



Exploring modes of sustainable value co-creation in renewable energy communities

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ABSTRACT

The renewable energy transition has prompted research into what business models in the transforming energy sector can look like. One key development of the spread of renewable energy technologies has been the emergence of citizens as engaged stakeholders in the energy transition through so-called energy communities. Energy communities, whether initiated by citizens, the private sector, or municipality, have the opportunity to leverage the engagement and skills of “energy citizens” in order to create sustainable value for the environment and community. We explore sustainable value co-creation between citizens and other stakeholders in the setting of the Positive Energy District (PED), a particular type of energy community. This leads us to analyze PEDs through the lens of business models for sustainability, using a stakeholder theory approach, as a way to understand how different stakeholders contribute to the overall sustainability goal of the community. In particular, we focus on the many roles citizens can play and extent in which they can be involved in value co-creation. We conclude that PEDs are polycentric business models in themselves wherein vision-holding stakeholder guide the dynamics of the PED ecosystem. Our findings point to further potential opportunities for sustainable value co-creation in PEDs and similar settings and open questions as to what extent citizens *should* be integrated into business models operating in such settings.

1. Introduction

The renewable energy transition has sparked researchers to reconceptualize what an energy system can look like with much discussion focused on opportunities for decentralization and reconfiguration of responsibility between participating actors (e.g. Gouliden et al., 2014; Brown et al., 2019; Wolsink, 2020, Gui and MacGill, 2018). Renewable energy technologies have made possible the spread of renewable energy communities (RECs) which support a localized, distributed conception of energy production, management, and consumption (Wolsink, 2020). Moreover, the related engagement of actors has led to the emergence of “energy citizenship” as a new topic for practice and research (cf. the recently begun EU Horizon 2020 project “Energy Citizenship and Energy Communities for a Clean Energy Transition”¹ or Campos and Marín-González, 2020). Both create a challenge for traditional business models as RECs are less dependent on the classic providers of energy like big utilities (Richter, 2012; Bryant et al., 2018) and energy citizens are not simply passive recipients of a business proposition; new business

models are needed to capture citizens’ engagement in energy communities (Massey et al., 2018). Hence, firms operating in the renewables-based space may need to redefine their business models, e.g. by capturing the notions behind sustainable business models (SBM) as a mode of value delivery across economic, social, and environmental dimensions (Schaltegger et al., 2016; Stubbs and Cocklin, 2008). However, and although this delivery of sustainable value can align with the goals of RECs, it still has to be seen in what respect the role of active energy citizens can be integrated.

Energy citizenship especially takes a key role within the EU’s Positive Energy District (PED) initiative (Olivadese et al., 2021). PEDs are districts that produce more energy than they consume through renewables. Importantly, they position citizens as active prosumers and participants in the energy transition with the overall aim of curbing energy emissions (European Commission, 2018, pp. ii). While PEDs do not always fall under the umbrella of RECs, citizen-led PEDs share similar characteristics to RECs. Against this backdrop, the question is in what respect energy business models are able to consider and capture value co-creation with energy citizens.

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Abbreviations

SBM	Sustainable business model(s)
BMfS	Business model for sustainability
PED	Positive Energy District

Business models are an important factor in successfully deploying PEDs as noted by the EU's Strategic Energy Technology (SET) Plan (European Commission, 2018). The aims behind the PED concept – to reduce carbon emissions, promote sustainable energy consumption, and foster an inclusive social environment – constitute the values that are meant to be delivered to involved stakeholders and fall across the three traditional sustainability dimensions, i.e. environmental, social, and economic (Elkington, 1997). Hence, it is fair to assume that business models operating in PEDs will be sustainability-oriented business models (also referred to as business models for sustainability or BMfS). The according SBM literature also posits that in order for BMfS to achieve their goals, they must recognize the increased importance of stakeholders in value creation; stakeholders, like consumers and users, are not just beneficiaries of a product/service but also active contributors in the value creation process. Business models are thus reframed as systems that bring together stakeholders in ways that facilitate joint value creation (Fischhendler et al., 2021).

In this way, the SBM literature seems to provide a basis for capturing the dimension of sustainable values as well as for conceptualizing the role of active citizens in general. We explore whether a representation of PEDs through the lens of BMfS is appropriate and develop an understanding to what extent energy citizens have been captured in value co-creation. Having an analysis of the implications for SBM stemming from PEDs can be important beyond the specific PED-context as a fuller understanding of a business model's value co-creation with citizens can also provide learnings for BMfS in other sectors. Ultimately, a better understanding of how BMfS can facilitate joint value creation with citizens can guide how these business models are configured and whether they have the potential to meet their sustainability ends.

Thus, in this paper, we frame PEDs within the current SBM literature, using the perspective of stakeholder theory (Freeman, 2015) to understand value co-creation. Given that the majority of PEDs remain in development stage and existing PEDs differ in their set-up, we take three differing cases for exemplification: Schoonschip in Amsterdam, Smart Energy Åland located on an autonomous island region of Finland, and Hunziker Areal in Switzerland see descriptions in Section 3). The novelty of this paper lies in its illustration of both theoretical implications related to value co-creation in BMfS and practical implications related to sustainable value creation in PEDs. The objective of this paper is to deepen the conceptualization of sustainable value co-creation by examining the stakeholder dynamics and potentials for value co-creation in this real-world environment. In this way, we can also identify opportunities for future co-creation in similar settings.

The article is structured as follows: we begin by reviewing existing literature on business models in the energy sector with a view to applying ideas from the SBM and energy citizenship literature. We then present the idea of PEDs together with PED examples and introduce the method for our analysis of BMfS in PEDs. The examples serve as focal points for our analysis and discussion of BMfS in relation to PEDs and RECs. Finally, we give an outlook for further research.

2. Literature review

Literature investigating business models in the energy sector has largely used the value elements (value proposition, value creation, and value capture) of the traditional business model canvas (Osterwalder and Pigneur, 2010) to create archetypes of business models in the energy

sector. For example, following Bocken et al. (2014), Hall and Roelich (2016) undergo a process of categorization of models in the electricity supply market and identify nine archetypes of local supply business models based on the three value components. Sepponen and Heimonen (2016) present new potential business concepts based on Osterwalder's business canvas related to smart energy solutions for districts. Gauthier and Gilomen (2016) look at four elements of business models (value proposition, supply chain, customer interface, and financial model) in their analysis of two large-scale energy projects in France.

