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From kilowatts to cents: Financial inclusion of citizens through Dutch community energy business model configurations

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ABSTRACT

Community energy initiatives (CEIs) emphasize citizen empowerment, equitable distribution of energy transition costs and benefits, and the importance of local knowledge. While CEI goals align with energy justice principles, they have been criticized for not fully incorporating distributive justice, particularly the distribution of the benefits of a sustainable energy transition. Therefore, they may potentially perpetuate income inequalities. There are insufficient studies to conclusively determine whether CEIs perpetuate or address income inequalities. Moreover, the integration of transition studies, energy justice and business model literature is lacking, hindering effective analysis of CEI configurations that address income inequalities. This paper aims to connect the sustainability, energy justice and business model literature by dissecting the business model configurations of CEIs and assessing the inclusiveness of these components. To do so, we develop and employ an adapted business model canvas that incorporates societal and environmental considerations in the value proposition, value creation and delivery and value capture. The canvas is used to determine whether sustainability and energy justice considerations, particularly distributive justice principles, are embedded in the CEI business models. The research is focused on the Netherlands, a country with a high number of CEIs. However, the study may yield insights relevant to other countries and CEIs, informing the integration of principles for societal inclusion in their own contexts. We utilize a mixed-method approach, including interviews, desk research and surveys, to ensure robust analysis through data triangulation. The study finds that there are elements of CEI business model configurations that are aligned with energy justice principles. However, models specifically targeting and aligning with minimum income social groups are rare.

1. Introduction

Energy transitions are multifaceted, with the literature suggesting that sustainable energy transitions include changes, shifts and/or transformations in the economic, governance, social, environmental and technological dimensions [1]. Implicit in the *sustainability* of "sustainable energy transitions" are elements of energy justice encompassing "procedural justice," ensuring fair and representative energy decision-making processes; "distributive justice," fairly distributing the costs, benefits, externalities and risks within society; and "recognitional justice," acknowledging diverse cultural identities and perspectives in shaping energy policies and practices [2]. The European Union (EU) Clean Energy for All Europeans package acknowledges the importance of incorporating energy justice principles into system-wide changes and highlights the role of community energy initiatives (CEIs) in facilitating a just transition [3]. CEIs, especially energy cooperatives, are grassroots innovations that enable renewable energy generation and promise to include aspects of energy justice in local energy production [4]. These initiatives promote increased citizen empowerment, strive for the equitable distribution of energy transition costs and benefits across communities and income groups through co-investment and profit sharing, and emphasize the significance of local knowledge and interest. The goals and aims of CEIs are aligned with principles of procedural, recognitional and distributive justice [5]. In essence, CEIs have positioned themselves as a form of socio-technical innovation that can bridge the gap between energy justice and business interests [6].

In line with EU directives, the Netherlands has a large and growing number of CEIs, and these initiatives are expected to play a significant role in achieving the Dutch goal of 50 % local ownership of electricity generation [7]. However, CEIs face criticism for potentially perpetuating

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inequalities, especially regarding the access of various income groups to CEIs, which is linked to their commitment to incorporating distributive justice principles [3,4]. However, there are insufficient studies to definitively determine whether CEIs perpetuate or reduce inequality through their distribution of costs and benefits. Energy transitions literature has increasingly noted that equity and justice considerations are underrepresented in the literature, and that this literature gap contributes to a lack of understanding by transitions researchers of how CEIs operationalize aspects of energy justice (see [1,8,9]). Although CEIs in the Netherlands have increasingly recognized the importance of citizens' financial inclusion in projects, there is limited knowledge about the internal structure of CEIs that would allow us to assess how they increase financial accessibility and their overall effectiveness in doing so.

Business models (BMs) provide an analytical lens to comprehend and categorize the approaches to community energy and citizen financial inclusion in CEIs. By examining the BM structure of CEIs, we will come to understand the reasons behind different investment costs associated with the same technologies and how the benefits of community energy are distributed to citizens. Moreover, researchers have advocated for integrating BM thinking, energy justice and transitions so as to comprehensively understand the role of BM structure and organization in socio-technical transitions, which involve fundamental shifts in social and technical systems that are interconnected in a feedback loop [10]. The term "business models" has not historically been applied to the analysis of CEIs but has gained increasing attention in the past few years [6,11,12]. Moreover, the term is appropriate for the study of CEIs, especially in the Netherlands, as energy cooperatives serve as the main legal vehicle and are incorporated as legal entities comparable to an ordinary Dutch limited liability company [13]. Dutch CEIs may be categorized as not-only-for-profit businesses, since they may legally make and distribute profits, although this is not their key focus. Thus, CEIs do have a type of BM, albeit not economically centered. The concept of BMs offers a lens to understand the architecture of CEIs in terms of the tools and/or instruments used to ensure the equitable distribution of costs and benefits in CEIs.

In summary, there are several critical research gaps concerning CEIs. These gaps include the lack of connection between transition studies, energy justice and BMs; the unclear understanding of how costs and benefits are distributed in CEIs to facilitate just energy transitions; and the limited comprehension of the internal configurations of CEIs that can foster greater financial inclusion of citizens. To address these gaps, we aim to answer the following question: Can CEI BM configurations support greater financial inclusion of citizens in the energy transition?

In examining the main research question, the study will delve into several key aspects concerning CEIs. First, the research will explore whether CEI BM configurations can facilitate increased financial inclusion of citizens in the energy transition. This investigation will encompass an analysis of the key BM configurations found within Dutch CEIs. Furthermore, the study will examine the mechanisms by which costs and benefits are distributed within these CEI BMs. Additionally, the research will focus on understanding how different socioeconomic groups are included within CEI BM configurations, thereby assessing the extent of social and financial inclusivity. Alongside these aspects, the study will also identify the key challenges associated with CEI BM configurations. These challenges include financial barriers, access to essential resources, regulatory and policy obstacles, existing socioeconomic disparities hindering equal participation and issues in relation to community engagement. This comprehensive examination aims to offer a thorough understanding of the multifaceted challenges of CEI BMs and to shed light on the complexities involved in pursuing greater citizen financial inclusion during the energy transition.

To address these questions, we develop and employ an adapted business model canvas (BMC), which captures the internal structure of CEIs. The BMC provides a blueprint for understanding how CEIs in the Netherlands create, deliver and capture social, economic and environmental value. While the BMC serves as our primary framework, we also draw on relevant aspects of the Multi-level Perspective (MLP), particularly focusing on the concept of "lock-in." In the context of BMs, lock-in refers to situations where certain models become deeply entrenched and resistant to change, as opposed to innovative models that challenge the existing norms. The paper adopts a mixed-method approach to examine the relationship between energy justice, BMs and CEIs. By integrating interviews, desk research and surveys, we ensure a robust analysis. Triangulating data from these sources enhances coherence and credibility and reduces bias. Interviews offer in-depth insights; desk research provides a broader overview and surveys expand geographic and technological reach. This approach identifies patterns and trends, contributing to a well-rounded exploration of the internal structure of CEIs, their financial accessibility and their contributions to energy justice.

2. Theoretical framework

2.1. The Business model canvas

The definition of BMs is not homogenous in the literature. Vial [14] outlines the most commonly used definitions in the BM literature (see Table 1). At its core, a BM is an arrangement of inputs and outputs used by companies to create, deliver and capture value around products and/or services [15]. Furthermore, BMs are characterized by their ability to innovate, differentiate and excel in the market. They provide a competitive advantage by demonstrating creativity and uniqueness in product or service offerings, ensuring a meaningful connection with customers [16]. BMs may be viewed as market devices that outline how emerging actors in the energy system are organized to develop a comparative advantage so they can compete with incumbent firms [17,18]. A BM consists of three interconnected components: the value proposition, value creation and delivery, and value capture.

The business model canvas (BMC) is a visual representation of BM elements that contribute to value creation, delivery and capture [19]. The most commonly used BMC, developed by Osterwalder and Pigneur [19], provides a clear decomposition of BM components. It includes nine blocks, illustrated in Table 2. Combining BMC and MLP allows for a graphical depiction of the relationships involved in the low carbon transition, highlighting the challenges faced by niche innovations such as CEIs and the competitive advantage provided by innovative BMs. The left side of the BMC is focused on the business (the internal configuration under company control), while the right side focuses on the customer or market (the external configuration beyond company control) [20]. The center block of the BMC is the value proposition (VP), which represents the exchange of value between the two sides of the canvas.

The canvas can be used to explain the value creation, delivery and capture processes of a business. The VP is the key value creation process, which describes the products and/or services being offered to customers: those products and/or services that are connected to fulfilling customer needs or addressing their problems [21]. The customer segment, key resources, partnerships, and activity blocks tend to cut across the three components, since they may have a role in value creation, delivery, and capture. In terms of value creation, customer segments support the identification of the needs and preferences of the customer base, to which the VP may be tailored. Similarly, by identifying the key resources, partners and activities required to meet customer needs and preferences, businesses can create VPs that provide them with a competitive advantage and drive customer engagement. At the same time, to deliver value to customers efficiently, businesses need the right resources, partners, and activities.

These four elements also relate to value capture: by identifying the right customer base, resources, partnerships, and activities may be directed to serving customers who are most likely to drive revenue. Optimizing resources, partnerships and activities can further support high efficiency and cost reductions which may improve profitability and therefore value capture. Channels (communication methods) and customer relationships are focused on delivering value to the customer

Table 1
Business model definitions. Source: Adapted from Vial [14].

Authors	Business Model definition
Timmers (1998)	"A business model is an architecture for product, service and information flows, including a description of the various business actors and their roles" (p. 4).
Amit & Zott (2001)	"A business model depicts the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities" (p. 493).
Chesbrough & Rosenbloom (2002)	"The business model provides a coherent framework that takes technological characteristics and potentials as inputs and converts them through customers and markets into economic outputs" (p. 532).
Magretta (2002)	"[Business models] are, at heart, stories—stories that explain how enterprises work" (p. 87).
Mangematin et al. (2003)	"Each business model has its own development logic which is coherent with the needed resources—customer and supplier relations, a set of competencies within the firm, a mode of financing its business, and a certain structure of shareholding" (p. 624).
Downing (2005)	"[The business model] is a set of expectations about how the business will be successful in its environment" (p. 186).
Morris et al. (2005)	"The model represents a strategic framework for conceptualizing a value-based venture" (p. 734)
Osterwalder et al. (2005)	"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams." (p.10)
Casadesus & Ricart (2010)	"The logic of the firm, the way it operates and how it creates value for its stakeholder"
Demil & Lecoq (2010)	"The way activities and resources are used to ensure sustainability and growth"
Gambardella & McGahan (2010)	"Business model is a mechanism for turning ideas into revenue at reasonable cost"
Itami & Noshino (2010)	"… business model is a profit model, a business delivery system and a learning system"
McGrath (2010)	"The business model construct offers some intriguing opportunities to capture better how a given set of resources translates into something a customer is willing to pay for. Which brings us to two core components of what constitutes a business model. The first is the basic 'unit of business', which is the building block of any strategy, because it refers to what customers pay for. The second are process or operational advantages, which yield performance benefits when more adroit deployment of resources leads a firm to enjoy superior efficiency or effectiveness on the key variables that influence its profitability" (p. 249).
Sabatier, Rousselle & Mangematin (2010)	"Crossroads of competence and consumer needs"
Teece (2010)	"How a firm delivers value to customers and converts payment into profits"
Williamson (2010)	"… cost innovation business model offers advantages in radically new ways meaning more for less"
Yunus, Moingeon & Lehmann- Ortega (2010)	"A value system plus a value constellation"
Zott & Amit (2010)	"… a system of interdependent activities that transcends the focal firm and spans its boundaries"
Gorge & Bock (2011)	"The underlying dimensions of the business model are resource structure, transactive structure, and value structure" (p.83)

base identified. Channels are used to interact with customers, while the customer relationship block outlines the type of relationship with customers that will deliver value.

