-down initiatives that can influence policy and bridge institutionalized learning through consultation [97]. However, the direction and outcomes of the Pinglin LCC were still impacted by the parochialism of URDD officers, who preferred that the strategies proposed for Pinglin LCC align with the existing operation framework and avoided tasks outside of their daily responsibilities, as well as the populism of government leaders in political considerations. The Pinglin LCC was the first application of RE technologies at the community level, and government contractors were unfamiliar with the implementation of new technology and engineering practices; in particular, the subsequent procurements for supporting convergence were still unable to meet the current task procedure framework. In light of this outcome, the two major related departments had different reactions in the follow-up to promote RE technologies. The LCCDC had a strong interest in the promotion of RE, while the URDD adopted a more conservative attitude.

(3) Land use and planning permission

The issue of strict land use controls by the TWSA strongly influenced the installation of public infrastructure RE technologies in Pinglin. However, a type of public building—the LCC education center—was designed to present two major functions. They are a showcase of integrated RE systems for building a zero-carbon-emission community for public education and promotion and a consultant service station for improving the EE of private buildings. However, according to the existing regulation of planning permission in the TWPA, the change in the land use category for building public facilities that is required to permit construction may take up to two years. Furthermore, the use of private property and the sharing of its interest between the public and private sectors are still not clearly defined in government-funded projects. The benefits received from REs and local EE actions require a new local institution to allow this technology to develop along with the community.

Therefore, the feasibility of RE development and EE deployment in Pinglin not only met financial barriers but also required the public and private sectors to build the transformative capacity of new green technologies. All these changes require a stronger and more supportive policy framework. A dual system encompassing a strong centralized regulatory framework combined with a focus on “top-down support for bottom-up initiatives” is suggested [98]. Thus, a supportive policy and financial framework within a well-structured niche market, trust and knowledge building, transparent communication, and value chain network will maintain a healthy public and private partnership.

5.3. What Drives Effective Work on Integrated 3E Assessment into Planning an LCC?

(1) Transparent information and flexible approaches in micro data

The adequacy of the community survey and 3E management depends on the collection of micro climatic and energy data. In Taiwan, however, the data at the community level were not sufficient or were scattered in various sectors, resulting in difficulties in data integration. For example, small-scale wind power generation technology is heavily dependent on accurate macro wind velocity information. However, in Taiwan, current data densities from weather stations are not sufficient to support community-scale wind power generation, and the use of large-scale measurements often leads to miscalculations. To resolve this issue, we proposed a flexible (step-by-step) assessment and planning process: first, data should be collected and made available as part of a hybrid approach involving the combination and comparison of data from regional statistics and local interviews. Next, LCC indicators are used as a tool for establishing a transparent process for building a monitoring system and evaluating the project from the beginning. Thus, these flexible approaches to micro data collection can gradually remedy the existing insufficiency of data and can offer more transparency and validity in the long run.

(2) Availability of appropriate technical and financial support

Although the government initiatives of LCCs development in Taiwan were ended in 2018, at that time, 144 LCCs had been selected and slightly reduced carbon emission by low carbon living or planting. Thus, the benefits to the RE companies involved in Plinglin's project included not only an opportunity to build a confident showcase through experimental experience with the first Taiwanese LCC, but also an opportunity to examine the maturity and capacity of assessing and planning community-scale RE systems. The process of debating the design of RE therefore shapes the thinking of decision makers concerning policies [99]. In line with this perspective, we agree with the researchers who stated that the implementation of REs by a public sector or private-public arena typically involves organizational and political attention to be given to the issues that they represent to make institutional change more accessible by overcoming the barriers presented by traditional patterns [33,100].

5.4. Planning Principles and Implementation Content Suggestions

Finally, to mitigate the expectation gap between public and private sector actors in actively empowering end-users to participate in energy transition projects, we emphasize that planning and design principles need to start from a vision of building incentives and commitment from collective actors and next consider the value of inclusive local environmental and cultural characteristics. Finally, we adjusted our model of planning principles that draws lessons from our study case, as shown in Figure 4, and each detailed implementation is suggested in Table 3.

Table 3. List of implementation contents for each planning principles.