Another strand of literature engages with the role of prosumers in new energy business models. For example, Brown et al. (2019) focus specifically on prosumer business models and find seven business models that represent existing projects and models in the UK. Bryant et al. (2018) conducted an analysis of business models in the changing energy sector and concluded with four types of business models for energy utilities, including the Green Energy Utility, Cooperative Energy Utility, Prosumer Energy Utility, and Prosumer Facilitator. The EU project PROSEU has also created an analysis of the variety of business models being adopted to facilitate the renewable energy transformation in the EU by looking at different prosumer business models existing in Germany, the Netherlands, UK, and Spain (Hall and Roelich, 2016).

These streams of literature on transforming energy business models give us a way to understand changing relationships and transactions within a traditional business model perspective. However, this literature does not sufficiently deal with the consequences of the energy transition for energy citizenship and value co-creation between stakeholders in the energy system. Rather, the business model is framed within a traditional schematic of financial flows in exchange for a product or service (one exception has been the positioning of individual prosumers as service providers to the grid e.g. Brown et al., 2019, thus acknowledging that this transaction can flow in both directions).

One motivation behind moving away from applying a traditional business model perspective within the framing of the renewable energy transition is that citizens can play roles that go beyond technology user and prosumer. The energy citizen is defined as a person who actively participates in the energy transition by engaging with renewable energy technology and participating in the political discourse (Devine-Wright, 2007). The role of the energy citizen has been further broken down: Chilvers and Longhurst (2016) present conceptualizations of the public in the energy transition as deliberative citizens, activist citizens, consumer-citizens, and resourceful citizens (as in citizen-led innovation) (for further mapping of participation in the energy system see Chilvers et al., 2018). Citizens can initiate, guide, and legitimize regime change (i.e. following the multi-level perspective) as user-producers, user-legitimizers, user-intermediaries, user-citizens, and user-consumers (Schot et al., 2016). The interaction of this plurality of roles with business models in the energy sector may be important for legitimizing renewable energy projects and communities, thus moving out of niche innovation and establishing new energy regimes. Businesses can serve as intermediaries, articulating the visions of niche actors and supporting the presentation of technological innovation to regime actors; thus, businesses can act as the link between the niche and the regime (Bidmon and Knab, 2018). Representing the many desires and needs of citizens may mean that a business model should first identify these desires and needs and capture them within the business model; conversely, business models may carve out space for citizens to play different roles themselves, supporting citizens in bringing their innovations out of the niche.

An option for integrating these multi-faceted roles of citizens into energy business models is by pivoting away from a traditional business model conceptualization (consumers as simple recipients of business propositions) and adopting ideas found in the SBM literature. Underpinning our argument for taking the SBM lens is the idea that business models operating in the energy transition are BMfS because the energy transition itself is a part of the broader sustainability transition. Accordingly, these business models aim to create value that goes beyond economic and encompasses the social and environmental dimensions.

This goes together with the derivation of what value is to be created in a BMfS through the concept of the triple-bottom line (TBL)² (Elkington, 1997). The TBL perspective to sustainable value creation opens the boundaries for whom value can be created, extending it beyond consumers to the environment and/or society as a whole (Lüdeke-Freund et al., 2020; Zott et al., 2011). Many authors have attempted to integrate these additional dimensions into the classic elements of the business model e.g. value proposition. For example, Boons and Lüdeke-Freund (2013, p.13) describe the value proposition of a BMfS as the “measurable ecological and/or social value in concert with economic value”. This is pertinent for PEDs, as we will see in the next section, as they represent a setting that brings multiple stakeholders e.g., firms, citizens, the municipality, together and relies on their cooperation to achieve certain sustainability aims. Further, the scope of value is redefined beyond the product or service offered to encompass the value that is created in the environmental, social, and economic dimensions. In recognition of the multiple benefits that business models in the new energy system create and capture and the ways in which these benefits are created and captured, Hall and Roelich (2016) describe these business models as creating “complex value.” That is, “the production of financial, developmental, social, and environmental benefits which accrue to different parties, across multiple spaces and times, and through several systems” (Hall and Roelich, 2016, p. 287).

Moving beyond the “what” that is being created through BMfS, the way the “who” is described in the SBM literature is promising for integrating the many roles of energy citizens into business models. The SBM literature moves away from the notion of value creation as a unidirectional process and instead posits that value is the outcome of co-creation between multiple stakeholders. In the traditional business model canvas, Osterwalder and Pigneur (2010) define the value proposition as the benefit that customers receive from products and services, while the value creation and value capture describe the means (e.g. activities, partnerships, resources) by which value is delivered and benefits (e.g. revenue) received in exchange (Osterwalder and Pigneur, 2010; Bocken et al., 2014). The SBM literature points out that the delivery of value does not necessarily follow this linear, unidirectional path from producer to consumer (Freudenreich et al., 2019; Stubbs and Cocklin, 2008). Instead, value is co-created by product/service providers and consumers, “jointly and reciprocally” (Vargo et al., 2008).

Further, the use of stakeholder theory in the SBM literature allows for a greater elaboration on the relationship between citizens and businesses in the new energy system. Stakeholder theory classically posits that businesses have obligations to many stakeholders beyond their shareholders (e.g. suppliers, political groups, employees, unions, etc.) and questions how these stakeholders are identified (Freeman, 2010) and prioritized (Fritz et al., 2018; Rawlins, 2006). The application of stakeholder theory to BMfS builds on the importance of these relationships, positing that stakeholders engage in a business model to achieve a joint purpose and are both beneficiaries and co-creators of this value. Further, the “value portfolio” of each stakeholder group can differ, though the activities engaged in by stakeholders contribute overall to the overarching joint purpose (Fischhendler et al., 2021, pp. 8).

Considering the user as not just a beneficiary, but also a part of the sustainable innovation process, has been investigated to some extent. Indeed, a user-centric approach to sustainable innovation can be helpful in validating the strategy, refining the product or service, and eventually increasing the potential for market acceptance (Zimmerling et al., 2017). Strategies that consider users in product design such as functionality matching, eco-feedback, scripting, and forced functionality help in developing products that encourage sustainable user behavior

² The triple bottom line framework pushes companies to think beyond their profits, by measuring a company’s social, environmental, and economic impact. Elkington has since criticized the way his framework has been adapted (Elkington, 2018).