2.2. Lock-in literature

According to MLP, a dominant transitions framework, energy transitions may be viewed as the result of the interplay between three heuristic levels: regime, niche and landscape [22]. Table 3 outlines the key concepts of MLP [23]. Tensions and new alignments between these levels may result in a transition. The MLP and lock-in literature underscore the role of BMs in sustaining the current energy regime through corporate political influence and limited shareholder liability [24]. Lock-in in MLP refers to the resistance of the incumbent regime (in our case fossil fuels) to the transition (in our case energy). Lock-in may be reinforced by factors such as the scale and central role of the current regime, corporate strategies, limited liability and economies of scale.

Overcoming lock-in requires disruptive niche innovations accompanied by innovative BMs that challenge and reshape the regime [17,18]. Researchers have therefore increasingly advocated for making a connection between BM literature and MLP literature to gain a more holistic understanding of energy transitions [23,24]. Fig. 1, from Wainstein and Bumpus [24], illustrates how the concept of lock-in can be applied to traditional BMs. These traditional BMs reinforce and support a centralized fossil fuel energy system. In contrast, the figure also illustrates the disruptive potential of new emerging BMs, which are characterized by a prioritization of environmental and social value that can challenge and replace incumbent firms. Consequently, by combining the MLP lock-in concept and BM theory, we can further conceptualize and understand the key lock-in dynamics and disruption potential of CEI BMs.

2.3. Energy justice and innovative business models

Energy justice encompasses several principles aimed at creating a fair and inclusive energy system [1,25–27]. First, *distributive justice* focuses on the equitable distribution of costs and benefits related to energy systems, ensuring that vulnerable populations are not disproportionately burdened. Second, *procedural justice* emphasizes transparent and inclusive decision-making processes that involve diverse stakeholders. Finally, *recognitional justice* involves acknowledging and respecting the rights and concerns of different social groups during energy interventions. According to Hiteva and Sovacool [6], emerging social innovation initiatives foster unique networks of actors and introduce diverse environmental, social and ethical values into business approaches, presenting an opportunity for BM innovation that incorporates energy justice principles. We use the term *energy injustice lock-in* to describe practices which are contrary to energy justice principles and that reinforce injustice. In contrast, we use the term *energy justice lock-in* to describe practices that have the potential to reinforce energy justice principles. The literature outlines various types of innovative BMs, which are called social, sustainable and/or inclusive models [14,15,28]. While the components of innovative BMs resemble the components outlined in the BMC, these innovative models have aspects of energy justice embedded in how business is done. CEIs may be viewed as a socio-technical niche in which social, business and technological innovation is solidified in a BM that has the potential to challenge incumbent fossil fuel technologies, centralized decision-making and businesses driven by the bottom-line [3,29]. Our definition of an *inclusive sustainable business model* refers to the configuration of an organization in which aspects of energy justice are embedded in its rationale of how to create, deliver and capture value. In other words, since energy justice is embedded in the rationale of the organization, it may generate profits, but not to the detriment of the environment and usually with a strong aspect of social inclusion in its processes and activities [28].

2.4. Adapted business model canvas to capture inclusive sustainable business model configurations

There have been several adaptations to the canvas to account for new

Table 2
Traditional business model canvas used for for-profit businesses (adapted from Osterwalder and Pigneur [19]).

<table>
<tr><td rowspan="2" colspan="2">Key partnerships
The suppliers and business partners that make the business model work</td><td>Key activities
The activities needed for the business model to work</td><td rowspan="2" colspan="2">Value proposition
The products and services that deliver value to customers.</td><td>Customer relationships
The different types of relationships with customer segments</td><td rowspan="2">Customer segments
The groups that the business aims to serve</td></tr>
<tr><td>Key resources
The assets needed to create and capture value</td><td>Channels
The methods in which a company communicates with customers</td></tr>
<tr><td colspan="4">Cost structure
The operating cost of the business model</td><td colspan="3">Revenue streams
The financial flows from customer segments</td></tr>
</table>

Table 3
Key concepts within the multi-level perspective on socio-technical transitions.

Concept	Stability	Description
Socio-technical landscape	Exogenous context	Slowly and autonomously changing background variables or deep structural trends
Socio-technical regime	Dynamically stable	Dominant rule and resource structures that stabilize the current functioning of the system and only allow for incremental innovation
Niche	Unstable	Protected spaces where radical innovation can develop, and rules and resource structures have not yet stabilized

Source: Adapted from Bidmon & Knab [23].

innovative BMs that include social and environmental elements (see [14,15,30–34]). The BMC is an analytical tool used to graphically illustrate a firm's internal configurations, but new BMs require adaptations to fit their unique nature. Many adaptations in the literature have adjusted or added blocks to the original ones to accommodate not-for-profit or not-only-for-profit enterprises. Some of the canvas block adaptations are relevant to CEIs, while others may not extend to them. Qastharin [30] included impact and measurement in the value capture segment to account for social enterprises' impact beyond profits. Sparviero [20] changed the VP to social VP to represent social value delivered by social enterprises. Additionally, the customer segment has been modified to include beneficiaries, as social enterprises may target people beyond their donors, while the customer relationship has been changed to customer and beneficiary engagement to reflect two-way communication. Joyce and Paquin [15] developed a triple layer canvas, expanding on the value capture segment by including social and environmental benefits and impact for societal and environmental firms.

To ensure that the canvas is aligned to our analysis of CEIs and suitable to our research, we have further adapted it to reflect the internal configurations of CEIs, as presented in Table 4. Moreover, the adapted canvas incorporates energy justice and business interest considerations in all segments of the canvas. Fig. 2 illustrates how our reconfiguration of the BMC and definition of components connects business interests

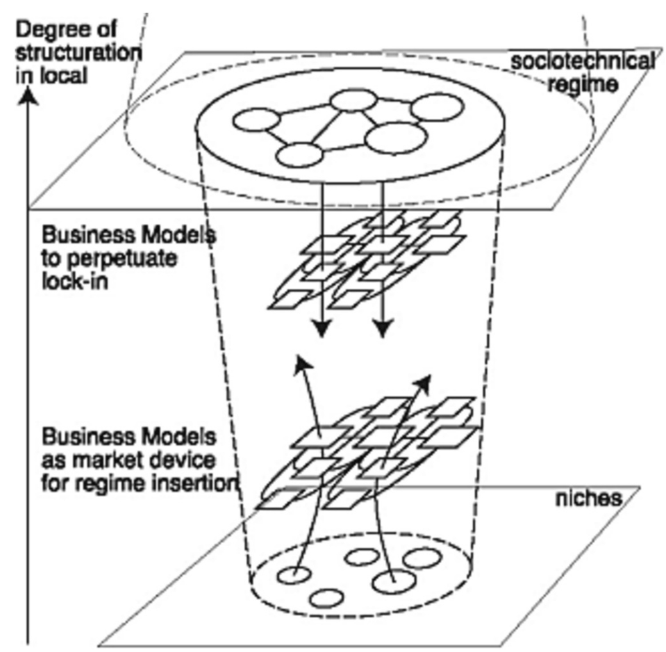

Fig. 1. Business Models in the Multi-Level Perspective. BMs as critical drivers of sociotechnical transitions, acting as market vehicles for niche and regime actors. (Source: Wainstein & Bumpus [24]).

outlined in the traditional BMC in Section 2.1. and the concept of energy justice outlined in Section 2.3. Building on the literature, we have adapted the VP to explicitly include a combination of environmental, social and economic values that are to be delivered [6]. Creating sub-VPs enables a holistic and integrated view of CEI configurations while also facilitating separate analysis of each dimension. Furthermore, analyzing all three VPs allows for a better understanding of the energy justice impact CEI BMs have. Similarly, we have adapted the value

Table 4
Adapted BMC for the study of CEIs.

<table>
<tr>
<td rowspan="2">Partners
[adapted definition]
Includes the co-owners of projects (the customers) and other partners needed to make the business model work e.g., the Municipality</td>
<td>Key activities
The activities needed for the business model to work.</td>
<td rowspan="2">Value proposition
[adapted definition]
The environmental, social, and economic services and/or products to be delivered to customers.</td>
<td>Citizen Inclusion
[adapted from customer relationships, and adapted definition]
The different ways citizens may be included in the CEI.</td>
<td rowspan="2">Customers & Beneficiaries
[adapted from customer segment, and adapted definition]
Groups of people that the CEI aims to reach and serve including prosumers and the broader community in which the projects occur</td>
</tr>
<tr>
<td>Key resources
The assets needed to create and capture value.</td>
<td>Channels
The methods in which a company communicates with customers</td>
</tr>
<tr>
<td colspan="3">Cost structure
[adapted definition]
The economic (operating costs), environmental (impact) and societal (impact) costs of the CEIs model.</td>
<td colspan="2">Income
[adapted from revenue, and adapted definition]
All financial and in-kind resources that the CEI receives (such as donations, fees, subsidies, investments etc.).
Benefits
[added to value capture]
Inclusion of financial, environmental, and social benefits which is a result of operating the business model.</td>
</tr>
</table>

capture segment to include social and environmental costs and benefits, which reflects earlier adaptations that include impact and benefits [20]. In addition, we modified customer segments to include both customers and beneficiaries, as CEI activities serve co-owners and participants while also delivering value to other residents and government entities in terms of climate and community benefits. This adaptation captures the target group of CEIs (as with the traditional BMC) and the marginalized groups that benefit from the CEI, including those who are not directly involved in the initiative.

While the partners block title has not been altered, we expanded the original definition to include co-owners who may be viewed as both internal and external to the BM to some extent. In other words, they are an input for value creation but are also the segment to which value is being delivered. In addition, customer relationships have been adapted to citizen inclusion. While the adaptation from relationship to inclusion is focused on two-way communication, which is relevant to CEIs, it is important to note that CEIs go beyond engagement to co-ownership, emphasizing citizen involvement at the core of their operations. Therefore, this component not only captures the CEI relationship to their customers but also how their BMs include citizens in the overall business logic and decision-making. Detailed definitions are listed in Annex 4. Understanding all components of the BMC is crucial to comprehending how CEIs are configured to contribute to energy justice. These components cannot be siloed; instead, they work together to capture the value of CEIs. However, certain segments in the Netherlands exhibit standardization due to the prevalent cooperative structure, which includes a standard model for decision-making [35]. Consequently, while we will analyze all segments, our focus lies on those with high variance.

3. Methodology

This paper employs a mixed-method approach combining interviews, desk research and survey results to confirm findings, increase validity and support the qualitative findings with more comprehensive data. This section outlines the methods used in the paper.

3.1. Interviews

The province of Groningen was used as a starting point, given that it houses a large number of CEIs, has a high number of subsidies and provides other fiscal support to CEIs. Moreover, there were existing connections based on previous research on CEIs in the region, making them more accessible to the researchers. The 2019 Local Energy Monitor (LEM) [36], which is an annual publication that takes stock of Dutch CEIs, was used to identify CEIs in the province of Groningen, with 45 local initiatives identified. A desk review was conducted of the publicly available information listed on the initiatives' websites, which included links, reports, newsletters, and blogs. To shortlist the CEIs, the websites were reviewed against the following criteria:

- Inclusivity and/or accessibility was listed as a key objective of the project.