Principle	Implementation Content
Phase 1. Collective action commitments: Clarify stakeholders who have authority and existing organizational structure as well as resources under their management	(a) Community culture and organizational analysis (b) Network of main stakeholders (c) Development context of related environmental and public affairs. (d) Analysis of local values, abilities, and knowledge conditions. (e) Formulation of a thematic framework and time and place for regular community discussions

Table 3. *Cont.*

Principle	Implementation Content
Phase 2. Values and resources identification: Define community scope and environment, and analyze the situation of cultural, social, and economic development.	(a) Analysis of geographical environment (b) Land area, population, administrative divisions, topography, and environmentally sensitive conservation areas. (c) Climate and microclimate conditions. (d) Land utilization and land ownership. (e) Analysis of population structure and socioeconomic conditions (f) Household population composition. (g) Economic activities of key industries. (h) Consumer behavior regarding food, clothing, housing, transportation, education, and entertainment. (i) Analysis of tools and systems of transport (j) Type, volume, and frequency of use of transportation means by households. (k) Analysis of transport systems that connect other regions and the convenience of public transport. (l) Analysis of the environmental friendliness of bicycles and people
Phase 3. Carbon footprint inventory: The inventory of the energy consumption behavior model and volume of households and industries in the community serves as the baseline comparison value of the subsequent development of an LCC.	(a) Set up a system boundary and community carbon footprint baseline (the scope and category definitions are estimated) (b) Take inventory of household carbon footprint • Interview survey of household population and lifestyle behavior. • Average annual energy requirements and carbon emissions from food, clothing, housing, transport, education, and entertainment. (c) Take inventory of industrial carbon footprint • Type and number of industrial sectors. • Calculation of the product lifecycle of each type of industry and carbon emissions. (d) Others: • For example, carbon emission of tourists from consumer behavior in the community.
Phase 4. Optimized integration of 3E action plans: Analysis of the application feasibility, suitability, and efficacy of green technologies.	(a) Current government policy and related supplementary operating procedure. • Application conditions for green electricity and coefficient of purchasing price. (b) Specifications of current technology and various green electricity technologies. (c) Feasibility assessment of renewable energy related technology products; survey and status of professional technology teams (d) Scale planning and layout of green electricity facilities (e) Level of acceptance of residents and land acquisition (f) Cost–benefit evaluation and analysis of socioeconomic benefits and education potential
Phase 5. Flexible strategic energy system plans: Propose flexible diversified plans and rank stagewise carbon reduction targets	(a) Main supplementary plan related to system integration • Perform diversified plan conception and system integration in one attempt to process environmental space issues. • Horizontal integration of and negotiation with the public sector and related agencies involved with the plan (b) Installment-, area-, and stagewise implementation of plan • Divide into stages according to implementation difficulty and financial plan. • Flexibility in making provisions for future plans that may present breakthroughs. (c) Prioritizing the implementation of demonstration projects with high-impact short-term effects (d) Marketing highlights implementation results to build confidence for follow-up projects. (e) External resource input and financial plan

Table 3. *Cont.*

Principle	Implementation Content
Phase 6. Digital performance monitoring: Evaluation indicators and performance transparency that assist in long-term implementation	(a) Community ownership and business management (b) Formulation of 3E evaluation indicators and formulation of a standard operation process (c) Proposal of strategic incentives and reward policy for long-term maintenance

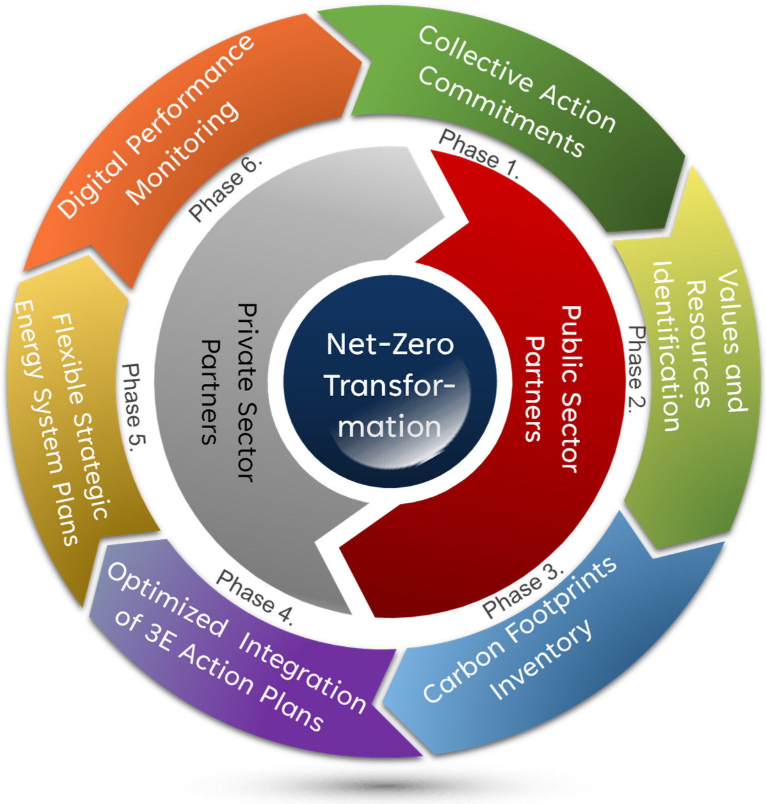

Figure 4. A holistic model of planning principles for local net-zero transformation.