(Wever et al., 2008). Further, involving end-users in the development of the value proposition can ensure that they are appealing and tailored to consumers’ values (Khan and Bohnsack, 2020). Tolkamp et al. (2018) explored the impact of a user-centered approach for sustainable business model design (specifically for energy efficiency measures). A user-centered approach can be used to understand what type of value users seek from the product/service and build trust between the user and the firm. The research builds on Cui and Wu (2016), extending users’ involvement to co-producing value and co-innovating the business model. Baldassarre et al. (2017) create a dynamic and iterative process for developing user-centered value propositions that create value for multiple stakeholders simultaneously, including environment and society.

At the same time, the idea of an approach to business model design being “user-centric” maintains that citizens’ role is primarily that of users. However, there may be potential for citizens to co-create value in BMfS outside of the traditional user role. The many roles one stakeholder group can play in value co-creation e.g. energy citizens further complicates this narrative. If we consider that for a business model’s sustainability goals to be achieved, all stakeholders must understand how the business model contributes to sustainable development and be involved in some way in the creation of the joint purpose, then the role of the sustainable business model becomes to align stakeholder relationships in such a way as to positively contribute to environmental, social, and economic value (Fischhendler et al., 2021). Understanding how to effectively leverage relationships and multiple roles of a stakeholder group into a BMfS may be important to achieving the overarching sustainability goals.

The energy transition and, particularly, RECs necessitate a further exploration of the stakeholders within the community. Indeed, community as a stakeholder group is often taken as an “error term” – a group that contains “all sorts of interests and externalities that fail to find homes within customer, supplier, employee, or shareholder groups” (Dunham et al., 2006, p. 24). Conversely, studies that looked at community energy projects through a business model perspective (e.g. Nolden et al., 2020; Söderholm, 2020) have not discussed value co-creation within the business model ecosystem. The application of the SBM lens, with emphasis on stakeholder theory, may reveal opportunities for joint value creation in RECs. In particular, it may clarify whether all stakeholders are being engaged in joint value creation and to what extent current business models capture the plurality of roles that citizens can play in the energy transition.

3. Renewable energy communities and Positive Energy Districts

In our paper, we study the PED as a way to gain insight for value co-creation in similar settings. PEDs hold similar characteristics to other concepts in the space of zero-emission neighborhoods (Brozovsky et al., 2021) and configurations of PEDs can vary (Lindholm et al., 2021; see Gollner et al., 2020 for examples). The development of PEDs is variable and may arise in different ways e.g., from a vision of citizens, the municipality, or public-private partnerships (Derkenbaeva et al., 2020).

RECs, too, can take many forms and exhibit a multiplicity of relationships between the stakeholders involved (e.g. firms, municipalities, citizens, and others). Given the diversity in ownership structures, technologies used and scale of their deployment, policy context and motivations, and number and type of actors involved, community renewable energy projects do not fall under a single definition (Hicks and Ison, 2018). Still, RECs are largely considered to be communities of interest i.e. citizens coming together with a shared energy-related objective, not brought together by fate (Moroni et al., 2019; see discussion in Fischhendler et al., 2021). PEDs, on the other hand, can be municipality-led or initiated by the private sector, thus often making them communities of place (see Bauwens, 2016 for more on this distinction). Thus, while PEDs can sometimes be RECs, this is not always the case. Nevertheless, certain PEDs are citizen-led and most exhibit a

Table 1

Value to be created in a PED across the economic, social, and environmental dimensions (adapted from Derkenbaeva et al., 2020).

Economic value	Social value	Environmental value
<ul style="list-style-type: none"> - Affordable energy costs - New opportunities for companies to offer products/services from different sectors e.g. energy, mobility, ICT - Creation of local jobs 	<ul style="list-style-type: none"> - Inclusion of people from different socioeconomic backgrounds - Feeling of community 	<ul style="list-style-type: none"> - Reduction of carbon emissions through technologies and environmentally-friendly lifestyles

multiplicity of stakeholder relationships. We consider this existing variability as an advantage as we are able to explore value co-creation in a number of different configurations e.g. citizen-led communities of interest vs. private company-led communities of place.

Method-wise, we describe the idea behind PEDs and showcase three example projects included in *Value Generation by PEDs: Best Practices Case Study Book* (Derkenbaeva et al., 2020). We do not present these examples as case studies (cf. Gerring, 2004) for understanding PEDs, but in order to illustrate the dimensions of joint value creation. Data was gathered primarily from secondary sources and complemented with informational interviews with key stakeholders involved in these projects, as well as an on-site visit to Hunziker Areal. We use the stakeholder theory approach (Freeman, 2010) expanded for SBM (Freudenreich et al., 2019) to identify stakeholders and value co-creation in the PED examples. Thus, we analyzed the according data by asking *with* and *for whom* value is being created in our PED examples.

3.1. Background on Positive Energy Districts

The EU SET Plan aims for the development and diffusion of 100 PEDs by 2025 (European Commission, 2018, pp. 1). Currently, more than a dozen projects have received funding from the EU's Horizon 2020 research and innovation program to develop PEDs across Europe.³ The overall goal behind the deployment of PEDs is to improve quality of life across European cities and enable the EU to reach COP21 targets (European Commission, 2018). The SET Plan highlights the importance of citizen participation and developing business models that ensure that energy services are affordable to the majority of citizens (European Commission, 2018, p. 50–51).

The sustainability vision of PEDs is to create value across the economic, social, and environmental dimensions (as summarized in Table 1). PEDs aim to create economic value by offering renewable energy technology at an affordable level for customers while creating opportunities for companies across a number of sectors e.g. energy, mobility, ICT. In the environmental dimension, the aim is to produce more energy than consumed through the use of renewable energy technology with at minimum annual net zero energy import and net zero CO₂ emission. In the social dimension, PEDs aim to be human-centric, providing access to renewable energy in an equitable and just way (Derkenbaeva et al., 2020). One of the guiding principles of PEDs is inclusiveness, with a focus on addressing energy poverty and creating affordable housing. Citizen participation and changes in user behavior and lifestyle are also considered important (Smart Cities Information System, 2020). The Horizon 2020 project ATELIER, which works on creating PEDs in a number of cities, cites climate justice and affordability as one of the local challenges it faces in ensuring citizens embrace development at the local level (Smart Cities Information System, 2020).

³ Examples of current projects working on PED development include: CityXChange, ATELIER, MAKING-CITY, STARDUST, REMOURBAN, Triangulum, SmartEn City, MATCHUP, IRIS, POCITYF, SPARCS, and NEWCOMERS.