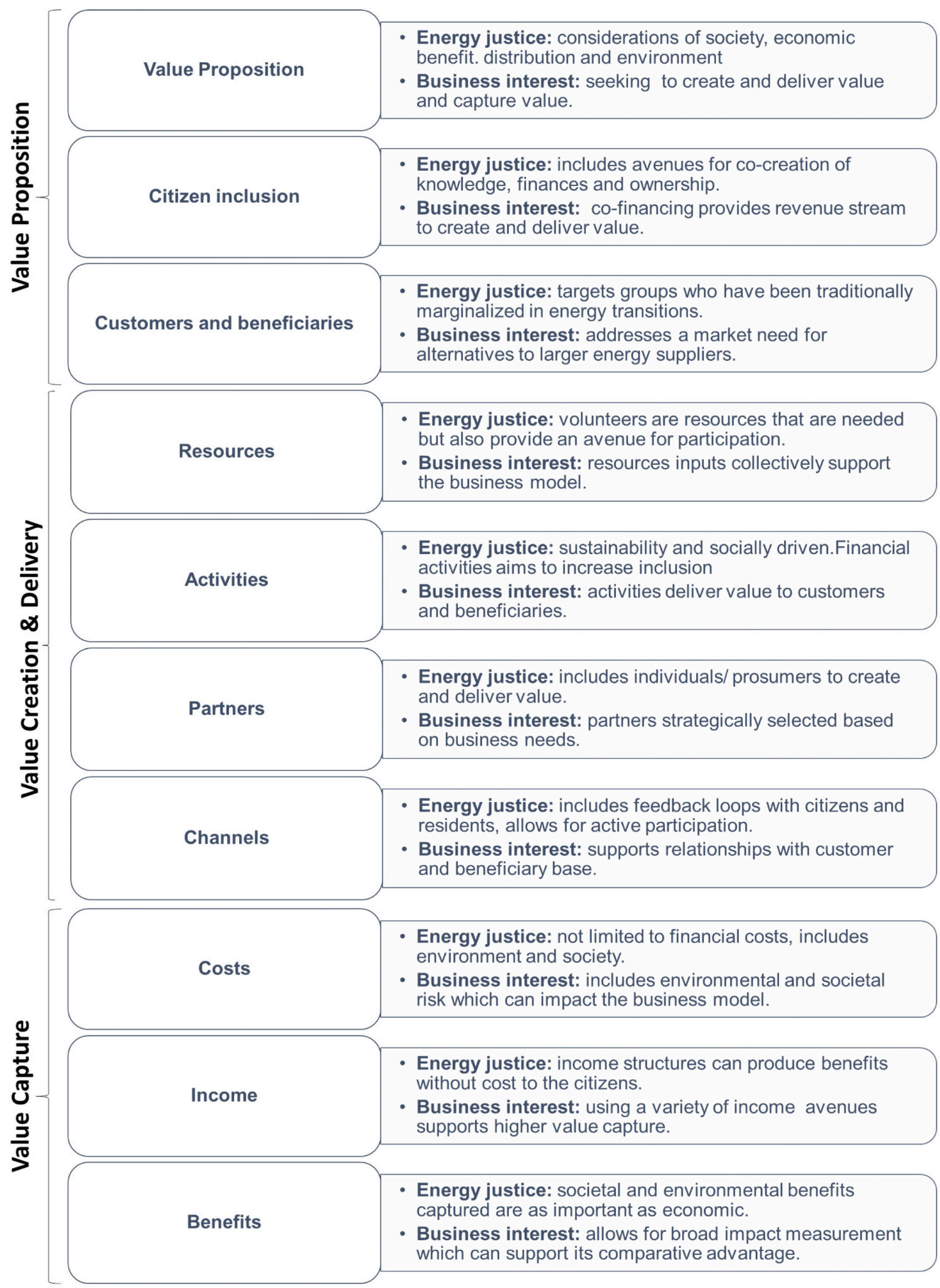

Fig. 2. Adapted BMC segment relation to energy justice and business interests (Based on the authors' interpretation of the literature).

Table 5
Summary of projects interviewed.

Energy cooperative	Project	Municipality	Start of project	End of project
Zonnedorpen energie coöperatie	Solar Park in 't Zandt	Loppersum/ Eemsdelta	2015	2019
Coöperatie Duurzaam Menterwolde UA	SunBrouck	Midden-Groningen	2017	2019
	Zuidbroek		2017	2019
Energie coöperatie Ten Boer (ECTB)	Woldwijk	Groningen	2018	Ongoing
	Fledderbosch		2021	2024
	De Groene Koelkast		Not listed	Not listed
GLOED	Keizer	Winsum	2017	2017
	Vellinga 1		2021	Ongoing
	Vellinga 2		2022	Ongoing
	Zuidhorn Carport		2023	Ongoing
Durabel	Wolddak	Het Hogeland	2017	Ongoing
Grunneger Power	Huren met Zon	Groningen	2020	2020

- Participation was said to be based on affordable investment.
- Projects were operational.
- Sufficient information was available for review on the website.

Based on these 4 criteria, 16 energy cooperatives were shortlisted for further study and were contacted for a 60-min semi-structured interview, of which 6 energy cooperatives responded positively to the request in 2020 (see Annex 1). Interviews were conducted with cooperative experts who understood the projects, challenges, and successes of the cooperative in great detail, which allowed for a broad but in-depth overview of CEI BMs in Groningen. The cooperatives represented 13 initiatives spread across 5 municipalities in the province of Groningen (see Table 5). While there were CEIs focused on a variety of renewable energy technologies, only solar initiatives fit our criteria in the region. Interview questions were developed around the various blocks of the adapted BMC to understand how CEIs embed energy justice principles into their BMs (see Annex 2). Key inclusive sustainable BM configurations were identified by coding the interview responses according to the adapted BMC.

3.2. Survey data

To extend the findings beyond the province of Groningen, a Google form survey was sent via email to all 262 Dutch energy cooperatives that existed in 2022 (see Annex 3). The survey received 48 responses (18.3 %) that offered wider geographical and technological insights, which supported the confirmation of or, when necessary, alteration to, the initial models identified through the interviews (see Figs. 3 and 4). The survey was necessary to validate the BMs identified through the interviews but also to understand whether the BMs identified were applicable to other contexts and to other technologies that may require different configurations.

3.3. Desk review

To further confirm the findings and to extend their coverage to the broader Netherlands, two desk reviews were conducted on all the CEIs in the Netherlands. In total, all 561 CEIs in the Netherlands were included in an initial screening in 2022, but only 240 (225 solar and 15 wind) were selected for further review because 48 CEIs listed had no operational website and 269 had insufficient information listed on their website. The remaining figure represents 42.7 % of all CEIs operating in the Netherlands. The review assessed the websites and project documents of CEIs to further determine whether the models previously identified were applicable to all the Dutch provinces and to identify any variance in the models. In 2023, a follow-up review was conducted on the same initiatives to confirm whether there were any changes to the 2022 findings.

3.4. Data analysis

To triangulate the diverse data sources in a systematic and coherent manner, a coding guidebook was developed, which details each component of the adapted BMC and subsequent codes (see Annex 4). All interviews, survey and desk review data were coded and analyzed

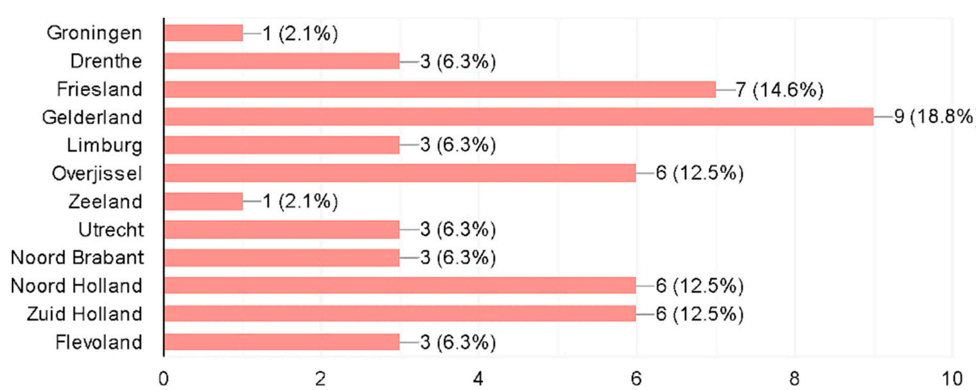

Fig. 3. Geographical representation of the CEIs included in the CEI Business Model Survey.

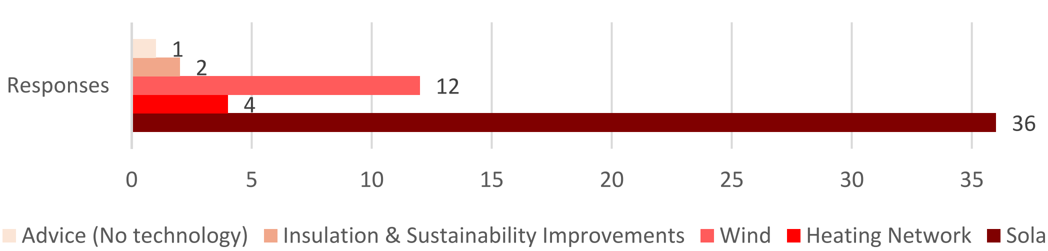

Fig. 4. Technologies represented by the CEIs included in the CEI Business Model Survey.

accordingly.

3.5. Scope

In the interview stage, the study focused on CEIs in Groningen, later expanding to include CEIs across the Netherlands through a survey and desk review. It is limited to data up to early 2023. Readers should interpret findings contextually.

4. Results

This section outlines the various configurations of the adapted BMC blocks identified in this study. As discussed in Section 2, these blocks are the components which create, deliver and capture value in CEIs. This section outlines the components of CEI BMs, which subsequently underscores the different configurations, financial accessibility and challenges with CEI BMs.

4.1. Value proposition

4.1.1. Value propositions

This section outlines the results related to the key value creation process, the value proposition (VP) block in the canvas, which outlines the products and/or services being offered to customers and beneficiaries. The initial VPs were identified through the interviews; thereafter, the survey was used to confirm whether the general VPs identified were applicable to other CEIs. All the results were then verified through the desk review, and any additional VPs not identified through the interviews were added.

The VPs of all the CEIs analyzed were aligned to the customer needs identified. Therefore, the general VPs of the CEIs analyzed were also similar. The initial economic VPs identified could be categorized into three types: (a) high returns on investment (ROI) and/or savings with affordable entry costs; (b) no entry costs; and (c) slightly higher entry costs with the potential for higher ROI (see Table 6). The review then identified the following additional economic VPs: a one-off consumption-based deposit; a two options model – either an affordable entry and installments, or a high entry and no installments; and an annual compensation model and much higher entry (above €400) with higher returns.

Table 6
The economic, social, and environmental value proposition categories identified in the projects interviewed and desk reviewed.

Economic Value Proposition		
Identified VPs	No. of interviewed projects (of total 13 projects)	No. of reviewed projects (of 225 solar and 15 wind projects)
Good Return of investment and/ or savings with an affordable entry cost (below € 250)	8 projects	70 solar projects 5 wind projects
No entry costs (€0)	2 projects	15 solar projects 0 wind projects
Slightly higher entry cost with the possibility of higher ROI plus savings (Between € 250–400)	2 projects	99 solar projects 6 wind projects
Very high upfront costs with high returns (Above €400)	0 projects	13 solar projects 3 wind projects
One-off consumption-based deposit	0 projects	3 solar projects 0 wind projects
Two options model: affordable entry costs or slightly higher entry cost (Above €100 + annual fee or €250 + no annual fee)	0 projects	17 solar projects 0 wind projects
Annual compensation	0 projects	0 solar projects 1 wind project
Social Value Proposition		
Collective ownership and decision making	All projects	All projects
Maintaining or improving aesthetic	2 projects	No projects explicitly stated on website.
Environmental Value Proposition		
Renewable energy generation	All projects except 1	All projects
Energy efficiency	1 project	None
CO_2 reduction	All projects	All projects

The annual compensation model only related to wind technology, whereas the one-off consumption-based deposit and two options model only related to solar projects. The much higher cost entry model was found in both solar and wind projects. While wind projects usually require more capital than solar projects, interestingly the much higher entry cost model related more to solar (13) than wind (3) projects in the desk review. The key social VP identified in the CEIs was collective ownership and decision-making in all the projects. However, two projects interviewed and five survey respondents also included the maintenance or improvement of the local aesthetic. The environmental VPs identified were renewable energy generation, energy efficiency and carbon emission reduction.