6. Conclusions

One of the barriers to the rapid growth of numbers in accelerating the transition to net-zero emissions is the lack of sufficient end-user (i.e., household) input for early planning participation. Therefore, this work aims to improve traditional planning approaches that do not reflect innovative technologies with uncertainty and may not be applicable due to the lack of community empowerment, which is a dynamic learning and intervention opportunity for end-users at different planning stages. Our participatory study examining the outcomes of planning and design to construction of Taiwan's first low carbon community found that the innovative transformation of national initiatives and policy choices in terms of technology, economics, and society continues to perpetuate the traditional community planning paradigm of the past and has created a gap in the implementation expectations of policy decision makers, community residents, and planners. The main reason for this gap was that empowering communities to integrate energy planning requires a systematic, phased, and long-term engagement. However, the current government procurement and contracting model in Taiwan still continued the traditional restrictive model of planning, and this kind of political consideration for short-term and immediate project demonstration results eventually led to only superficial acceleration, which is not beneficial to the overall net-zero carbon transformation.

Finally, to mitigate the expectation gap between public and private sector actors in actively empowering end-users to participate in energy transition projects, we emphasized that planning and design principles need to start from a vision of building incentives and commitment from collective actors. Second, consider the value of inclusive local environmental and cultural characteristics. Future studies are suggested to identify the structural barriers within different sectors and different communities to establishing value chain management of community empowerment.

In conclusion, this study provides evidence to support the benefits of incorporating community empowerment into the planning process. It provides insights for future research in this field aimed at better understand the barriers and opportunities for implementing innovative technologies, and at informing the future practices of planning and design net-zero carbon emissions at the local level.

Supplementary Materials: The supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/smartcities6010006/s1.

Author Contributions: L.L.: Conceptualization, software, validation, formal analysis, project supervision, visualization, funding acquisition, and writing—original draft. K.W.L.: Review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by a grant from the National Science and Technology Council, Taiwan to Prof. Liwen Li (MOST 106-2218-E-029-001) at Tunghai University.

Acknowledgments: We are very grateful to the New Taipei City Government and Innovosol Consulting Ltd. for administrative and technical support.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Krikštolaitis, R.; Bianco, V.; Martišauskas, L.; Urbonienė, S. Analysis of Electricity and Natural Gas Security. A Case Study for Germany, France, Italy and Spain. *Energies* **2022**, *15*, 1000. [CrossRef]
2. Traber, T.; Hegner, F.S.; Fell, H.-J. An Economically Viable 100% Renewable Energy System for All Energy Sectors of Germany in 2030. *Energies* **2021**, *14*, 5230. [CrossRef]
3. Wang, Y.; Fang, X.; Yin, S.; Chen, W. Low-Carbon Development Quality of Cities in China: Evaluation and Obstacle Analysis. *Sustain. Cities Soc.* **2020**, *64*, 102553. [CrossRef]
4. Tantau, A.; Şanta, A.-M. New Energy Policy Directions in the European Union Developing the Concept of Smart Cities. *Smart Cities* **2021**, *4*, 241–252. [CrossRef]
5. Song, Q.; Liu, T.; Qi, Y. Policy Innovation in Low Carbon Pilot Cities: Lessons Learned from China. *Urban Clim.* **2021**, *39*, 100936. [CrossRef]
6. Cherp, A.; Vinichenko, V.; Jewell, J.; Brutschin, E.; Sovacool, B. Integrating Techno-Economic, Socio-Technical and Political Perspectives on National Energy Transitions: A Meta-Theoretical Framework. *Energy Res. Soc. Sci.* **2018**, *37*, 175–190. [CrossRef]
7. Li, L.W.; Yu, Y.H. Planning Low Carbon Communities: Why Is a Self-Sustaining Energy Management System Indispensable? *Energy Sources Part B Econ. Plan. Policy* **2016**, *11*, 371–376. [CrossRef]
8. Alexander, R.; Hope, M.; Degg, M. Mainstreaming Sustainable Development—A Case Study: Ashton Hayes Is Going Carbon Neutral. *Local Econ.* **2007**, *22*, 62–74. [CrossRef]
9. Moloney, S.; Horne, R.E.; Fien, J. Transitioning to Low Carbon Communities—From Behaviour Change to Systemic Change: Lessons from Australia. *Energy Policy* **2010**, *38*, 7614–7623. [CrossRef]
10. Middlemiss, L.; Parrish, B.D. Building Capacity for Low-Carbon Communities: The Role of Grassroots Initiatives. *Energy Policy* **2010**, *38*, 7559–7566. [CrossRef]
11. Xie, Z.; Gao, X.; Feng, C.; He, J. Study on the Evaluation System of Urban Low Carbon Communities in Guangdong Province. *Ecol. Indic.* **2017**, *74*, 500–515. [CrossRef]
12. Azarova, V.; Cohen, J.; Friedl, C.; Reichl, J. Designing Local Renewable Energy Communities to Increase Social Acceptance: Evidence from a Choice Experiment in Austria, Germany, Italy, and Switzerland. *Energy Policy* **2019**, *132*, 1176–1183. [CrossRef]
13. Hanke, F.; Lowitzsch, J. Empowering Vulnerable Consumers to Join Renewable Energy Communities—Towards an Inclusive Design of the Clean Energy Package. *Energies* **2020**, *13*, 1615. [CrossRef]
14. Carlisle, N.; Van Geet, O.; Pless, S. *Definition of a "Zero Net Energy" Community*; National Renewable Energy Laboratory: Golden, CO, USA, 2009.
15. Karunathilake, H.; Hewage, K.; Mérida, W.; Sadiq, R. Renewable Energy Selection for Net-Zero Energy Communities: Life Cycle Based Decision Making under Uncertainty. *Renew. Energy* **2019**, *130*, 558–573. [CrossRef]
16. Schwarz, L. Empowered but Powerless? Reassessing the Citizens' Power Dynamics of the German Energy Transition. *Energy Res. Soc. Sci.* **2020**, *63*, 101405. [CrossRef]