EU projects that aim to build PEDs, like SPARCS, Stardust, and MatchUP,⁴ regularly describe their efforts in engaging with citizens. The level of engagement can vary from provision of information at events to active consultations up to co-design and collaboration. Existing examples of PED or PED-like communities have had varying success in creating value across these domains (Derkenbaeva et al., 2020).

PEDs operate within an energy landscape that requires collaboration between stakeholders in order to achieve its ends. While the idea of collaboration and exchange to reach a business outcome is not novel (Vargo et al., 2008), it takes on a different importance when the desired outcome is related to sustainable development. Interoperability between product and service providers becomes critical in order to effectively create sustainable value. For example, a firm that develops electric vehicle charging stations may need to work with grid operators or navigate relationships with e-mobility service providers (Sustainable Transport Forum, 2019) in order to enter the market and successfully integrate its technology. In another instance, if RECs are to be connected to flexibility markets, thus allowing energy demand and supply to be balanced, Distribution System Operators (DSOs) and Transmission System Operators (TSOs) may need to navigate their way among third-party firms that connect them to aggregators (Hadush and Meeus, 2018; Schittekatte et al., 2019). Finally, the potential introduction of peer-to-peer energy trading markets, which could point toward community energy self-sufficiency, would also necessitate collaboration between different actors (e.g. energy storage system providers, grid managers, blockchain platforms, etc.) (Hahnel et al., 2020). This collaboration extends to the community and individual citizens as well; citizens are not only consumers of energy, but can also act as prosumers. Partnerships between stakeholders in PEDs are valuable in pooling skills and resources, increasing efficiencies, and sharing risks and responsibilities, thus enabling better value creation. Moreover, collaboration can result in greater public and social acceptance by giving agency to a variety of stakeholders and sharing benefits (see Eitan and Herman, 2019 for summary).

Thus, PEDs offer an interesting and innovative setting for studying sustainable value co-creation. Firms acting as product and service providers in this environment are embedded in a pluralistic stakeholder network wherein their value creation should reflect the needs of the stakeholders e.g. firm, citizen, as well as, society, economy, environment and contribute to the PED's overall sustainability objectives. The role of a BMfS is to align stakeholders in such a way that they create value in the environmental, social, and economic dimensions (Fischhendler et al., 2021). The question then is how firm-level business models can consider citizens and the PED as an environment in their value co-creation process.

3.2. Positive Energy District: Schoonschip

Schoonschip is a community of houseboats located in the Johan van Hasselt Canal in the north of Amsterdam. It is a resident-initiated community composed of 46 households. Schoonschip aligns with the energy goals of a PED by generating its own electricity with photovoltaic solar panels; batteries in the homes can store surplus electricity. Additionally, heat pumps source aquathermal heat from the canals and solar is used for boilers and passive heat. All homes are connected to the same smart grid which has one connection to the national grid; eventually, residents may be able to trade solar electricity with each other in a peer-to-peer exchange. Finally, sustainable mobility is promoted through shared electric vehicles, electric bicycles, and electric cargo bicycles (Schoonschip – a pioneering floating Schoonschip – a pioneering floating energy community, 2021).

As a citizen-initiated project, Schoonschip's residents (also the

⁴ SPARCS: <https://www.sparcs.info/>; Stardust: <https://stardustproject.eu/>; MatchUP: <https://www.matchup-project.eu/>.

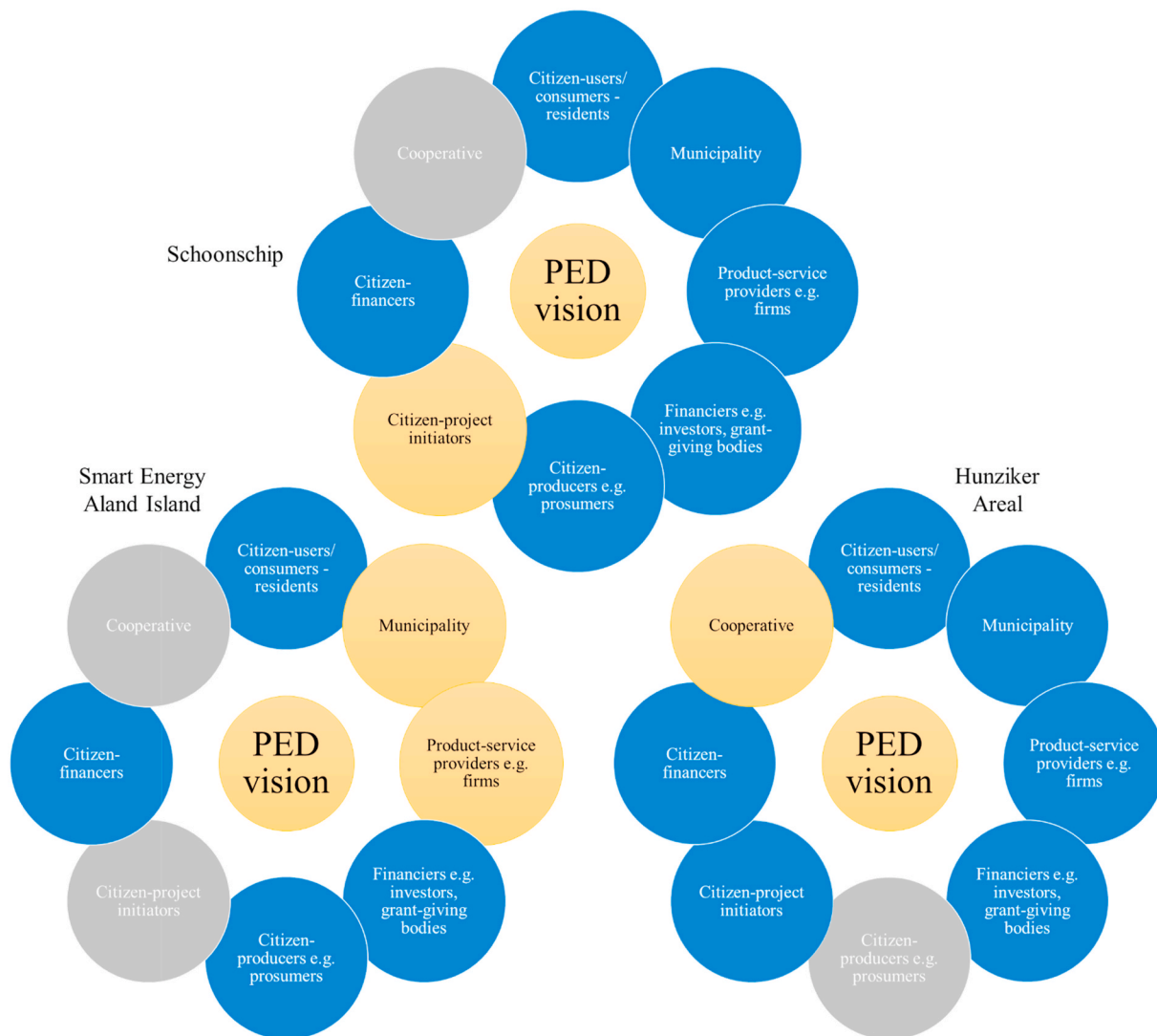


Fig. 1. Visualization of involved stakeholders in PED business model for each example project. Gray color indicates stakeholder not involved and yellow color indicates holder/co-creator of PED vision; all other identified stakeholders in blue.

