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The influence of social innovation on biomass-based community energy acceptance in the special economic zone of Thailand

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Abstract

This research studied a social innovation model to generate energy for community biomass power plants in the Chana district special economic zone (SEZ) region, Songkhla Province, southern Thailand while considering regional sensitivity to political conflicts, religion, and individual lifestyles to build trust and acceptance from community residents. Qualitative research was done with data gathered by literature analysis and case study. Results indicated that social innovations help sensitive areas accept community energy evolution through required dual track social innovations, through (1) social business; and (2) community development activities working in tandem: the social business model for biomass power plants and social innovation through community-based development activities.

Introduction

Yala, Pattani, and Narathiwat, three southern border provinces, and Chana district in Songkhla Province are designated as security areas subject to government legal enforcement and widespread application of the Emergency Decree on Government Administration in States of Emergency B.E. 2548 (2005; the Emergency Decree) in Thailand's three southern provinces. In addition to maintaining peace and order, the region strongly emphasizes economic development. One distinctive aspect of these southern provinces is the culture of the local population, differing from other parts of Thailand. Most inhabitants are Muslim, with a small Thai Buddhist population in urban and rural areas. This distinct way of life contributes to a clear regional identity. Many area residents work in nature tourism, agriculture, and fishing, while development projects rely on industrial labor. The Chana District is home to natural marine beaches and communities with abundant natural resources, playing a vital role in sustaining the local population.

In 2020, the Thai government approved development of a special economic zone (SEZ) in the southern region of Thailand with the goal of promoting Chana district, Songkhla Province, as a model city for advanced future

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industries. As a coastal area physically prepared to operate a deep seaport, it can support industrial estates as well as centralizing regional imports and exports. The SEZ is expected to generate about 100,000 jobs. In future industrial model city development, diverse support infrastructures will be developed, including large-scale privately-owned alternative energy power plants and biomass-based community energy to use considerable regional biomass as electricity generation fuel (Ceglia et al., 2022). However, some local groups oppose the SEZ project and biomass-based community energy from concern about potential impact on local occupations, including fishing, farming, and maritime tourism, as well as Muslim community customs. There are also suspicions that entrepreneurs will benefit, rather than most of the community (Southern Border Provinces Administrative Centre, 2021).

In many world regions, social innovation has been introduced as a mechanism for tackling resistance against government projects, including power plants. In Asia, social innovation often takes the form of social business (Sengupta et al., 2018), or a business organization aimed at solving social and environmental problems in tandem through financial sustainability (Dart et al., 2010; Pongpiachan, 2019; Pongpiachan et al., 2021). This means allowing more communities to participate in business processes or coopting businesses and a role in community social and environmental activities. Community involvement and stakeholder support affects social business dynamics (May & Diesendorf, 2018; Wirth, 2013). Resistance from regional activists, including local influence and political groups, are obstacles preventing social businesses from connecting with beneficiaries and local networks (Kooij et al., 2018; Maher & Hazenberg, 2021, Pongpiachan, 2018). The transition to low carbon energy systems cannot be achieved by one-sided technological innovation; instead, it relies on social innovation (Hoppe & De Vries, 2019).

However, community energy as a theme remains in the early stages of research. Extant studies are multidimensional, usually defining and characterizing organizational structure (Van Veelen et al., 2016). Social innovation research may complement undefined areas in terms of conceptual framework and organizational structure, especially in the renewable energy sector context (Becker et al., 2017). Government of Thailand policy promotes community energy to enhance local resident participation and create added value for agricultural products. This research aims to study social innovation suitable for the context of developing a SEZ in southern Thailand while considering regional sensitivity to political conflicts, religion, and individual lifestyles to build trust and acceptance from community residents.

Literature Review

Social Innovation

Social innovation has continually attracted the attention of researchers in government and business sectors. However, defining the scope of social innovation differs according to perspectives from each sector. Previously, social innovation was recognized as a solution to social problems, a collaborative method between individuals and/or community groups to resolve social problems by new resource management and work methods (Pulford, 2010). It also refers to changing culture, lifestyles, or social structure to improve societal member life quality and well-being. Groups of individuals or networks motivate solutions for identified target audiences to clearly discern root causes for issues and initiate new solutions, potentially upgraded to formulate practical guidelines with wider applications (Howaldt & Schwartz, 2010). Social innovation requires guidelines for solving spatial problems. Development goals often have more than one target, and may combine three objectives: environmental, social, and economic (Schartinger, 2019). Environmental goals tend to focus on energy efficiency, water management, and pollution reduction. Social goals usually reflect social geographic problems such as destitution, disability, and poverty (Moulaert et al., 2015).