17. Coy, D.; Malekpour, S.; Saeri, A.K.; Dargaville, R. Rethinking Community Empowerment in the Energy Transformation: A Critical Review of the Definitions, Drivers and Outcomes. *Energy Res. Soc. Sci.* **2021**, *72*, 101871. [CrossRef]
18. Fraser, E.D.; Dougill, A.J.; Mabee, W.E.; Reed, M.; McAlpine, P. Bottom up and Top Down: Analysis of Participatory Processes for Sustainability Indicator Identification as a Pathway to Community Empowerment and Sustainable Environmental Management. *J. Environ. Manag.* **2006**, *78*, 114–127. [CrossRef]
19. Herbes, C.; Rilling, B.; Holstenkamp, L. Ready for New Business Models? Human and Social Capital in the Management of Renewable Energy Cooperatives in Germany. *Energy Policy* **2021**, *156*, 112417. [CrossRef]
20. Denis, G.S.; Parker, P. Community Energy Planning in Canada: The Role of Renewable Energy. *Renew. Sustain. Energy Rev.* **2009**, *13*, 2088–2095. [CrossRef]
21. Cunha, F.B.F.; Carani, C.; Nucci, C.A.; Castro, C.; Silva, M.S.; Torres, E.A. Transitioning to a Low Carbon Society through Energy Communities: Lessons Learned from Brazil and Italy. *Energy Res. Soc. Sci.* **2021**, *75*, 101994. [CrossRef]
22. Liu, T.; Wang, Y.; Li, H.; Qi, Y. China's Low-Carbon Governance at Community Level: A Case Study in Min'an Community, Beijing. *J. Clean. Prod.* **2021**, *311*, 127530. [CrossRef]
23. Skutsch, M.M. The Gender Issue in Energy Project Planning Welfare, Empowerment or Efficiency? *Energy Policy* **1998**, *26*, 945–955. [CrossRef]
24. Eitan, A.; Herman, L.; Fischhendler, I.; Rosen, G. Community–Private Sector Partnerships in Renewable Energy. *Renew. Sustain. Energy Rev.* **2019**, *105*, 95–104. [CrossRef]
25. Natarajan, L. Socio-Spatial Learning: A Case Study of Community Knowledge in Participatory Spatial Planning. *Prog. Plan.* **2017**, *111*, 1–23. [CrossRef]
26. IEE. *Sustainable Energy Communities—8 Innovative Projects for an Energy Intelligent Europe*; Intelligent Energy Europe: Brussels, Belgium, 2006.
27. Gallagher, J.; Coughlan, P.; Williams, A.P.; McNabola, A. Innovating for Low-Carbon Energy through Hydropower: Enabling a Conservation Charity's Transition to a Low-Carbon Community. *Creat. Innov. Manag.* **2018**, *27*, 375–386. [CrossRef]
28. McLaren, D.; Markusson, N. The Co-Evolution of Technological Promises, Modelling, Policies and Climate Change Targets. *Nat. Clim. Chang.* **2020**, *10*, 392–397. [CrossRef]
29. Gui, E.M.; MacGill, I. Typology of Future Clean Energy Communities: An Exploratory Structure, Opportunities, and Challenges. *Energy Res. Soc. Sci.* **2018**, *35*, 94–107. [CrossRef]
30. Ostrom, E. A Diagnostic Approach for Going Beyond Panaceas. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 15181–15187. [CrossRef]