initiators of the project) were responsible for partnering with energy companies and the municipality in the development of the smart grid. They chose developers for their project and secured necessary funding and legal allowances in order to implement their project. Schoonschip’s residents are energy citizens as initiators of the project, prosumers as households that secure energy through solar power, and deliberative citizens as individuals that united to negotiate with banks and navigate legalities with the municipality in order to be allowed to develop their smart grid (Greenprint: Schoonschip, Amsterdam, 2021).

3.3. Positive Energy District: Smart Energy Åland

Smart Energy Åland is a collaborative project of public and private stakeholders from the Åland Islands and Finland. It was initiated by Flexens, a partnership made up of research institutes, technical experts in sustainable and circular processes, the government of Åland, and operators and energy companies. The vision behind Smart Energy Åland is to create a 100% renewable and self-sufficient energy system. From the BMfS perspective, Flexens intends to create sustainable value by reducing dependence on fossil fuels and promoting renewable energy deployment; this is achieved through alignment of various stakeholders whose knowledge and resources can be transformed into innovative technologies (Lindstrom and Häger, 2020).

Additionally, Flexens tries to engage the citizen in Smart Energy Åland. The value it offers the citizen is a sustainable energy system that does not increase costs for the consumer. At the same time, the citizen is recognized as a player in the energy system – on the Smart Energy Åland website, the visitor can access resources related to making their homes (broken up by detached home and apartment) more energy efficient, changing their consumption habits, investment support for electric vehicles and solar panels (with the vision of eventually making households into prosumers), and calls to public discussion about energy (Du kan göra skillnad, 2020). This is in line with Flexens’ goal of engaging citizens to “actively take part in the project as consumers, producers and financiers” (Schalin, 2019, pp. 17). In the future, it is envisioned that citizens will be able to participate in blockchain system of crowdfunding future energy innovation projects. At the same time, certain legal and financial barriers have prevented citizens from being integrated into the system as prosumers.

3.4. Positive Energy District: Hunziker Areal

The Hunziker Areal is a project of the housing cooperative “mehr als wohnen” (trans. More than living) located in Zurich, Switzerland. Its aim is to create a holistically sustainable community for its resident with a focus on environmental and social sustainability. The Hunziker Areal

qualifies as a PED due to its alignment with the goals of the Swiss 2000-Watt society – an area where consumption of energy reserves per capita is restricted to 2000 W (2000-Watt-Areal - mehr als wohnen, 2021). The neighborhood achieves this through rooftop solar photovoltaic, energy efficient construction, restrictions of mobility solutions to a shared pool of electric vehicles and bikes, and re-cycling waste heat from a nearby data center for heat. Additionally, the cooperative strives for social inclusion by providing affordable housing for a diversity of residents and a built environment that promotes a community feeling. Residents are frequently engaged in dialogue and are encouraged to create local interest groups. Currently, there are over 40 interest groups based on hobbies and an active resident WhatsApp group (mehr als wohnen, 2017).

The mehr als wohnen cooperative plays an aligning role between the municipality, stakeholders with technical expertise, and residents of the community. An ongoing dialogue and recognition of needs between the cooperative and the citizens ensures that this overall sustainable vision is met. For example, while the Hunziker Areal restricts residents from owning a private vehicle in order to curb fuel-induced carbon emissions, residents who have physical disability or are in need of transportation due to a work situation are still allowed to bring a vehicle. In this way, mobility solutions contribute to environmental sustainability goals without being restrictive; they enable residents to take up electrified transportation and meet the needs of those who need other solutions.

At the Hunziker Areal, residents play the “energy citizen” role as informed users. However, their ability to influence energy consumption is restricted by the building’s construction. For example, because the buildings are optimized for energy efficiency from the outset, thermostats and individual heating are taken out of the user’s control. Even the ability to open windows within individual homes is limited (as this would affect temperature and ventilation). In a recent brochure, the cooperative questions whether restricting resident control of heating and ventilation has affected the occupants’ satisfaction levels and whether being able to adjust the internal systems would make occupants more satisfied (mehr als wohnen, 2017).

4. Analysis and discussion

The three PEDs showcased in the previous section exemplify how ideas from the SBM literature are a useful way to describe the dynamics that help create sustainable value. Analysis through an SBM lens can enlighten the ways in which citizens participate in value co-creation process.

4.1. PEDs as business models for sustainability

While business models are traditionally conceptualized at the firm-level, the three PED examples illustrate how PEDs can be understood as BMfS in themselves. PEDs center stakeholders around a “joint purpose” – the sustainability-based value proposition of the ecosystem for those living in the PED or working to achieve its goals. In our three examples, the successful implementation of the project and its goals resulted from a partnership between a diversity of stakeholders e.g. technical experts, municipality, research institutes, and citizens. From this perspective, value in the environmental, social, and economic dimensions is achieved through an alignment of stakeholders. Individual products and services contribute to the overall project vision i.e. joint purpose and there is multi-directionality to the way value is created. The example projects and involved stakeholders are visualized in Fig. 1.

Schoonschip, as a BMfS, illustrates how value was created for multiple stakeholders, across multiple sustainability dimensions. Sustainable value was created in the environmental dimension through technologies that reduce carbon emissions, as well as water waste; in the social dimension through a community-powered project which relied on social cohesion; and in the economic dimension through creation of local jobs. This value was created when future residents of Schoonschip

partnered with technical developers to realize their vision. Citizens received value in the form of services from their technical partners; technical partners received revenue and a site where they could deploy innovative technology. Achieving the citizens’ vision became part of a joint value creation process wherein technical developers and the citizen group needed to align in order to meet their goals. This process necessitated negotiation between the desires of the citizens and the technical capabilities and legal allowances they were given.