4.1.2. Customer and beneficiaries

This section presents the key findings related to the customer and beneficiary segment of the canvas block, which may cut across value creation, delivery and capture, as noted in Section 2. The customer and beneficiary segment allows CEIs to identify the needs and preferences of the customers and beneficiaries, which in turn can drive value creation by tailoring VPs to provide competitive advantage and drive citizen inclusion. By identifying the key customer and beneficiary base, CEIs can direct their resources, partnerships and activities to customers and beneficiaries, which may increase the efficiency of value capture.

Interviewees and survey respondents were asked to identify the needs of their targeted customers and beneficiaries. Interviewees noted that sustainability, generating income and/or savings above what is offered by bank savings and larger energy companies, and control over their own energy were the key needs that the projects aimed to address. The survey results aligned with the initial findings. The survey indicated that increased sustainability (24), increased income (12), affordability (10) and ownership (8) were the key customer needs (Fig. 5). Similarly, the 240 projects reviewed generally promoted increased participation and ownership, financial gain, and sustainability.

The targeted customers and beneficiaries of the CEIs interviewed were selected from a geographically demarcated area, either by postal code, municipality, neighborhood, or street. Most projects targeted homeowners as they were more willing to invest higher amounts in a home they owned, compared to renters, who were more reluctant to pay high investment costs for a property they might eventually leave. However, the project Huren met Zon was specifically designed for renters under the housing association; therefore, the investment costs were specifically oriented around a very low entry to incentivize renters to agree to the project. Of the CEIs interviewed, only two were specifically designed for lower income groups.

The survey (see Fig. 6) and desk review confirmed that low-income groups were generally not specific target groups of CEIs. Only one survey respondent specifically stated that they targeted lower income residents. This was an energy cooperative that focused on low-income residents living on the social minimum (<€39,000 gross per year) and social renters. Similarly, of the 225 solar projects reviewed, only 15 were oriented to lower income residents, while none of the 15 wind projects were specifically directed to lower income residents.

4.1.3. Citizen inclusion

This section outlines the results based on the citizen inclusion block of the adapted canvas, which was adapted from customer relationships. The block has been used to identify the different avenues for citizens to be included in CEIs. The interviews indicated that citizen inclusion in

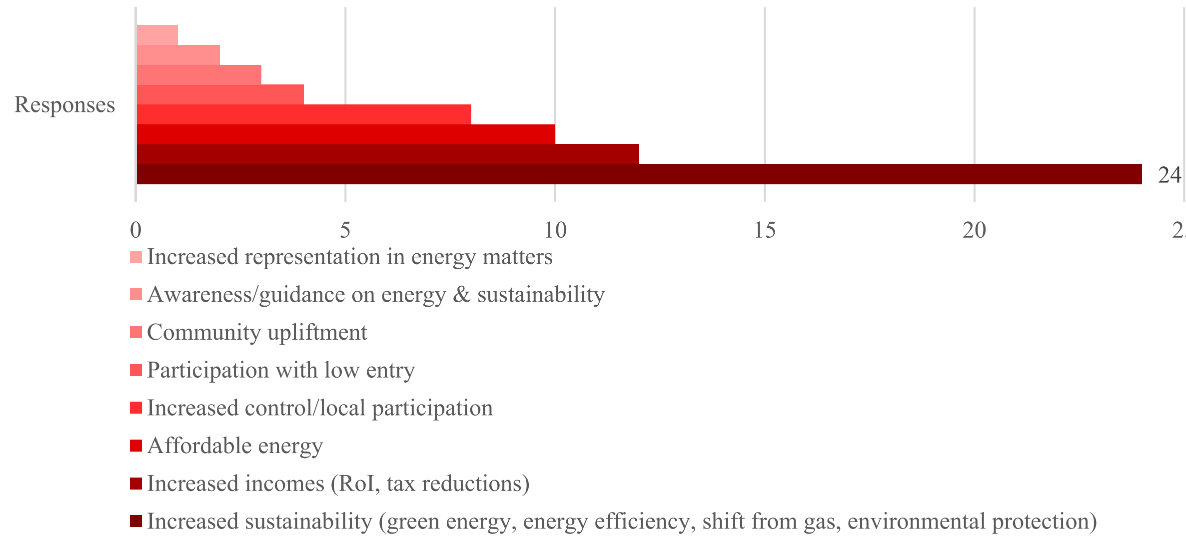

Fig. 5. The needs of customers and beneficiaries according to CEIs covered in the CEI Business Model Survey.

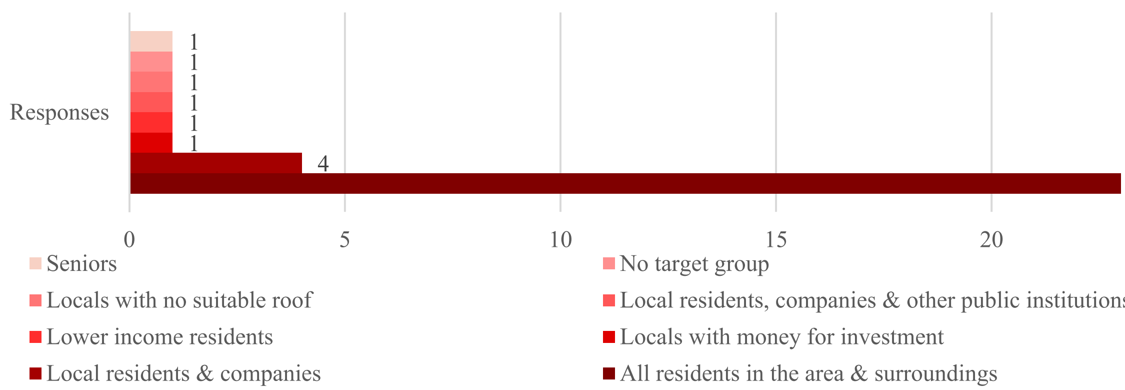

Fig. 6. The targeted customers and beneficiaries of CEIs covered in the CEI Business Model Survey.

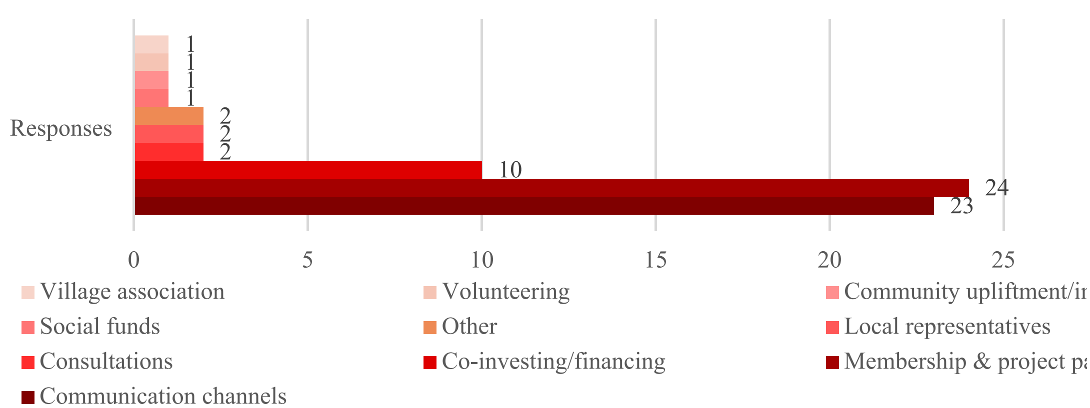

Fig. 7. The ways in which CEIs include citizens in their projects, as identified in the CEI Business Model Survey.

CEIs was generally through energy cooperative voting rights, traditional communication channels and through co-financing options. The desk review and survey results aligned with the initial findings (see Fig. 7). One project interviewed, Huren met Zon, was initiated by a housing association rather than a cooperative, but the project still needed two thirds of renters to agree to moving forward with the project, while Grunneger Power (an energy cooperative and consultant for the project) included citizens through its cooperative structure.

4.2. *Value creation and delivery*

4.2.1. *Key activities*

The activity block in the adapted canvas cuts across value creation, delivery, and capture. The activities are designed to meet customer needs and preferences and may provide CEIs with a competitive advantage. Additionally, activities may be directed to serving customers who are most likely to participate, therefore driving value capture.

The key relevant activities in the CEIs were categorized as activities

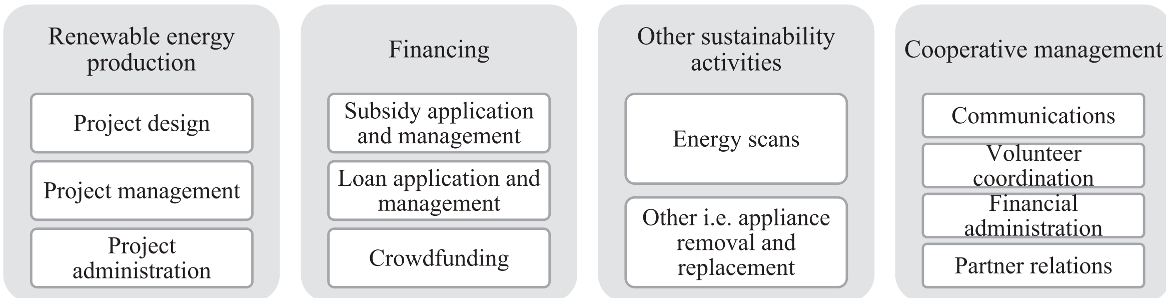

Fig. 8. The key activities of CEIs identified in this study.

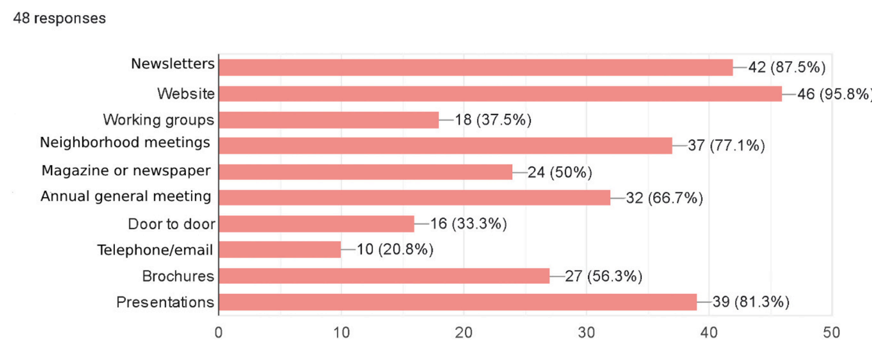

Fig. 9. The key communication channels used by CEIs covered in the CEI Business Model Survey.

related to renewable energy production, financing, energy cooperative management and/or other sustainability activities listed in Fig. 8. The activities of the CEIs analyzed aligned with the customer and beneficiary block and VP of CEIs. Project activities were almost unavoidably intertwined with energy cooperative management activities, as the initiatives were usually initiated and managed by cooperatives. Few projects included other sustainability activities; however, broader sustainability activities were usually offered separately by the energy cooperative, that is, under a separate initiative. Crowdfunding was not frequently used: only two projects interviewed included it.