31. Hain, J.; Ault, G.; Galloway, S.; Cruden, A.; McDonald, J. Additional Renewable Energy Growth through Small-Scale Community Orientated Energy Policies. *Energy Policy* **2005**, *33*, 1199–1212. [CrossRef]
32. Heldeweg, M.A.; Saintier, S. Renewable Energy Communities as 'Socio-Legal Institutions': A Normative Frame for Energy Decentralization? *Renew. Sustain. Energy Rev.* **2020**, *119*, 109518. [CrossRef]
33. Zhan, C.; de Jong, M. Financing Eco Cities and Low Carbon Cities: The Case of Shenzhen International Low Carbon City. *J. Clean. Prod.* **2018**, *180*, 116–125. [CrossRef]
34. John, D. Opportunities for Economic and Community Development in Energy and Climate Change. *Econ. Dev. Q.* **2008**, *22*, 107–111. [CrossRef]
35. Harper, M. Planning to Make the Future Renewable. The Role of Local Authorities in Renewable Energy Resource Assessments. *Renew. Energy* **1993**, *3*, 217–220. [CrossRef]
36. Conradie, P.D.; De Ruyck, O.; Saldien, J.; Ponnet, K. Who Wants to Join a Renewable Energy Community in Flanders? Applying an Extended Model of Theory of Planned Behaviour to Understand Intent to Participate. *Energy Policy* **2021**, *151*, 112121. [CrossRef]
37. 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]
38. Petersen, J.-P. The Application of Municipal Renewable Energy Policies at Community Level in Denmark: A Taxonomy of Implementation Challenges. *Sustain. Cities Soc.* **2018**, *38*, 205–218.
39. Gudde, P.; Oakes, J.; Cochrane, P.; Caldwell, N.; Bury, N. The Role of Uk Local Government in Delivering on Net Zero Carbon Commitments: You've Declared a Climate Emergency, So What's the Plan? *Energy Policy* **2021**, *154*, 112245. [CrossRef]
40. Lutz, L.M.; Fischer, L.-B.; Newig, J.; Lang, D.J. Driving Factors for the Regional Implementation of Renewable Energy—A Multiple Case Study on the German Energy Transition. *Energy Policy* **2017**, *105*, 136–147. [CrossRef]
41. Bodorkós, B.; Pataki, G. Linking Academic and Local Knowledge: Community-Based Research and Service Learning for Sustainable Rural Development in Hungary. *J. Clean. Prod.* **2009**, *17*, 1123–1131. [CrossRef]
42. Markard, J.; Geels, F.W.; Raven, R. Challenges in the Acceleration of Sustainability Transitions. *Environ. Res. Lett.* **2020**, *15*, 081001. [CrossRef]
43. Balachandra, P.; Nathan, H.S.K.; Reddy, B.S. Commercialization of Sustainable Energy Technologies. *Renew. Energy* **2010**, *35*, 1842–1851. [CrossRef]
44. Soini, K.; Pouta, E.; Salmiovirta, M.; Uusitalo, M.; Kivinen, T. Local Residents' Perceptions of Energy Landscape: The Case of Transmission Lines. *Land Use Policy* **2011**, *28*, 294–305. [CrossRef]
45. Rodrigues, L.; Gillott, M.; Waldron, J.; Cameron, L.; Tubelo, R.; Shipman, R.; Ebbs, N.; Bradshaw-Smith, C. User Engagement in Community Energy Schemes: A Case Study at the Trent Basin in Nottingham, Uk. *Sustain. Cities Soc.* **2020**, *61*, 102187. [CrossRef]