Smart Energy Åland can also be considered a BMfS: sustainable value was created in the environmental dimension through innovative technologies that reduce carbon emissions and in the economic dimension through creation of local jobs. Value in the social dimension is less clear, though the relatively small size of the islands and autonomy of the region foster inclusion in the shared vision of sustainability. Environmental and economic value was co-created through the partnership of the municipality, technical experts, and research institutes. Citizens are envisioned to play a role in the future as prosumers and financiers, though legal and technological barriers currently hinder this implementation.

Finally, Hunziker Areal as a BMfS creates value in the environmental dimension through energy efficient construction and renewable energy technologies; in the economic dimension through local jobs and affordable energy; and in the social dimension through a focus on a human-centered community living. Value in the environmental dimension is co-created between the citizens and cooperative through the citizens’ decisions to live in the cooperative housing and be part of the realization of the vision. Citizens are most active in the co-creation of value in the social dimension – the developers of Hunziker Areal designed the neighborhood to foster community and participation; in turn, residents have been active in creating local interest groups and nurturing this community spirit.

PEDs as BMfS show how value creation could be the result of the interaction of multiple parties simultaneously and how value moves multi-directionally in order to achieve sustainability ends. Value captured by a firm in exchange for service is no longer restricted to revenue generation; rather, the product/service provider (e.g. a firm participating in the PED) can rely on the consumer to also help create value in environmental or social dimensions. Borrowing from Freudenreich et al.’s term (2019), the system relies on an exchange of varying “value portfolios” (pp. 8) that different stakeholders offer in order to achieve the PED’s sustainability goals. This is shown, for example, in the case of Hunziker Areal wherein citizens are provided with the means to live an environmentally friendly and community-focused lifestyle – but this value is only realized in the engagement of residents in community projects and discourse.

Importantly, in the PED as a BMfS, the value proposition is the result of a stakeholder vision: in the case of Schoonschip, citizens developed the initial purpose of the project; in the case of Smart Energy Åland, the public-private partnership Flexens did so; and in the case of Hunziker Areal, the cooperative developed the overarching value proposition. This vision-initiator can be thought of as the guiding force of the ecosystem, responsible for aligning the other stakeholders in order to achieve the vision of the project. Thus, the BMfS ecosystem of value co-creation is the result of implementing the vision. Further, while in a traditional sense, the firm would be at the center as the product/service provider, the PED shows that the holder of the vision and guiding force can be a citizen group.

Thus, we arrive at the polycentrism of the BMfS – the “center” of the business model is dynamic and mobile: one can view the perspective of various stakeholders in the system relative to how they contribute to delivering the PED’s value proposition. This differs from the conceptualization of a traditional business model which 1) has a scope that is primarily limited to product/service provider and consumer and 2) is fundamentally driven by an exchange of product/service for revenue. A dynamic BMfS requires an understanding of the overall ecosystem and the whole vision. This aligns with the idea of “relational interpretation

Table 2

PED examples with the roles of the citizens they exemplify in relation to overall sustainable value created.

PED example	Project initiators/holders of vision	Citizen roles within PED ecosystem	Value resulting from co-creation	Sustainable value resulting from co-creation
Schoonschip	Citizens	<ul style="list-style-type: none"> Project initiators, producers, vision creators Deliberators/negotiators in public space e.g. attaining right to form community from the municipality Consumers/users of technology 	<ul style="list-style-type: none"> Citizen-citizen: negotiation and creation of vision and plan Citizen-technical expert: development of project and implementation of technical aspects Citizen-municipality: legal allowance for development of local innovative energy project 	<ul style="list-style-type: none"> Innovative project that addresses sustainability in several spaces e.g. energy, water, food waste Space for technological innovation Social cohesion among residents
Smart Energy Åland	Flexens	<ul style="list-style-type: none"> Residents of island Informed public i.e. Flexens and municipality are transparent around developments Consumers/users of technology Potential for future role as prosumer, participation in crowdfunding of new technologies 	<ul style="list-style-type: none"> Flexens (public-private partnership): creation of technology test bed, innovative solutions Citizen-Flexens: future potential for prosumption, citizens choose projects via crowdfunding 	<ul style="list-style-type: none"> Innovative technological solutions aimed at curbing use of fossil fuels Promotion of vision of sustainability to islands' residents
Hunziker Areal	Cooperative	<ul style="list-style-type: none"> Residents of housing cooperative Consumers/users of installed energy efficient technologies (though not necessarily in an active way) Active participants in community of the neighborhood through shared interest groups 	<ul style="list-style-type: none"> Cooperative-municipality: allowances for development of innovative local project Cooperative-developers: construction of energy-efficient housing and installation of renewable energy technologies Cooperative-citizens: sense of community in the built environment, sustainable use of technologies 	<ul style="list-style-type: none"> Energy efficient construction A built environment that centers around its residents and promotes social inclusion

of value creation" (Lüdeke-Freund et al., 2020, pp. 82) wherein, given the multiple ways in which value is created and multiple roles that stakeholders play, value creation can be considered from different stakeholders' points of views, contributing to a dynamic view of the business model. We build on this and propose that the BMfS is polycentric in that the "center" of the business model depends on our viewpoint; the viewpoint is the focal value contribution that we are considering from an individual stakeholder relative to the value that is being contributed from other stakeholders to the overall joint purpose. At the same time, the joint purpose and stakeholder that holds the vision of the overall business model guides the dynamics among the other stakeholders.

It may be interesting to further consider the role of the PED ecosystem itself as a rule-setting force among the stakeholders. As a business model in itself, the PED holds a value proposition for a multitude of stakeholders: involved firms and research organizations, the municipality, citizens and the community, as well as the environment, society, and the economy (stakeholders encompassed by the sustainability dimensions). This holds consequences for firm-level stakeholders in the ecosystem. The value proposition at the firm-level needs to complement the overarching value proposition of the PED in order to contribute to the joint purpose. A common understanding of this value proposition may become a regulating force in itself that guides the alignment of stakeholders and prompts value co-creation.

4.2. Involvement of citizens in value co-creation in PEDs and RECs

Viewing PEDs as polycentric business models with a dynamic center opens up the possibility to view value creation from multiple perspectives. Such a framing can help enlighten the ways in which citizens are considered stakeholders in the co-creation process. Further, the diversity of PED configurations allows for the elaboration of differences between citizen-led PEDs (what is commonly viewed as an REC) and other PEDs.