Social innovation is a new paradigm, a singular element uniting with technological and economic innovation to lead to systematic, holistic social change. Organization theory interprets this new interaction as hybrid innovation (Tepsie, 2014). Social innovation is a hybrid organization created to mitigate weaknesses of traditional organizations such as government agencies and private businesses. It contributes to creating social and environmental value while achieving financial sustainability (Battilana & Lee, 2014). The first type of social innovation considered is social entrepreneurship, aiming to reduce unfair resource allocation and inefficient resource usage. Innovative approaches are duly created to reduce or resolve existing social issues (Leadbeater, 1997) and generate new values to address social problems relevant to the local context (Dacin et al., 2011).

Researchers have focused on defining and analyzing social business, another form of social innovation from different perspectives. All agree that the purpose of

social business is to reduce social and environmental problems, as well as transmit social and environmental values to future generations (Austin et al., 2006; Martin & Osberg, 2007) to potentially reduce social and environmental issues (Murray et al., 2010) by designing new approaches to remove constraints from non-profit organizations. Resolving social and capital problems as well as creating long-term financial sustainability are further goals (Kirkman, 2012). However, which organizational structure, system, and management mechanism is appropriate to propel the business and create the most social and environmental impact remains undecided (Smith et al., 2013). A social business is a hybrid organization with the principal goal of solving social and environmental problems, with a sustainable business and financial model as supporting mechanism. Social enterprises may operate through different legal organizational forms, but share common core elements such as social and environmental impact, value chain, governance structure, and financial sustainability (Comini et al., 2021). In Europe, social businesses evolved from a traditional social economic base, such as cooperatives, while in North America, they evolved from private businesses. In developing countries, free market competition exists with the goal of solving social and environmental problems as well as the third principle governing return on investment. Most such organizations are established to resolve social and environmental problems with a supportive business model (Comini et al., 2012).

Advantages and disadvantages of using social innovation to mitigate conflict in the Chana SEZ context may be summarized as follows: mitigating advantages of social innovation comprise: (1) promoting collaboration between local residents and the private sector, fostering a sense of ownership and shared decision-making and uniting diverse stakeholders to share knowledge and co-create solutions effectively addressing conflict; (2) providing spaces for open dialogue and improved communication channels between local communities and the private sector to facilitate mutual understanding, build trust, and lessen misunderstandings and misinterpretations potentially leading to conflict; (3) promoting inclusivity by encouraging active participation by all relevant stakeholders, including marginalized groups and local communities whose involvement in decision-making processes empowers them with a voice to ensure that their concerns are heard to reducing potential conflicts; and (4) social innovation approaches prioritizing long-term sustainability by integrating social, economic, and environmental considerations and promoting development of solutions addressing conflicts while supporting overall community well-being to attain sustainable, resilient outcomes.

By contrast, disadvantages of social innovation processes to mitigate conflict comprise: (1) it can be slow and resource-intensive in funding and human resources to engage diverse stakeholders, facilitate dialogue, and co-create solutions, especially when resources are limited and timelines tight; (2) power imbalances and unequal representation may result in certain stakeholders dominating decision-making processes and marginalized voices going unheard, perpetuating or escalating conflict and making equal participation and addressing power dynamics critical challenges; (3) required changes in existing practices, policies, or structures often encounter resistance from local communities and the private sector, hindering social innovation initiative effectiveness so fostering a culture of openness and adaptability are needed to successfully mitigate conflict; (4) context-specific initiatives may not easily translate to other settings, so if conflict mitigation solutions successfully developed for one SEZ are replicated or magnified for other zones, they might fail due to contextual differences.

In conclusion, social innovation offers diverse operational characteristics, possibly in social entrepreneurship or business format. Yet obstacles and challenges in socially innovating through spatial solutions are omnipresent. Fundraising skills, the knowledge gap, political party opposition, shortage of experts, legal restrictions, governance structure, and lack of community involvement, as well as public communication are issues, in decreasing order of significance (Comini et al., 2021). In addition, to function as a mechanism continuously solving social problems, social innovation requires dynamic competency, the ability to identify societal transitional needs, the ability to derive innovative products or services from social requirements, and skill in integrating new knowledge and practices into culture (Kim et al., 2014, Vézina et al., 2019).