4.2.2. *Channels*

This section outlines the results of the channels block in the adapted canvas. Specifically, it outlines how CEIs interact with customers and beneficiaries to deliver value to them.

The key channels illustrated by the survey and presented in Fig. 9 is also reflective of the channels used by the CEIs covered in the survey and desk review. In general, the key channels used by CEIs were newsletters, project websites, presentations, neighborhood meetings, the energy cooperative annual general meeting and brochures.

4.2.3. *Resources*

This section outlines the results of the resource block in the adapted canvas, which cuts across value creation, delivery, and capture. Key resources may support CEIs in meeting their customer and beneficiary needs and to delivery value to customers and beneficiaries. Moreover, optimizing resources may support high efficiency and cost reductions, which may improve value capture. Interviews, the survey and the desk review were used. However, the interviews provided the most detailed insights.

Table 7 illustrates that quite a few resources are needed to make the CEI BMs work. Volunteer hours were seen as an important resource in all the CEIs of this study. This is due to the fact that the financial structure of the projects aims to have minimal overhead costs and maximum energy-related outputs. Notably, since wind projects usually require more technical expertise and capital than solar projects, financing and appropriate skills and expertise were viewed as more important resources than was noted in the solar projects. Renewable energy technologies were central to the VP of all the CEIs included in this study and therefore a key resource in all projects.

In all the CEIs interviewed, there were specialist services needed; however, the nature of these services was project dependent. For example, the 't Zandt project required a tax specialist to support the structuring of the cooperative payments as finance repayments rather than energy services, since the latter is VAT taxable in the Netherlands. This allowed the project to have no upfront costs for participation. All solar and wind projects required land or roofs except the Groene Koelkast project, which was focused on replacing inefficient refrigerators. There are different agreements and arrangements in relation to land and roof rentals. For example, the Menterwolde cooperative was able to obtain 1.57 ha of land at a reduced rate from the municipality of Maarssenbroek, as it was an abandoned cross track that was in poor condition. Similarly, in the Woldwijk project, 40 ha of land was rented from the municipality with a 15-year guarantee. In other cases, agreements were reached with homeowners to rent their roofs for solar projects. A notary agreement is needed for the rental of land and/or roofs.

The most important resource highlighted in both the interviews (all projects) and the survey (27 respondents noted subsidies and 17 loans)

Table 7
Key resource needs of CEIs identified in the semi-structured interviews.

Volunteer hours	Permits	Technology and/or connection	Feasibility studies	Surveys	Savings account/community fund
100 % of projects	100 % of projects	100 % of projects	33.3 % of projects	8.3 % of projects	8.3 % of projects
Financing	Specialist services	Land/Roof	Crowdfunding platform	Office space	Annual consumption figures
100 % of projects	100 % of projects	91.6 % of projects	16.6 % of projects	8.3 % of projects	8.3 % of projects

Table 8
Regional funds that support Dutch CEI BMs through low interest loans.

Province	Fund
Groningen	Fonds Nieuwe Doen Groningen
Overijssel	Energie Fonds Overijssel
Gelderland	Innovatie- en Energiefonds Gelderland
Friesland	Fûns Skjinne Fryske Enerzjy
Drenthe	Energiefonds Drenthe
Flevoland	EEF Flevoland
Limburg	Limburg Energie Fonds
Noord Brabant	Energiefonds Brabant
Noord Holland	Participation Fund Sustainable Economy North Holland
Utrecht	Energiefonds Utrecht
Zuid Holland	ENERGIIQ

was financing. However, financing sources differed across projects according to subsidy type, loan arrangements, crowdfunding, and other income sources (discussed under the income block). The Postcoderoosregeling (PCR) scheme offers a tax exemption for 15 years on jointly generated solar projects, in proportion to the number of solar participations/panels owned. The investment amount for solar participation/panels was determined by the initiating energy cooperative, with the investment amount determined and tax refunds forming the basis of the project revenue model. In 2017, the benefit per kWh was €0.1226, including VAT [37].

The PCR scheme was replaced on April 1, 2021 by the Cooperative Energy Generation Subsidy Scheme (SCE), which pays out an amount per kWh produced [38]. Energy price fluctuations determine the amount of subsidy received. The Stimulering Duurzame Energie (SDE) is a long-term operating grant, which starts when an installation has already been built and commissioned [39]. Project initiators can apply for a total amount needed per kWh or to capture 1 ton of CO_2. The higher the average market value, the less subsidy is received, as the value is retrieved from paying customers. To apply for an SDE subsidy, a feasibility study is needed. However, project initiators who were not using the SDE subsidy have still conducted feasibility studies for their own benefit. The desk review found that the key subsidies for solar were the PCR, SCE and SDE schemes. For wind projects, the SDE was the primary subsidy being used. Regional funds were a key source of funds to CEIs. These funds provide loans to energy initiatives with a low interest rate (Table 8).

4.2.4. Key partners

This section outlines the results of the partnerships block of the adapted canvas, which has a role in value creation, delivery and capture. Partners can support CEIs in creating value tailored to customer and beneficiary needs, to deliver value to customers and to improve value capture through higher efficiency and cost reductions.

Commonly, the key partners of CEIs are the municipality, provincial organizations, developers, installers and utility companies, the Netherlands Enterprise Agency, and other financiers. However, there are other partners that CEIs may include in projects. The configuration of partners is highly dependent on the business needs of the CEI (Fig. 10). Most of the projects work with Energie VanOns (formerly Noordelijk Lokaal Duurzaam), which is an umbrella cooperative with only three statutory members, which are regional cooperatives of each province. CEIs have an agreement with Energie VanOns in which reseller compensation for each signed up member is returned to the cooperative.

Projects may also partner with village associations to ensure that all residents are represented in the project. Duurzaam Menterwolde had a unique configuration: it originated from an active working group which became an energy cooperative that opened another energy cooperative called SunBrouck energy to manage the PCR project (later the SCE). A private company called Menterstroom was set up to specifically focus on the Zuidbroek SDE project [40]. Similarly, a private company, Zonnepark Fledderbosch BV, was set up by three initiating institutions. One of the initiators was Bronnen VanOns (a cooperative developer), which

Table 9
Key partnership formations identified in the study.

Energy cooperative key partner rather than initiator/ lead AND collaborates with other partners	Private company formed as the lead AND collaborated with other partners including owner institutions of the company	Subsidiary cooperative under the umbrella cooperative is the lead AND collaborates with other partners	Energy cooperative is the initiator/lead AND collaborates with other partners

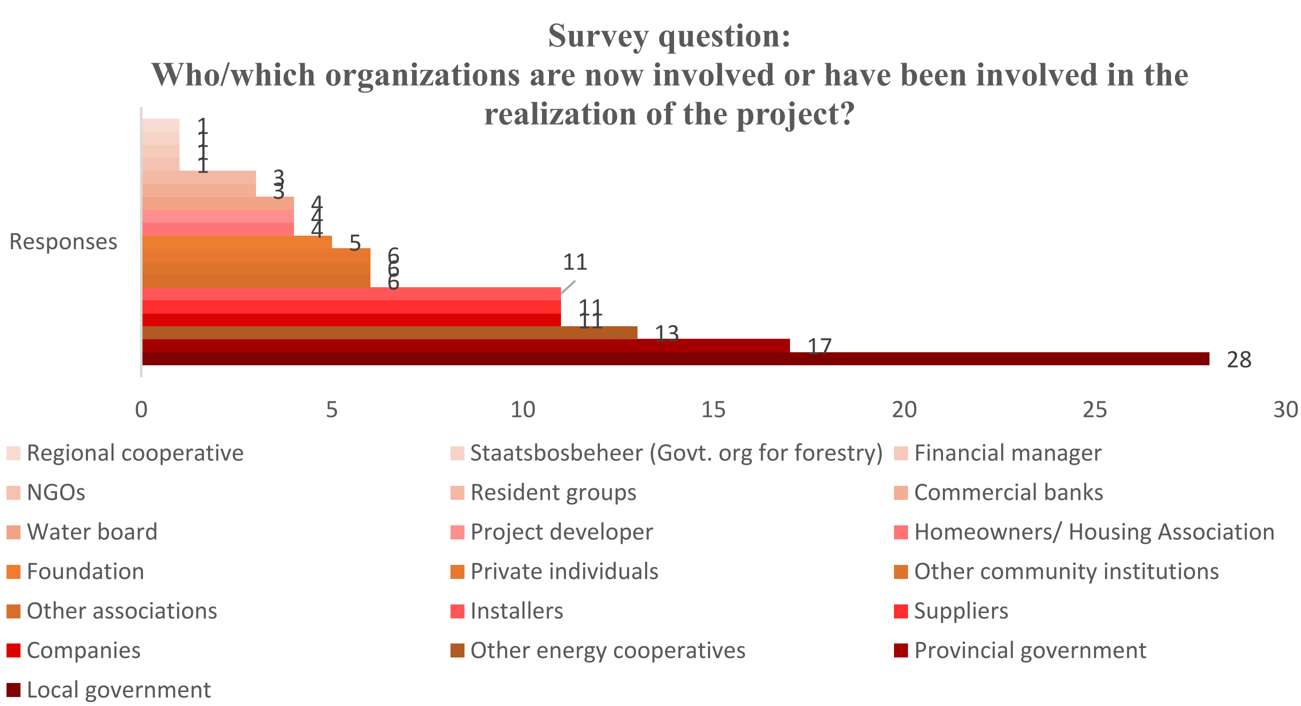

Fig. 10. Key partners of CEIs identified in the CEI Business Model Survey.

provides the local energy cooperative with a share of ownership in the project [41]. Another unique configuration was the Huren met Zon project, as the initiator and leading organization was Nijestee, which is a housing association with support from Grunneger Power (energy cooperative). Not only is Nijestee the initiator and lead of the project, but it is also the financier of the project through its sustainability fund. There were four broad partnerships configurations identified in the study, as illustrated in Table 9.

The survey noted that CEIs frequently work with other energy cooperatives to deliver value (13 respondents). While commercial banks play an important role in scaling up renewable energy projects [42], only three survey respondents had projects that partnered with a commercial bank. Similarly, only 22 projects (16 solar, 8 wind) in the review explicitly mentioned commercial bank financing.

4.3. Value capture

4.3.1. Income

This section outlines the results for the income block in the adapted canvas, which supports CEIs in capturing value. The income model of a project determines the entry costs for citizens to financially participate in the project. Three overarching income structures were identified in the CEIs interviewed and reviewed: (a) upfront investment structure; (b) no participation costs structure; and the (c) spread payment structure.

4.3.1.1. Upfront investment income structure. The upfront investment income structure requires an upfront purchase or deposit from the customers and/or beneficiaries, as listed in the economic VP under Section 4.2. It was the most common income structure in CEIs covered in this study. About 10 of the projects interviewed, 14 of the wind projects reviewed, and 202 solar projects used some variation of this structure. The upfront investment income structure was configured with several different options which form the key means to finance the project and distribute its benefits to customers and/or beneficiaries (see Fig. 11). The choice of the options selected was dependent on the CEI itself and was not, under any conditions, set through external financial streams. There was significant variation in upfront investment costs, which ranged from €50 to €1000.