46. Islam, M.; Das, B.K.; Das, P.; Rahaman, H. Techno-Economic Optimization of a Zero Emission Energy System for a Coastal Community in Newfoundland, Canada. *Energy* **2021**, *220*, 119709. [CrossRef]
47. Gustafsson, S.; Ivner, J.; Palm, J. Management and Stakeholder Participation in Local Strategic Energy Planning—Examples from Sweden. *J. Clean. Prod.* **2015**, *98*, 205–212. [CrossRef]
48. Akrofi, M.; Okitasari, M. Integrating Solar Energy Considerations into Urban Planning for Low Carbon Cities: A Systematic Review of the State-of-the-Art. *Urban Gov.* **2022**, *2*, 157–172. [CrossRef]
49. Bagheri, M.; Delbari, S.H.; Pakzadmanesh, M.; Kennedy, C.A. City-Integrated Renewable Energy Design for Low-Carbon and Climate-Resilient Communities. *Appl. Energy* **2019**, *239*, 1212–1225. [CrossRef]
50. Shandiz, S.C.; Rismanchi, B.; Foliente, G. Energy Master Planning for Net-Zero Emission Communities: State of the Art and Research Challenges. *Renew. Sustain. Energy Rev.* **2021**, *137*, 110600. [CrossRef]
51. Prinsloo, G.; Dobson, R.; Mammoli, A. Smart Village Load Planning Simulations in Support of Digital Energy Management for Off-Grid Remote Rural Community Microgrids. *Curr. Altern. Energy Spec. Issue Standalone Renew. Energy Syst. Remote Area Power Supply* **2018**, *2*, 1–29.
52. Amado, M.; Poggi, F.; Amado, A.R. Energy Efficient City: A Model for Urban Planning. *Sustain. Cities Soc.* **2016**, *26*, 476–485. [CrossRef]
53. Lode, M.; Boveldt, G.T.; Coosemans, T.; Camargo, L.R. A Transition Perspective on Energy Communities: A Systematic Literature Review and Research Agenda. *Renew. Sustain. Energy Rev.* **2022**, *163*, 112479. [CrossRef]
54. Walker, G. What Are the Barriers and Incentives for Community-Owned Means of Energy Production and Use? *Energy Policy* **2008**, *36*, 4401–4405. [CrossRef]
55. Nilsson, J.S.; Mårtensson, A. Municipal Energy-Planning and Development of Local Energy-Systems. *Appl. Energy* **2002**, *76*, 179–187. [CrossRef]
56. Chacón, L.; Austin, M.C.; Castaño, C. A Multiobjective Optimization Approach for Retrofitting Decision-Making Towards Achieving Net-Zero Energy Districts: A Numerical Case Study in a Tropical Climate. *Smart Cities* **2022**, *5*, 405–432. [CrossRef]
57. Ullah, K.; Prodanovic, V.; Pignatta, G.; Deletic, A.; Santamouris, M. Technological Advancements Towards the Net-Zero Energy Communities: A Review on 23 Case Studies around the Globe. *Sol. Energy* **2021**, *224*, 1107–1126. [CrossRef]
58. Xiao, J.; Zhen, Z.; Tian, L.; Su, B.; Chen, H.; Zhu, A.X. Green Behavior Towards Low-Carbon Society: Theory, Measurement and Action. *J. Clean. Prod.* **2021**, *278*, 123765. [CrossRef]
59. Shao, M.; Han, Z.; Sun, J.; Xiao, C.; Zhang, S.; Zhao, Y. A Review of Multi-Criteria Decision Making Applications for Renewable Energy Site Selection. *Renew. Energy* **2020**, *157*, 377–403. [CrossRef]