Social Innovation in Community Energy

The concept of community energy began in the United Kingdom (UK), where different regional communities were encouraged to mutually own small-scale energy projects (Smith et al., 2016). This approach became widespread in Europe, and in Denmark, community energy is a traditional community ownership scheme in which municipalities and residents share power plant and grid ownership (Eikeland & Inderberg, 2016). In the Netherlands, community energy refers to small-scale

local initiatives, often social movement-based (Van der Schoor et al., 2016). In Germany, the community energy concept is multifarious, including cooperatives and other collective ownership structural formats (Berlo et al., 2016). However, some national efforts to use renewable energy cooperatives as a mechanism for community energy development have failed; in Spain, regime resistance on the national and supra-national level impeded progress (Capellán-Pérez et al., 2020). Community energy development is characterized by grassroots innovation, with limitations allowing small-scale innovations to be upscaled, requiring intermediary actors to gather lessons learnt from past projects to design site-specific solutions and define frameworks for cooperation among local stakeholders, including representing extra-community actors such as investors and regulators (Hargreaves et al., 2013). Widespread research on grassroots innovation began after the community energy concept expanded to Europe (Smith et al., 2016). Supporting mechanisms, planning procedures, attitudes about the cooperative model, and local energy activism connected individual and communal power cooperative participants in Denmark, Germany, Belgium, and the UK (Bauwens et al., 2022; Hewitt et al., 2019).

In Asia, many nations use social innovation as a mechanism for increasing access to electricity for rural residents; in Bangladesh, social business initiatives were launched by Muhammad Yunus. Grameen Shakti is a solar power company established in 1996 to promote the use of solar energy in rural Bangladesh, boosting life quality for rural residents by offering clean energy at affordable prices (Yunus & Weber, 2010). Grameen Shakti has installed solar power plants for 1.2 million households, with 38 technical training centers to instruct female technicians to install solar generators and repair them when needed. Social businesses aim to resolve problems and increase opportunities on the grassroots level. Professor Yunus defines social businesses as non-loss, non-dividend companies benefiting from all business management tools and marketing techniques (Hasan, 2016). Another example is in Vietnam, where transition to free trade has resulted in a nationwide macro restructuring and energy demand plan (Hansen, 2017). Vietnamese economic development is heavily influenced by incoming foreign capital, in industrial and third sector contexts such as social enterprises (Dupuy et al., 2016). The Vietnamese government has enabled social enterprise incubation systems, allowing individual investors to establish businesses. However, political influencers may obstruct policies supporting business operations, impeding opportunities for social enterprises to develop in a bottom-up approach prioritizing societally disadvantaged groups. The ability of social enterprises to connect with ecology, society, and the economy is a key factor in enabling them to bridge the power gap between state and community (Maher & Hazenberg, 2021). Previous social innovation research in the community energy context has expanded to further areas of interest, including purpose, ownership, and benefit sharing, as well as funding and resources for community social movements and stakeholder learning exchange (Becker et al., 2017).

The Biomass-based Community Energy Context in Thailand

Abundant harvests in Thailand make it a base for agricultural and biotechnology industries, producing much waste, termed biomass energy, by crop harvesting. The government duly encourages biomass use to add value instead of traditional polluting incineration. By 2018, 296.34 million tons of biomass was produced nationwide from agriculture. Of these, 18.2 million tons were used in the agricultural sector and 118.34 million tons in the industrial sector, leaving 159.8 million tons for potential use in electricity generation. The Power Development Plan of Thailand 2018–2037, Revised Edition No. 1 (PDP2018 Revision 1) states a major relevant energy policy to promote: (1) renewable energy use from agricultural waste to add value; and (2) energy security for self-reliance, distributing fossil and renewable fuels according to local fuel source potential and provide opportunities for communities and individuals to participate in regional energy production and management (Energy Policy and Planning Office Ministry of Energy, 2020).

In February 2021, Thailand had 223 biomass power plants nationwide. Ten were in the lower southern region, representing 4 percent (Department of Alternative Energy Development and Efficiency Ministry of Energy, 2021). Biomass types produced after harvest by farmers in Thailand included cassava rhizomes, rice straw, sugarcane shoots and leaves, as well as stumps and roots of rubber trees. In the lower southern region, biomass power plants often use wood chips as fuel material, as abundant rubber plantations produce large amounts of chopped wood as byproducts (Renewable Energy to Community Association of Thailand, 2021). However, biomass power plants have notable limitations, including potentially polluting surrounding communities if competent standardization is lacking, and impacting agricultural areas for food production and competing for water resources to cultivate energy crops.

In Southeast Asia, Malaysia and Indonesia have used SEZs to stimulate national economies, creating jobs and generating income for workers while developing infrastructure to facilitate national development. In Thailand in 2020, the cabinet approved an SEZ development to expand model cities following a strong triangle, prosperous, sustainable policy governmentally approving Chana district, Songkhla Province, as the fourth model city. Chana district is a coastal area physically suited to operating a deep sea port, so that upcoming industrial estates may easily import and export goods. SEZ status is expected to create about 100,000 jobs, with electricity as key infrastructure for future industrialization and import reduction. Therefore, to support the industrial city and aforementioned policies, a biomass community power plant that uses different scrap materials as biomass fuel to generate electricity was conceived (Ministry of Energy, 2019).