Depending on the configuration selected by a CEI, the upfront investment costs could be reduced significantly (by €30–100) or even reduced to €0. For example, most of the CEIs with lower upfront costs used subsidy schemes and/or regional funds to cover a substantial share of the costs of the project. This would make financial participation costs lower and these lower participation investments could be redirected to cover the remainder of the project. Most CEIs used a combination of the reseller fee with membership fees, annual contributions or the sale of electricity or other funds to reduce upfront investment costs. There were instances where the subsidy and regional funds covered the entirety of the project. This meant upfront investment was much lower and could be redirected to repay the loans and interest. Additionally, the upfront costs could include an annual contribution for 15 years.

Table 10
The upfront investment income structure one-off consumption-based deposit calculation and configuration.

One-off consumption-based deposit
Calculation example
Annual consumption is 3000 kWh.
Participation will then be 85 % of 3000 = 2550kWh.
One-time deposit will then be 2550 × 1 cent = €25,50
One-off deposit settled the first year the participant receives their energy tax back.
PCR Scheme

There were projects which configured the upfront costs differently. For example, the SunBrouck project had two options, either an upfront payment of €250, or €50 upfront and the remaining €200 paid in installments. Similarly, 17 of the solar projects reviewed offered the choice of a higher participation investment of approximately €250 with no annual costs or a lower participation investment of approximately €100 with an annual cost of €17.50. Based on the projects reviewed, three solar projects used a one-off consumption-based deposit always in tandem with the PCR scheme (see Table 10). Solar projects either used a PCR or SCE subsidy, but wind projects with this structure usually used the SDE subsidy.

4.3.1.2. No participation cost income structure. There are several ways CEIs can arrange a project so that there are no upfront costs for participants. However, this structure was generally uncommon, and it was absent from wind projects. Two of the projects interviewed had a no participation costs income structure, meaning the project was largely financed externally. In the 't Zandt project, the loan covered most of the project costs along with a €50,000 PCR premium. This was then repaid through the PCR, the reseller fee and cooperative membership fees. The Zuidhorn carport used the SCE to fully finance the project, with the participants of the project low-income earners, who received the financial benefit but at no cost to them.

While the SCE and PCR schemes were the most common subsidies for this structure, CEIs also used the SDE to cover the costs of the project and also provided crowdfunding. The latter was only linked to SDE projects in the CEIs covered in this study and is generally uncommon in CEIs. One of the wind projects reviewed had no upfront participation costs; however, the structure was not aimed at participation but instead compensation (Table 11). All the income was derived from an SDE subsidy coupled with a loan. This was used to finance a wind turbine. The proceeds of the project were used to compensate residents living in close proximity to the turbine. The 15 solar projects reviewed that had no participation costs used a "No participation structure" configuration, illustrated in Fig. 12.

4.3.1.3. Spread payment participation costs income structure. The spread

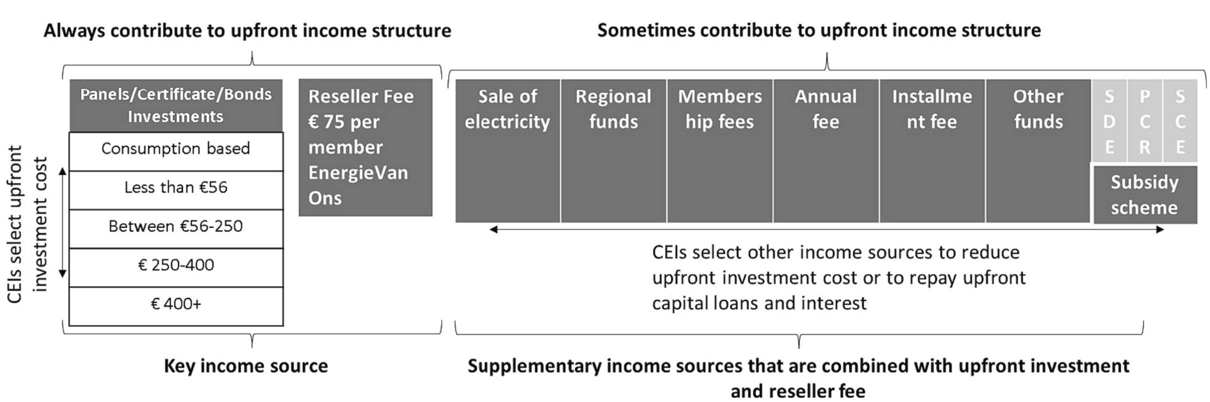

Fig. 11. The upfront investment income structure configurations.

Table 11
The no participation costs income structure variant “Annual compensation structure” configuration.

Income)		
Subsidy scheme	**Loan**	
SDE	Yes	
Compensation annually		
€300	€200	€100
Up to 800 meters from turbine	800 to 1,000 meters from turbine	1,000 to 1,200 meters from turbine

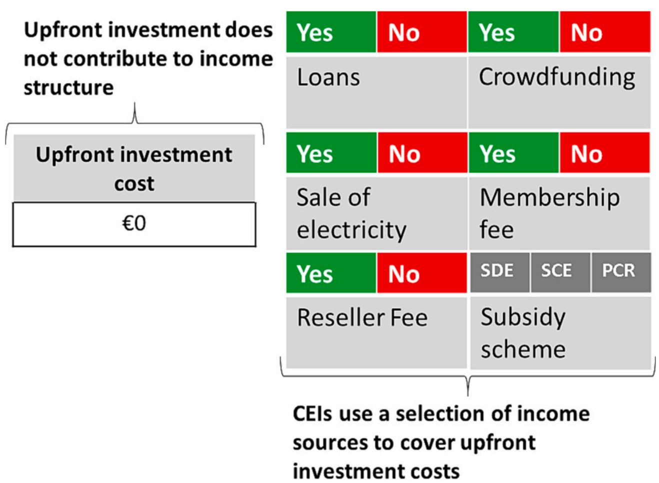

Fig. 12. No participation costs income structure configurations.

Table 12
Spread payment income structure configurations.

Income source	De Groene Koelkast	Huren met Zon
Spread payment	€3 per month until €180	€12 rental increase
Other fund	Cooperative funds	Nijistee sustainability fund

payment structure had no upfront costs but did have a monthly payment that was usually coupled with other funds to finance the project (Table 12). This structure was extremely rare, and only two projects using this structure were identified (based on the interviews and review). Both projects were financed through other funds and neither used subsidies or loans. The Huren met Zon project was unique in that the targeted group was renters, with the spread payment including a slight rental increase, thereby making it attractive to renters who would otherwise be reluctant to invest large sums in a property that they do not own.

4.3.2. Costs and benefits

This section outlines the results for the cost and benefit blocks of the adapted canvas which supports CEIs in capturing value. The income structure selected by projects was used to cover the costs associated with the project. Table 13 outlines the key costs incurred by CEIs, as identified in the interviews and survey. In terms of the societal costs, most interviewees and survey respondents claimed that there were no societal costs, apart from the much needed volunteered time of residents. Similarly, the solar projects stated that the only environmental cost was

Table 13
The key costs of CEIs identified in the study.

Societal Costs	Volunteer time, noise nuisance (only wind)	
Environmental Costs	Land-use, wildlife endangerment (only wind), non-recyclable material (only wind)	
Economic Costs	Loan and interest repayment	Land/roof rental
	Inverter	Installer fees
	Permits	Developer fees
	Asbestos removal	Enexis fees
	Specialist services	

land use. However, the wind projects noted that the turbine noise nuisance was a societal cost associated with their projects. The survey respondents also noted that wind turbines may harm birds and that the materials used in the blades of turbines are incinerated at the end of their use.

For the most part, survey respondents and interviewees believed that the societal and environmental benefits of the projects far outweighed the costs. The key financial costs for many projects were loan and interest repayments. Apart from the loan, the annual costs of the projects largely concerned land or roof rental. Wind projects had higher fiscal costs associated with them, compared to solar projects. Most projects with an affordable or no entry participation structure broke even, whereas those with slightly higher or very high upfront costs had higher returns and the capability to finance new projects.

The economic, social, and environmental VPs of the CEIs analyzed are illustrated in Table 5 and aligned with the actual benefits distributed by the projects, such as ownership, control, community uplift, renewable energy generation and CO_2 reduction, along with energy savings or ROI. Annex 5 provides more detail on the exact benefits generated by the projects interviewed.

4.4. Summary of results

Tables 14, 15 and 16 provide a summary of the key results and their relation to energy justice principles. The justice value (JV) indicates whether a component has the potential to contribute to energy justice principles, whether negatively or positively. The results value (RV) indicates the findings obtained from our data in relation to each component.

Table 14 provides key results for the VP component in the BMC. While CEIs aim to create social, economic and environmental value along the same lines, a no-cost economic VP was uncommon. Community uplift in the social VP of CEIs was limited. Moreover, CEIs followed a similar inclusion blueprint, involving voting rights, co-ownership, co-financing and profit sharing. They mostly targeted homeowners and local residents/institutions, with very few focusing on renters or low-income groups. The common needs addressed by most CEIs were

Table 14
Results on value propositions of Dutch CEIs and the potential to contribute to energy justice or injustice.

Sub-component	Sub-component options										
Value proposition	**Economic VP**				**Social VP**				**Environmental VP**		
	High ROI with affordable entry cost	No entry cost	Slightly higher entry cost with higher ROI	Much higher entry with higher returns	Collective ownership	Decision making power	Community upliftment	Maintaining local aesthetic	Renewable energy generation	Energy efficiency	Carbon emission reduction
Justice value	+1	+1	-1	-1	+1	+1	+1	+1	+1	+1	+1
Results value	+1	-1	+1	-1	+1	+1	-1	-1	+1	+1	+1

Sub-component	Sub-component options					
Citizen inclusion	**Ownership and decision making**		**Financial participation**		**Information sharing**	
	Energy cooperative voting rights	Co-ownership	Co-financing options	Increase income options	Two-way information feedback loop	Unilateral information sharing
Justice value	+1	+1	0	0	+1	-1
Results value	+1	+1	+1	+1	+1	-1

Sub-component	Sub-component options									
Customers and beneficiaries	**Needs targeted and addressed**			**Customers and beneficiaries targeted and addressed**						
	Sustainability	Income/savings	Control over energy production	Homeowners	Renters	No target	Low income	All local residents and institution	Local residents and institution with funds to invest	Broader residents and institutions
Justice value	+1	+1	+1	-1	+1	0	+1	+1	-1	+1
Results value	+1	+1	+1	+1	-1	-1	-1	+1	-1	+1

Justice values (JV): A potentially negative (-1), positive (+1) or neutral (0) impact on energy justice lock-in.

Results value (RV): based on the results of the study, +1 indicates the sub-component exists and is common, -1 indicates the sub-component is uncommon or missing in the cases analyzed.

Positive impact and common/in existence=**positive lock-in**

Negative impact but uncommon/non-existent= **limited negative lock-in**

Positive impact but uncommon/non-existent=**limited positive lock-in**

Negative impact and common/in existence= **negative lock-in**

Neutral impact/unknown impact.

Table 15
Results on value creation and delivery in Dutch CEIs and the potential to contribute to energy justice or injustice.