60. Kenny, T.; Gray, N. Comparative Performance of Six Carbon Footprint Models for Use in Ireland. *Environ. Impact Assess. Rev.* **2009**, *29*, 1–6. [CrossRef]
61. Dwyer, L.; Forsyth, P.; Spurr, R.; Hoque, S. Estimating the Carbon Footprint of Australian Tourism. *J. Sustain. Tour.* **2010**, *18*, 355–376. [CrossRef]
62. Matuštík, J.; Kočí, V. What Is a Footprint? A Conceptual Analysis of Environmental Footprint Indicators. *J. Clean. Prod.* **2021**, *285*, 124833. [CrossRef]
63. Herring, H. Energy Efficiency—A Critical View. *Energy* **2006**, *31*, 10–20. [CrossRef]
64. Perry, S.; Klemeš, J.; Bulatov, I. Integrating Waste and Renewable Energy to Reduce the Carbon Footprint of Locally Integrated Energy Sectors. *Energy* **2008**, *33*, 1489–1497. [CrossRef]
65. Čuček, L.; Klemeš, J.J.; Kravanja, Z. A Review of Footprint Analysis Tools for Monitoring Impacts on Sustainability. *J. Clean. Prod.* **2012**, *34*, 9–20. [CrossRef]
66. Nigim, K.; Munier, N.; Green, J. Pre-Feasibility Mcdm Tools to Aid Communities in Prioritizing Local Viable Renewable Energy Sources. *Renew. Energy* **2004**, *29*, 1775–1791. [CrossRef]
67. Cai, Y.; Huang, G.; Yang, Z.; Lin, Q.; Tan, Q. Community-Scale Renewable Energy Systems Planning under Uncertainty—An Interval Chance-Constrained Programming Approach. *Renew. Sustain. Energy Rev.* **2009**, *13*, 721–735. [CrossRef]
68. Then, D.; Bauer, J.; Kneiske, T.M.; Braun, M. Interdependencies of Infrastructure Investment Decisions in Multi-Energy Systems—A Sensitivity Analysis for Urban Residential Areas. *Smart Cities* **2021**, *4*, 112–145. [CrossRef]
69. Ford, R.; Maidment, C.; Vigurs, C.; Fell, M.J.; Morris, M. Smart Local Energy Systems (Sles): A Framework for Exploring Transition, Context, and Impacts. *Technol. Forecast. Soc. Chang.* **2021**, *166*, 120612. [CrossRef]
70. Mavrigiannaki, A.; Pignatta, G.; Assimakopoulos, M.; Isaac, M.; Gupta, R.; Kolokotsa, D.; Laskari, M.; Saliari, M.; Meir, I.; Isaac, S. Examining the Benefits and Barriers for the Implementation of Net Zero Energy Settlements. *Energy Build.* **2021**, *230*, 110564. [CrossRef]
71. Jakica, N. State-of-the-Art Review of Solar Design Tools and Methods for Assessing Daylighting and Solar Potential for Building-Integrated Photovoltaics. *Renew. Sustain. Energy Rev.* **2018**, *81*, 1296–1328. [CrossRef]
72. Whitfield, M. Measuring the Performance of Sustainable Communities. *Strateg. Plan. Energy Environ.* **2017**, *36*, 41–77.
73. Tan, S.; Yang, J.; Yan, J.; Lee, C.; Hashim, H.; Chen, B. A Holistic Low Carbon City Indicator Framework for Sustainable Development. *Appl. Energy* **2017**, *185*, 1919–1930. [CrossRef]
74. Li, L.; Yu, Y. From Self-Interest to Community-Interest: Low Carbon Community-Based Process and Practice. *Int. J. Green Energy* **2013**, *10*, 984–998. [CrossRef]