The Schoonschip example depicts citizens as taking on a diversity of roles fitting to the concept of the "energy citizen." In this example, citizens were project initiators, financiers, negotiators, and, of course, users/consumers. On the other hand, projects which are not citizen-initiated may find other ways to engage the citizen. This is illustrated by the examples of Smart Energy Åland and Hunziker Areal. In these examples, the citizen is informed and encouraged to play a role in the

energy system through the provision of resources and eventual prosumption (Smart Energy Åland) and is seen as vital part of creating a social community, though not necessarily in matters of energy (Hunziker Areal).

An explanation for this could be the community of interest vs. community of place distinction. Schoonschip, which arose from a shared vision, is most reliant on its residents in creating its vision and is most fitting of the description of a REC. Smart Energy Åland and Hunziker Areal are communities of place, though Hunziker Areal can also be considered a community of interest if residents moved in due to neighborhood's sustainability goals. By necessity, the future residents of Schoonschip took on a multitude of roles to realize their vision. Involvement of citizens may also vary due to the geographical scope of the examples. Schoonschip is the smallest community, thus necessitating some social cohesion. Hunziker Areal is a bounded neighborhood of hundreds of flats. Åland Islands have a much larger geographical scope, composed of many islands.

Schoonschip, the example most aligned with a classic REC, illustrates how citizens can initiate and engage in value co-creation when there is a guiding vision from the citizens themselves. This may highlight how citizens could be integrated into the value co-creation process in non-citizen-led projects. Recognizing the multitude of roles that citizens can play may broaden the value portfolio that comes from this stakeholder group. For example, the Hunziker Areal brochure recognizes the residents' limited capacities in energy actions in its brochure, questioning the Hunziker Areal's own restrictions over control of household heating and ventilation.

Overall, the background on PEDs and relevant examples demonstrate that citizens are integrated into the business model to varying extents (summarized in Table 2). The example of the citizen-led PED shows citizens taking on roles as project initiators, vision creators, coordinators, facilitators, financiers, and eventually product/service users. Conversely, the non-citizen-led PEDs remain more firm-centric, leveraging citizen roles to a lesser extent. Our analysis points to the potential behind a stakeholder mapping to business models for sustainability, as applied to PEDs: we can begin to understand the ways in which different stakeholders are involved in the co-creation process and highlight ways in which citizen roles may be under-integrated. A more methodical analysis could better categorize citizen roles in this setting, especially in relation to business models, and identify opportunities

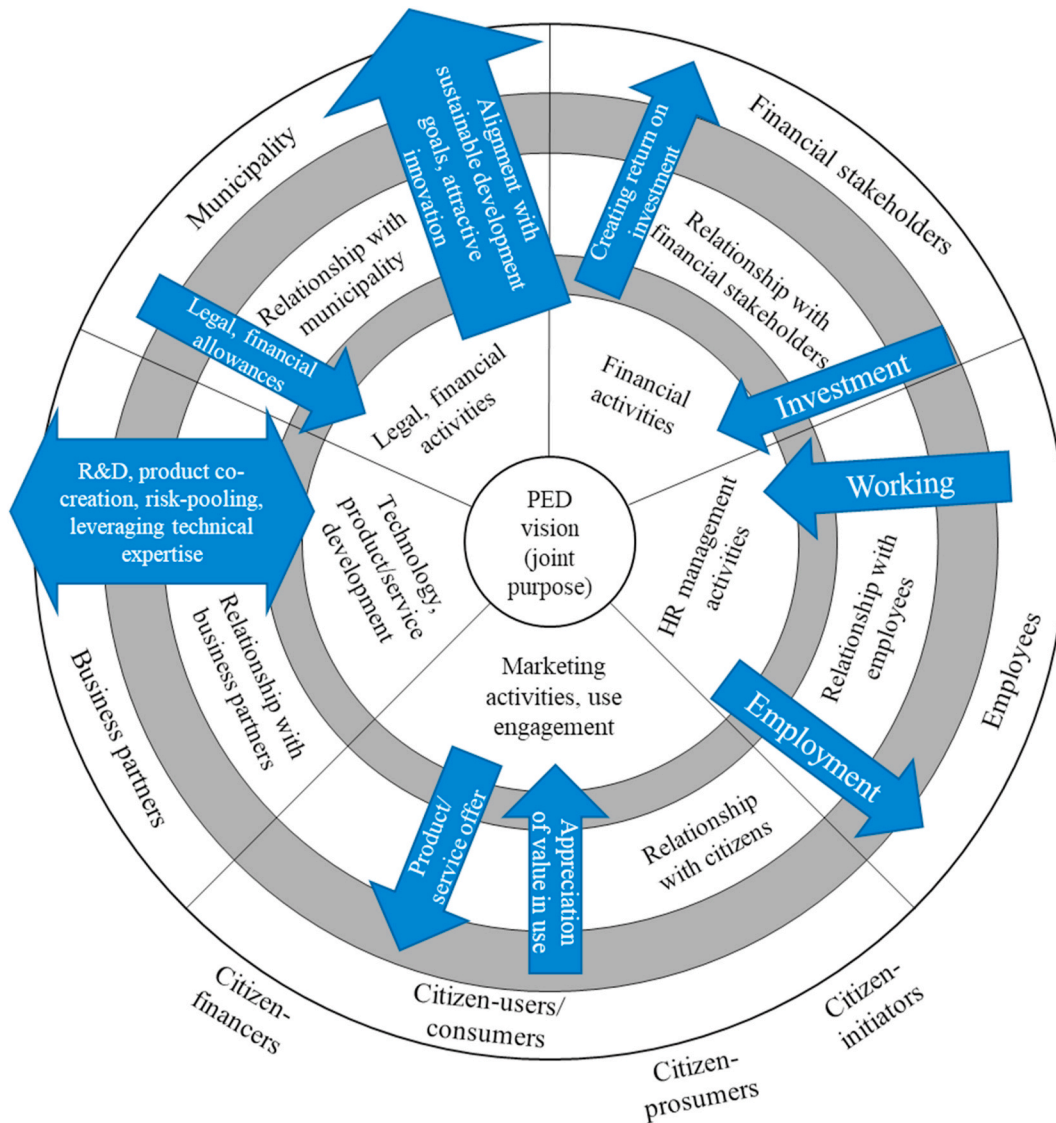


Fig. 2. Stakeholder value creation framework from focal business perspective, adapted from Freudenreich et al. (2020) and modified for purpose of PEDs. This figure depicts the value co-created between a firm and other stakeholders in a PED. Citizen-financers, citizen-prosumers, and citizen-initiators are shown on the outskirts of firm’s co-creation relationships. There may be potential to integrate these other citizen roles or make space within the PED to leverage these values in other ways.

where citizens could play a role.