Sub-component: Resources	Needed in all CEIs				Needed in some CEIs						
	Specialist services	Volunteers	Technology	Permitting	Feasibility studies	Surveys	Savings account/ community fund	Crowdfunding platform	Office space	Annual consumption figures	Land/Roof
Justice value	0	+1	+1	-1	0	+1	+1	+1	0	0	+1
Results value	+1	+1	+1	+1	-1	-1	-1	-1	-1	-1	+1

Sub-component: Activities	Renewable energy production	Financing	Other sustainability initiatives	Cooperative management
Justice value	+1	+1	+1	+1
Results value	+1	+1	-1	+1

Sub-component: Partners	Other targeted partners						Citizen targeted partners				
	Government	Commercial banks	Private companies	Utilities	Suppliers	Installers	Non-governmental organizations	Housing association	Other community associations or cooperatives	Private Individuals	Resident groups
Justice value	0	+1	0	0	0	0	+1	0	+1	+1	+1
Results value	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1	-1

Sub-component: Channels	**Newsletters**	**Websites**	**Working groups**	**Neighborhood meetings**	**Magazine/ newspaper**	**Annual general meeting**	**Door to door**	**Telephone /email**	**Brochures**	**Presentations**
Justice value	0	0	+1	+1	0	+1	+1	+1	0	+1
Results value	+1	+1	-1	+1	+1	+1	-1	-1	+1	+1

Justice values (JV): A potentially negative (-1), positive (+1) or neutral (0) impact on energy justice lock-in.

Results value (RV): based on the results of the study, +1 indicates the sub-component exists and is common, -1 indicates the sub-component is uncommon or missing in the cases analyzed.

- (green) Positive impact and common/in existence=**positive lock-in**
- (yellow) Positive impact but uncommon/non-existent=**limited positive lock-in**
- (grey) **Neutral impact/unknown impact.**
- (orange) Negative impact but uncommon/non-existent= **limited negative lock-in**
- (red) Negative impact and common/in existence= **negative lock-in**

Table 16
Results on value capture Dutch CEIs and the potential to contribute to energy justice or injustice.

Sub-component	Sub-component options					
Cost	**Social costs**		**Environmental costs**			**Economic costs**
	Volunteer hours	Noise/nuisance	Land-use	Wildlife endangerment	Non-recyclable material	All financial costs
Justice value	-1	-1	-1	-1	-1	0
Results value	+1	+1 (wind only)	+1	+1 (wind only)	+1 (wind only)	+1

Sub-component	Sub-component options								
Income	**Upfront investment**					**No participation cost**		**Spread payments**	
	Consumption based	Less than €56	Between €56-250	€ 250-400	€ 400+	Participation	Compensation	Rental increase	Instalment plan
Justice value	0	+1	0	-1	-1	+1	+1	+1	+1
Results value	-1	-1	+1	+1	-1	+1	-1	-1	-1

Sub-component	Sub-component options									
Benefits	**Economic benefits**			**Social benefits**				**Environmental benefits**		
	Affordable entry cost	No entry cost	Return on Investment	Collective ownership	Decision making power	Community upliftment	Maintaining local aesthetic	Renewable energy generation	Energy efficiency	Carbon emission reduction
Justice value	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Results value	+1	-1	+1	+1	+1	-1	-1	+1	+1	+1

Justice values (JV): A potentially negative (-1), positive (+1) or neutral (0) impact on energy justice lock-in.

Results value (RV): based on the results of the study, +1 indicates the sub-component exists and is common, -1 indicates the sub-component is uncommon or missing in the cases analyzed.

- Positive impact and common/in existence=**positive lock-in**
- Positive impact but uncommon/non-existent=**limited positive lock-in**
- **Neutral impact/unknown impact.**
- Negative impact but uncommon/non-existent= **limited negative lock-in**
- Negative impact and common/in existence= **negative lock-in**

sustainability, income/savings and energy control.

Table 15 shows the value creation and delivery results. All CEIs require specialists, volunteers, technology, permits and land/roofs. Permits were often a hinderance to CEIs' ability to create and deliver value. Common activities of CEIs included renewable energy production, financing and cooperative management, while few had other sustainability initiatives. CEIs formed diverse partnerships with government, NGOs, housing associations, private companies and others, but rarely involved commercial banks or local residents.

Table 16 displays the value capture results. Most CEIs had minimal social and/or environmental costs, with larger costs associated with wind CEIs. Economic costs were similar for all CEIs, the largest costs included loans, interest and installation. The most common income structure was upfront investment, while no participation costs and spread payment structures were rare. Government subsidies were a vital income source. The benefits generated by CEIs align with the VPs in Table 16.

5. Discussion

This section outlines the key discussion points based on the results. Section 5.1. aims to answer the question of which configurations increase the financial accessibility of projects to citizens and which income structures are oriented to lower income earners. Section 5.2. aims to answer the question of how the costs and benefits are distributed in CEIs, while Section 5.3. aims to identify the key challenges to CEI BM configurations. Section 5.4 looks at the applicability of findings to CEIs outside the Netherlands and, finally, Section 5.5 reflects on our theoretical framework and methodology.

5.1. *Increasing financial accessibility through different configurations*

The three types of income structures and the configurations selected may each allow for the financial inclusion of citizens, although the citizens targeted for each model are likely to have different financial capabilities. Most importantly, the choice of partners and resources and how CEIs use these may make projects more or less financially accessible to a larger audience.

First, the *no participation cost structure* may be especially beneficial for citizens with limited financial resources, as it allows them to participate in a project without bearing any financial burden. Consequently, this income structure has the potential to support energy justice lock-in, as it is well situated to deliver value on both affordability and accessibility. The Zuidhorn Carport, for example, combined several income streams external to the citizens because it focused on generating income for residents living on the social minimum. An annual compensation wind income structure was similar, although it targeted residents based on proximity rather than income. In this project, anyone within a certain radius had access to the project without upfront investment.

Through a combination of subsidies, membership fees, crowdfunding, and loans, CEIs can thus offer projects with no upfront investment costs. The 't Zandt project, for example, funded most of the project costs through the regional fund, with the PCR scheme used to cover the rest. The project used the sale of electricity generated by the project, cooperative membership fees and the reseller fee to cover the loan and interest repayments. In other instances, projects received high subsidies and could entirely cover the cost of the project through these.

While, generally, the no participation cost model would lead to the most financially accessible projects, be the most feasible in extending community energy to low-income earners and remove the cost burden from citizens, this income structure was not commonly used and citizens on low incomes were not frequently targeted by CEIs. Moreover, currently, citizens with low incomes only have the option to participate in solar projects, since there are no wind projects apart from the compensation project with no upfront costs. Thus, our review of CEIs indicated that a no participation cost structure is not frequently used, and it is near absent in projects involving wind technologies.

Second, the *spread payment income structure* may also be broadly financially accessible, as it allows citizens to pay for renewable energy installation and maintenance costs over a longer period. This spreads the financial burden over a longer time, making it more manageable for citizens with lower incomes. In addition, this model may make participation in renewable energy projects more financially accessible to renters, who are usually not targeted by CEIs. For example, the Huren met Zon project provided renters with access to solar panels at about €14 extra per month on top of their rent. This may have been inaccessible to them otherwise, due to high upfront costs or the inability to install panels on rented property. The structure has the potential to include lower income earners and renters in the decision-making spaces of CEIs, contributing to energy justice lock-in. However, the model is not widespread in the CEIs analyzed.

Third, the *upfront investment structure* was the most commonly used income structure in the study. However, the financial accessibility of all projects using this model differed greatly, as the amount of investment needed varied depending on the size and type of the project. However, in general, it ranged from as little as €35 to well over €400. For low-income households, particularly those living on the social minimum, this upfront investment model may be less accessible because it may be difficult for them to raise the required funds upfront. We found that initiatives offering participation costs of €100 or lower (affordable entry with ROI) were more accessible to both lower and higher income earners, whereas projects of €250 and above (higher entry with higher ROI) were more likely to be more accessible to households with higher incomes and thus higher disposable income. Projects with €400 plus (higher entry with higher ROI) participation costs would most likely only be accessible to those with much higher incomes.

Consequently, an affordable entry upfront investment model has the potential to positively contribute to distributive justice principles, particularly affordability and accessibility, whereas higher upfront models have less potential to contribute positively to these energy justice aspects. Promisingly, the affordable entry cost structure was the most common model used by the CEIs and projects analyzed, with entry costs above €400 rare. However, initiatives with participation costs of €250 were also common. The participants interview noted that while participation costs could be reduced to below €50 or even to €0, this was not always attractive to the residents in the project location, who were interested in higher returns.

Each income model clearly has its advantages and disadvantages and is suitable for different citizen income groups. The results indicate a trade-off between different energy justice principles, in which CEIs may prioritize affordability and accessibility or higher resident interest (participation) and a higher distribution of economic benefits. It would be useful to further examine the financial accessibility of CEIs based on income distribution in the project location. However, the CEIs analyzed did not collect information about income from participants to avoid breaching their privacy, so income structures were not directly tailored to income levels in the project area.

Most CEIs assumed the project was readily accessible based on the number of participants in the project; however, this is not a good indicator, since projects may have many higher income participants and little or no lower income participants precisely due to the investment costs. Studies have confirmed that higher income earners are more likely to participate in renewable energy projects [43]. In terms of distributive justice principles, the lack of consideration of income groups in CEIs may be problematic, since a mismatch between the cost of participating in CEIs and disposable income levels in the project area may unintentionally exclude lower income citizens from participation. Using a range of income structures in a single project location would provide flexibility and allow for greater financial accessibility to citizens with different income levels residing in the project location, without the need to collect income data. Nevertheless, anonymized income data is available in the Netherlands and is frequently captured in other countries' national statistics. Therefore, CEIs should first check the available income data to identify any information gaps before determining the investment costs and structure.

5.2. Cost and benefit distribution in Dutch CEIs

The income generated by the CEIs was generally used to cover the costs associated with the project, such as loan and interest repayments, land, or roof rental costs, and compensating residents nearby for any noise nuisance. In most instances, the upfront cost of the project was either solely financed through subsidies or through a combination of loans and subsidies. The repayment of the loan and interest rates was then usually financed through co-financing or by selling the electricity generated. CEIs distributed their benefits to customers and beneficiaries through co-ownership, control, community uplift and energy savings or ROI.

Community uplift and CO_2 reduction are benefits of projects that may also be distributed beyond project participants to a broader citizen base (beneficiaries). The benefits were aligned with the VP of CEIs and distributed equitably among co-financers. However, there were variations depending on the technology, scale, and income structure. Wind technology-oriented initiatives were generally more expensive to participate in than solar initiatives, which may be attributed to higher technology-related costs associated with wind technologies. However, very high upfront co-investment was related more to solar projects than wind projects. Moreover, wind projects generally had higher capacity and ROI than the solar projects in this study, therefore generating greater economic and environmental benefits.

At the same time, wind projects require greater technical expertise than solar projects, so they may be less accessible to citizens in terms of process participation [44]. Scale also determined the cost of a project. In most instances, the larger the scale, the greater the upfront investment costs for citizens, but there was also greater capacity generated and greater ROI. In terms of societal cost, there was a trade-off with scale and procedural participation. Larger scale initiatives were more professionalized: often this entailed less active participation from residents, and a separate private entity was commonly established to drive the business interests of the initiative.

The cost burden was also distributed differently depending on the income structure of the CEI. The no upfront cost income structure had no financial participation costs for citizens, with the cost burden usually lying with the energy cooperative, which was financed through regional funds and governments (through subsidies). The affordable upfront investment income structure and higher upfront investment income structure were different in the sense that participants usually shared the cost burden of the project with the energy cooperative and/or CEI. While the benefits were the same as with the no upfront cost model, there were higher returns in the upfront investment model. The spread payment model shared costs between participants and project initiators; however, the costs incurred by participants were lower than the costs incurred by the initiator. Additionally, participants usually did not benefit in terms of profit but rather in energy savings.

5.3. Challenges with Dutch CEI business models

One of the main challenges facing CEIs is access to funding. Many CEIs lack the capital necessary to get started, and securing funding can be difficult due to their limited history and perceived risk. Commercial banks are often hesitant to lend to CEIs, as they may not have a proven track record of financial stability and profitability. In addition, CEIs may struggle to meet the collateral requirements and other lending criteria set by commercial banks. Moreover, many banks do not find financing of small projects attractive, since the returns are lower for them. However, based on our desk review, Rabobank, Triodos and ASN Bank in the Netherlands have been more active in funding CEIs over the past years.