75. Innes, J.E.; Booher, D.E. Indicators for Sustainable Communities: A Strategy Building on Complexity Theory and Distributed Intelligence. *Plan. Theory Pract.* **2000**, *1*, 173–186. [CrossRef]
76. Adams, M.; Wheeler, D.; Woolston, G. A Participatory Approach to Sustainable Energy Strategy Development in a Carbon-Intensive Jurisdiction: The Case of Nova Scotia. *Energy Policy* **2011**, *39*, 2550–2559. [CrossRef]
77. McGookin, C.; Gallachóir, B.; Byrne, E. Participatory Methods in Energy System Modelling and Planning—A Review. *Renew. Sustain. Energy Rev.* **2021**, *151*, 111504. [CrossRef]
78. Pawson, R.; Tilley, N. *Realistic Evaluation*; Sage: London, UK, 1997.
79. Macaulay, A.C.; E Commanda, L.; Freeman, W.L.; Gibson, N.; McCabe, M.L.; Robbins, C.M.; Twohig, P.L. Participatory Research Maximises Community and Lay Involvement. *BMJ* **1999**, *319*, 774–778. [CrossRef]
80. Haro-Monteagudo, D.; Palazón, L.; Zoumides, C.; Beguería, S. Optimal Implementation of Climate Change Adaptation Measures to Ensure Long-Term Sustainability on Large Irrigation Systems. *Water Resour. Manag.* **2022**, 1–16. [CrossRef]
81. Borge, L.; Bröring, S. What Affects Technology Transfer in Emerging Knowledge Areas? A Multi-Stakeholder Concept Mapping Study in the Bioeconomy. *J. Technol. Transf.* **2020**, *45*, 430–460. [CrossRef]
82. Li, L.W.; Birmele, J.; Schaich, H.; Konold, W. Transitioning to Community-Owned Renewable Energy: Lessons from Germany. *Procedia Environ. Sci.* **2013**, *17*, 719–728. [CrossRef]
83. Hicks, J.; Ison, N. An Exploration of the Boundaries of 'Community' in Community Renewable Energy Projects: Navigating between Motivations and Context. *Energy Policy* **2018**, *113*, 523–534. [CrossRef]
84. MEA. *Renewable Energy Development Act*; Bureau of Energy, Ed.; Ministry of Economic Affairs: Taipei, Taiwan, 2009.
85. Gregg, J.S.; Nyborg, S.; Hansen, M.; Schwanitz, V.J.; Wierling, A.; Zeiss, J.P.; Delvaux, S.; Saenz, V.; Polo-Alvarez, L.; Candelise, C.; et al. Collective Action and Social Innovation in the Energy Sector: A Mobilization Model Perspective. *Energies* **2020**, *13*, 651. [CrossRef]
86. Gölz, S.; Wedderhoff, O. Explaining Regional Acceptance of the German Energy Transition by Including Trust in Stakeholders and Perception of Fairness as Socio-Institutional Factors. *Energy Res. Soc. Sci.* **2018**, *43*, 96–108. [CrossRef]
87. Jabareen, Y.; Carmon, N. Community of Trust: A Socio-Cultural Approach for Community Planning and the Case of Gaza. *Habitat Int.* **2010**, *34*, 446–453. [CrossRef]
88. Burch, S. In Pursuit of Resilient, Low Carbon Communities: An Examination of Barriers to Action in Three Canadian Cities. *Energy Policy* **2010**, *38*, 7575–7585. [CrossRef]
89. Fleeger, W.E.; Becker, M.L. Creating and Sustaining Community Capacity for Ecosystem-Based Management: Is Local Government the Key? *J. Environ. Manag.* **2008**, *88*, 1396–1405. [CrossRef] [PubMed]
90. Schweizer-Ries, P. Energy Sustainable Communities: Environmental Psychological Investigations. *Energy Policy* **2008**, *36*, 4126–4135. [CrossRef]
91. Walker, G.; Devine-Wright, P. Community Renewable Energy: What Should It Mean? *Energy Policy* **2008**, *36*, 497–500. [CrossRef]
92. Rickenbacker, H.; Brown, F.; Bilec, M. Creating Environmental Consciousness in Underserved Communities: Implementation and Outcomes of Community-Based Environmental Justice and Air Pollution Research. *Sustain. Cities Soc.* **2019**, *47*, 101473. [CrossRef]
93. Rogers, J.; Simmons, E.; Convery, I.; Weatherall, A. Public Perceptions of Opportunities for Community-Based Renewable Energy Projects. *Energy Policy* **2008**, *36*, 4217–4226. [CrossRef]
94. Liu, Y.; Hong, Z.; Zhu, J.; Yan, J.; Qi, J.; Liu, P. Promoting Green Residential Buildings: Residents' Environmental Attitude, Subjective Knowledge, and Social Trust Matter. *Energy Policy* **2018**, *112*, 152–161. [CrossRef]
95. Zhang, M.; Mu, H.; Ning, Y. Accounting for Energy-Related Co_2 Emission in China, 1991–2006. *Energy Policy* **2009**, *37*, 767–773. [CrossRef]
96. Gao, A.M.-Z.; Fan, C.-T.; Liao, C.-N. Application of German Energy Transition in Taiwan: A Critical Review of Unique Electricity Liberalisation as a Core Strategy to Achieve Renewable Energy Growth. *Energy Policy* **2018**, *120*, 644–654. [CrossRef]
97. Seyfang, G. Community Action for Sustainable Housing: Building a Low-Carbon Future. *Energy Policy* **2010**, *38*, 7624–7633. [CrossRef]
98. John, D.; Mlay, M. Community-Based Environmental Protection: Encouraging Civic Environmentalism. In *Better Environmental Decisions*; Sexton, K., Alfred, A., Marcus, K., Easter, W., Burkhardt, T.D., Eds.; Island Press: Washington, DC, USA, 1999; pp. 353–376.
99. McCauley, D.; Ramasar, V.; Heffron, R.J.; Sovacool, B.K.; Mebratu, D.; Mundaca, L. Energy Justice in the Transition to Low Carbon Energy Systems: Exploring Key Themes in Interdisciplinary Research. *Appl. Energy* **2019**, *233–234*, 916–921. [CrossRef]
100. Ahmadabadi, A.A.; Heravi, G. The Effect of Critical Success Factors on Project Success in Public-Private Partnership Projects: A Case Study of Highway Projects in Iran. *Transp. Policy* **2019**, *73*, 152–161. [CrossRef]