5. Stakeholder value creation framework for PEDs

We build on the findings from the previous sections to develop a framework for stakeholder value creation in PEDs (featured in Fig. 2). This framework builds on the stakeholder value creation framework of Freudenreich et al. (2019) and depicts stakeholder relationships from the perspective of an individual firm. We adapt this framework for the PED to illustrate the stakeholders that contribute to the joint purpose in this specific setting.

Our framework differs from Freudenreich et al.’s (2019) in its choice of stakeholder groups. Freudenreich et al. (2019) cover six stakeholder groups based on Parmar et al. (2010): societal stakeholders, financial stakeholders, customers, business partners, and employees. In our framework adapted for PEDs, we add specificity and break down societal stakeholders and customers to include the municipality and citizens. This adaptation is a generalized result of the initial stakeholder analysis conducted in Section 4. Importantly, the central joint purpose needs to align with that of the PED vision. Further, following on Section 4.2, we open up the possibility for including distinct citizen roles within the

overall citizen stakeholder group.

Such a framework may be used to identify any uncaptured value co-creation. We show the different roles citizens can play in relation to the focal business model. These roles were identified in our examples of PEDs, but future empirical work could continue to map the types of roles citizens can hold in PEDs and other energy communities. We show citizens as financers, prosumers, and initiators as external to the framework because the non-citizen-led PEDs leveraged these citizen roles to a lesser extent.

While there is potential for citizens to be integrated into-the firm level business model, they may also operate external to the firm, within the overall PED business model. Firms may find it useful to leverage the capacity of citizens as financers, prosumers, and project initiators in a similar way that they leverage the technical expertise of their business partners to co-create the overall sustainability vision. However, an un-addressed question in this paper is whether certain citizen roles *should* be integrated into BMfs. While a joint stakeholder relationship has potential to contribute to value co-creation and achievement of sustainable efforts, certain citizen roles such as initiator (or even innovator or entrepreneur), prosumer, financer may contribute to the PED value ecosystem through citizen efforts that are independent of firm-level

business models. Within the ecosystem, citizen groups' energy initiatives may complement, run parallel to product/service provider activities, and even compete with them. Further, active citizen participation is not always a given and citizens may be indifferent to energy projects (Delicado et al., 2016). Willingness to participate in energy projects is determined by a number of factors that could present a challenge to the overall business model e.g. social norms, trust, community identity (Kalkbrenner and Roosen, 2016). A study of energy cooperatives in Germany (Yildiz et al., 2015) found that although members of the cooperatives appreciated the democratic approach, actual active participation in further development of the cooperative was low. Importantly, the community itself is not a homogenous being and can have its own tensions around vision; understanding internal dynamics could be critical to developing successful energy projects (Fischhendler et al., 2021). With regard to business models, segmentation studies may be useful in understanding citizen profiles and prospective interest in engagement and to frame appealing value propositions (e.g. Khan and Bohnsack, 2020; Vasseur and Kemp, 2015; Petrovich et al., 2019).

Further research may assess how citizen-initiated groups co-exist with firms in PEDs and similar ecosystems. An interesting question is how business models as intermediaries (Bidmon and Knab, 2018) can represent niche actors to the established regime, thus legitimizing and promoting energy innovation, while at the same time ensuring that the initial "critical edge of community action" (Nolden et al., 2020, pp. 9) – that is, the initial potentially radical motivation of the citizen group – is not lost.

Another area for further exploration could be the role of intermediary organizations such as non-profit organizations or community interest groups in the PED ecosystem. These organizations work on behalf of the community interest in brokering relationships with other stakeholders and are of particular importance to community energy projects which may require legal, financial, and technical expertise to navigate the energy ecosystem e.g. establishing Power Purchase Agreement (PPA) contracts (Nolden et al., 2020).

6. Conclusion and outlook

This paper was motivated by a need for understanding how to conceptualize energy business models and their integration of energy citizens in their value co-creation processes. Our work supports the use of a SBM perspective for PEDs and similar settings as a way to illustrate how stakeholder relationships contribute to overall sustainability value, indicating that PEDs can be thought of BMFs in themselves. Further, mapping of stakeholder relationships in relation to a joint purpose may help identify future opportunities for value co-creation. Our paper serves as a first step to overcome linearity of business models as a move to much more polycentric settings, but we support further empirical work in building on these notions. There is further potential to understand whether our conclusion of business models for sustainability as polycentric, dynamic environments is applicable in other settings.

Our work points to the value of applying a stakeholder-focused outlook on BMFs in order to identify dynamics leading to value co-creation. Further, with regard to the energy citizen, this type of mapping exercise can indicate ways in which business models integrate the plurality of roles that an energy citizen can take, highlighting potential opportunity for added value co-creation possibilities. Empirical research with a fortified case study approach could further differentiate the roles citizens can play vis à vis business models, mapping archetypes for potential value co-creation. Future research could explore whether it is useful to integrate all facets of the energy citizen into a business model operating in a transforming energy system or whether these roles can be leveraged in other ways that complement or compete with stakeholders in the system.

One area not covered in this paper is financial flows within the BMFs. However, this is an important component that guides stakeholder relationships. Although policies like feed-in-tariffs (FIT) have supported

the financial viability of business models in the renewable energy space, these policies expire, thus necessitating a further reimagining of business models without FIT (Rövekamp et al., 2021). This holds consequences for how citizens are integrating in BMFs. Further research could explore the impact of a lack of financial security on business model's co-creation processes and engagement of citizens. Similarly, it would be worthwhile to investigate legal barriers that hinder value co-creation e.g. by limiting prosumers' opportunities.

CRediT authorship contribution statement

Darja Mihailova: Conceptualization, Investigation, Writing – original draft, Conceptualization, Writing – review & editing. **Iljana Schubert:** Conceptualization, Writing – review & editing, Supervision, Funding acquisition. **Paul Burger:** Conceptualization, Writing – review & editing, Supervision, Funding acquisition. **Morgane M.C. Fritz:** Conceptualization, Writing – review & editing.

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.

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