In addition, regional funds in the Netherlands offer various financing options for CEIs at a lower interest rate than commercial banks.

Another challenge is that, while CEIs are often established with the goal of promoting social and environmental aims, sustainable economic growth is important for the continuity of CEI projects, if they are to have a larger impact on the energy transition and subsequently generate greater economic and environmental benefits for citizens. However, it can be difficult to achieve such sustained profitability and viability. This is particularly true for initiatives that are established in areas with limited economic infrastructure, as they may struggle to compete with established businesses in the region. To achieve greater energy justice impact, CEIs will need to consider refining their business models to ensure that they are economically viable and competitive within the current energy system, while promoting environmental and social objectives. At the same time, the current energy system needs to create an enabling environment for business models with a greater focus on environmental and social impact than economic impact. This would provide CEIs with a competitive advantage over fossil fuel businesses and could be achieved through policy changes, such as offering subsidies for renewable energy or introducing regulations that favor community-owned energy projects.

Scaling up is another critical component of the success of any CEI BM, as it enables the initiative to reach a broader audience and have a greater impact on the community. However, scaling up can be a significant challenge for CEIs, as it requires significant investment in resources and infrastructure [45]. One of the primary challenges with scaling up a CEI is the need for additional capital. As the initiative grows, it may require additional resources such as equipment, labor and marketing to sustain its operations. This can be a significant financial burden, and CEIs may struggle to secure the necessary funding to support their growth. Another challenge with scaling up is the need to maintain the quality of the goods or services provided. As a CEI grows, it may become more difficult to maintain the same level of quality that was provided in the early stages of the initiative, particularly citizen engagement.

5.4. Applicability to CEIs outside the Netherlands

While the paper did not study CEI BMs in different countries, the components of the adapted BMC can be compared to earlier comparative studies. In line with this study, previous literature suggests that energy cooperatives are the key legal form in many European countries [46]. Our findings on social, economic and environmental VPs are in line with other studies of European CEIs, which indicate they are mostly focused on community ownership, renewable energy and energy efficiency, and profits and/or savings [4,46]. Further studies have confirmed that Dutch, British and German CEIs have a strong tendency to strive for independence and self-sufficiency, which provides strong avenues for procedural justice [47,48]. While most European CEIs are bottom-up, in China and South Korea there are different approaches, which include bottom-up, top-down, state-led and entrepreneur-driven approaches to community energy [49].Top-down, state-led and entrepreneur-driven CEI BMs are not accounted for in this paper, but further research on the energy justice value of these models is merited.

Affordability considerations are more prominent in some countries, such as Italy, Spain, Poland and Estonia, than in the Netherlands and Belgium [4]. The research also noted that profit distribution was more of a consideration in the Netherlands, Belgium and Estonia than in other countries in the study. This is aligned with the CEIs analyzed in this study, which prioritized upfront investment models due to ROI considerations, despite the fact that the adoption of a no upfront investment model was possible and would have been more financially accessible to citizens on lower incomes. Similarly, studies on the UK have noted that while profits were not the main aim of CEIs, the distribution of profits to the community was a high priority [46,50]. An analysis of UK CEIs also noted that profits became increasingly important as CEIs professionalized and shifted away from models dependent on grant financing [11]. Similarly, CEIs in the US were closely linked to financing of renewable energy projects and distributing profits [48].

Overall, other studies suggest that CEIs operating in countries with a higher low-income population may more seriously consider aspects of affordability than countries with a lower low-income population, which may focus more on benefit distribution. Generally, the activities identified in our study were comparable to those identified in European countries, the US, China and South Korea [4,48,49]. Lupi et al. [4] noted that citizen investment was essential for CEIs in all the EU countries covered except Poland. CEIs in the UK, Germany and US also relied on the financial participation of citizens [48]. Several studies also highlight the key role of subsidies to de-risk CEI investments, and the reliance of CEIs on grant financing [11,51].

Research also suggests that private banks play a limited role in European CEIs, with the exception of Estonia. This is in line with Dutch CEIs, which we found to rely on subsidies for their business models to work. In China and South Korea, banks and government funding played a more prominent role than citizen investments [49]. Further research is needed to investigate whether CEIs that receive increased private financing coupled with government subsidies create more commercially viable CEI BMs, and whether there is a trade-off between increased commercial viability and energy justice principles. While further research is needed to specifically identify and compare the BMs of CEIs in different countries to those in the Netherlands, the existing body of research suggests that several of our findings will be useful to the study of CEIs in other countries.

5.5. Reflection on theoretical framework and methodology

By using the MLP lock-in literature, we were able identify how BMs can support lock-in or breakthrough. This helped in analyzing the complexity of energy justice principles and CEI BMs, in terms of the potential of a BM component to contribute to energy justice lock-in. The dominant BMC framework of the paper allowed for a more detailed analysis of the specific BMs used by CEIs and the configuration of CEI BM components that are aligned with energy justice principles, particularly distributive justice considerations. Furthermore, this helped to identify the key drivers of CEI success, which can inform other CEIs as well as policies that align with energy justice considerations.

As such, the MLP concepts such as lock-in and BMC can be used in a complimentary way. The lock-in literature provides a broader socio-technical context in which CEIs operate, and it can be used to explain the dynamics of system change, including a shift from an unjust energy system to a just energy system. In contrast, the BMC literature captures the specific details of CEI organizational structure to determine if and how CEIs contribute to energy justice. However, the traditional BMC is mainly focused on the economic aspects of a business and cannot fully capture the environmental and social impacts of CEIs. By including environmental and social factors in our adapted BMC, it was possible to incorporate the elements of sustainability and social benefits of community energy initiatives. By taking a holistic view of CEIs, the framework makes it possible to identify potential trade-offs and synergies between different aspects of a business.

In addition, we used a mixed-method approach to analyze the CEI BMs. The use of interviews allowed for in-depth exploration of the experiences of energy cooperatives, while the survey helped to extend the findings beyond the province of Groningen to the broader Netherlands. The desk review provided a way to confirm the findings and identify any variance in the models. By using a mixed-method approach, the study was able to increase the validity of the findings and support the results with more comprehensive data. The overall sample of CEIs covered in our study was representative of most of the CEIs in the Netherlands.

However, there are several improvements that could be made to our framework and methodology. Our framework and analysis relied heavily on qualitative data, which makes impact measurements more difficult to compare with each other and may skew the results concerning benefits toward key CEI member perspectives rather than actual benefits generated. Quantitative considerations and integration would further improve the income analysis and assist in determining the commercial viability of CEIs. While the desk review was useful for identifying larger BM trends and considerations, the results may not reflect all Dutch CEI BMs, since desk research relies on CEI websites providing all the information needed and having up-to-date information. In future research, we would retain the desk review component of the methodology to identify broader trends but would also expand the interview data to several regions/contexts to gain a more detailed and up-to-date overview of CEI BMs. Further research is needed to explore the potential of the adapted BMC for analyzing and comparing cases across broader geographical contexts. Additionally, more empirical research is needed to test the validity and generalizability of the framework in practice.

6. Conclusion

The key BMCs of Dutch CEIs were mostly aligned in terms of value proposition, value creation and delivery. Variations in value creation and delivery configurations were not significant but there were key differences in the partner and resource segments. Most BM variance in CEIs concerned their value capture process, in particular their income structures. Income structures also accounted for the variance in value creation and delivery, as resources and partners were selected or sourced on the basis of the income structure the CEI aimed to have.

Consequently, the key CEI BMs could be categorized into an upfront investment model; a no upfront investment model; and a spread payment model, which reflect the dominant income structures used by CEIs. The no upfront investment model and spread payment model would be the most suitable models for lower income residents and in ensuring greater energy justice returns. Affordable entry upfront investment models may support the inclusion of both lower and higher income groups, thereby having the potential to contribute to energy justice lock-in. In contrast, higher cost upfront investment models are less financially accessible to lower income households and are therefore unlikely to be good candidates for distributive justice considerations. Consequently, the no upfront investment, spread payment and affordable entry cost upfront investment models fit the criteria of inclusive, sustainable BMs as we defined them.

The distribution of costs and benefits also depended on the BM income structure. Upfront investment models often yielded greater economic and environmental benefits but with a higher cost burden to citizens. No upfront investment models placed the cost burden of projects with government and energy cooperatives instead of citizens and were more inclusive of lower income residents. However, the economic benefits generated were often lower than those of the upfront investment model CEIs.

Additionally, scale and technology also determined the costs and benefits associated with a project. Wind projects provided higher economic and environmental benefits but at a higher average financial cost. However, interestingly, very high upfront co-investments were associated more with larger solar projects. Larger scale projects provided greater economic and social benefits but usually at a higher financial cost and with less active procedural participation from citizens. Thus, one challenge of CEI business models is this seeming trade-off between costs and benefits, and between greater economic and environmental benefits and procedural participation.

However, there is also a trade-off between sustained profitability, scaling up and serving lower income groups. Our study of CEI BMs in the Netherlands also indicated that there is a lack of economically viable business models, with access to commercial financing products, scalability, and replicability key challenges. Commercial financing plays a big role in the funding of Estonian CEIs, and perhaps this could be a starting point for further research. Since most CEIs are highly dependent on subsidy schemes, it would be useful to further research how subsidy schemes and other policy instruments could support CEIs in scaling up and achieving sustained growth while increasing inclusivity of citizens.

In conclusion, answering our question, "Can CEI BM configurations support greater financial inclusion of citizens in the energy transition?," the study found that inclusive, sustainable CEI BMs have the potential to support the greater financial inclusion of citizens in the energy transition through affordable and accessible projects. However, the no upfront investment and spread payment models, which offer the greatest financial inclusion potential, were not common among Dutch CEIs. It would be useful to compare our results with other country contexts to investigate whether there are contexts in which these models are more prominent and if there are factors which could enable further dissemination of these models. While high upfront investment models were less accessible and therefore less likely to support the greater financial inclusion of citizens, these were also uncommon in the CEIs analyzed. This indicates that while most CEIs use an upfront investment model, the entry costs are usually low enough to allow for broader financial inclusion of citizens.

With the current fluctuation of energy prices due to the Russian-Ukrainian War, there is more urgency for EU countries to find affordable CEI models, and even more so as the cost price of renewable energy is currently, on average, below the market price for electricity. Therefore, it would be of benefit to energy cooperatives for CEIs to sell the electricity produced by their assets directly to their members and thus minimize market trade. However, this is currently prohibited in the Netherlands. To enable this, a lobby organization, Energie Samen, as well as front-running cooperatives and cooperative energy suppliers are collectively researching the opportunities for a cost price plus (CP+) model. Such a model entails supplying energy for the cost price plus a small fee for risk management and service provision. These developments make for interesting future research on inclusive, sustainable BMs, as cooperatives are gaining more control of where the benefits of their energy production go. However, since regulatory barriers such as those imposed on Dutch CEIs hinder their ability to compete with larger established energy firms and may also hinder energy justice goals, there is an urgent need for EU-level assessment of any potential national regulatory barriers, if EU countries are to deliver on the EU directives.

CRediT authorship contribution statement

Aamina Teladia: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft, Visualization. **Esther van der Waal:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Jasmijn Brouwer:** Investigation, Data curation. **Henny van der Windt:** Supervision, Writing – review & editing, Resources, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share certain data such as interviews. However, anonymized survey data is available in the annex.

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Appendix A. Supplementary data

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