As in many nations where the industrial sector developed as a development mechanism, negative consequences include destruction of natural resources such as soil, water, forests, and air. Land, water, and air organisms are affected by pollution and face environmental problems generationally. The government expects SEZ emergence and community biomass power plants to economically develop lives of local residents, but inhabitants of Chana district and nearby worry about the environmental, societal, and underlying community economic impact, and that benefits will be allocated inequitably, with entrepreneurs mainly profiting. Chana district community discussions forecast that the project may negatively impact the region, as did the Map Ta Phut Industrial Estate as part of the Eastern Economic Corridor development.

Methodology

Qualitative research was done with data gathered from the target group, stakeholders from all sectors of the SEZ in three Chana District subdistricts: Na Thap, Taling Chan, and Sakom, Songkhla Province. Samples were chosen by purposive sampling and data collected following triangulation approach principles (Yin, 2009) through relevant documentation, gathering data from a focus group discussion and in-depth interviews as well as domestic and international documents and research papers about biomass power plants, social innovation, social businesses, social enterprises, residential/community participation. The target group comprised stakeholders from different SEZ area sectors. Data collection may be summarized as follows (Table 1):

Data were collected by semi-structured interviews, with flexible questioning with thorough information gathering. Criteria for selecting target groups were set to cohere with research objectives and data collection guidelines, including: (1) stakeholders in area of power plant use; (2) identity as area resident, local government official, and businesspeople; and (3) willing providers of information. Data collection was done to improve research quality in terms of content reliability and validity (Creswell, 2009). For research analysis and conclusions, a content analysis method (Elo et al., 2014) was used to study communications content, dividing it to elucidate content structural order and detail scope following the qualitative educational approach to answer research problems, analyze content, grouping and categorizing material and media content, and formulating and defining criteria to analyze detailed log data sections for words, phrases, and descriptive concepts.

Table 1 Data collection method and informants

Data collection method	Informants
Documentation	Grouping according to the sufficiency economy philosophy
	Social enterprise
	- Mae Fah Luang Foundation under the Royal Patronage (Doi Tung Development Project) Chiang Rai
	- Farmer group, Na So, Yasothon
	- Siam Organic Co., Ltd., Bangkok
	VSPP biomass power plant in southern Thailand
	- Songkhla Biomass Company Limited, Khuntadwai, Chana, Songkhla
	- Thung Sang Green Biomass Power Plant (TSG) Thung Yai, Nakhon Si Thammarat
	- Biomass Power Plant: BSW, BSW, Phra Saeng, Surat Thani
	- Biomass Power Plant: OSW1 / OSW2, Chawang, Nakhon Si Thammarat
	- Gulf Yala Green Co., Ltd. Na Tham, Muang, Yala
	- Community-based Power Plant for Local Economy Project, Mae Jam, Chiang Mai
	- Community-based Power Plant for Local Economy Project (Pilot project)
Focus group and in-depth interview	11 Government policy agency representatives (Southern Border Provinces Administrative Centre)
	15 community leadership representatives and three village network leaders

Results

Developing a Social Innovation Model to propel Community Biomass Power Plants

This research began with study and analysis of case study elements with similar contexts and best practices at the national level. Three power plants were selected, including community power plant prototype projects: (1) for a basic economy following Energy Regulatory Commission guidelines; (2) for a foundation economy in Mae Chaem District, Chiang Mai Province, northern Thailand, operated by a state-owned power producer; and (3) Khun Tad Wai Power Plant, Chana District, Songkhla Province, southern Thailand, operated as a joint venture by the state, private sector, and local cooperatives.

A community power plant model for a basic economy following Energy Regulatory Commission guidelines

In 2020, energy regulatory commission regulations on sourcing electricity from very small power producers were established as legal guidelines in Thailand to encourage establishment of community power plants for different regional basic economies. The community power plant project for fundamental economy 2020 aimed at establishing foundational economies to encourage community participation and joint ownership of electricity production and distribution so that consumers at all levels might access electricity. It also helped increase income and reduce social inequality at a foundational level.

The community power plant business model allowed community participation in two main aspects: shareholding and sale of agricultural materials by the community to fuel power plant production processes. For shareholding, basic economy community power plants are assigned a power generation capacity of 3.0 megawatts. The operation is a joint investment between (1) public or private enterprises and (2) community enterprises with at least 200 household members who are local farmers in an area where public or private enterprises hold 90 percent of common shares and community enterprises have 10 percent of preferred shares.

Energy crops used to generate electricity derive from sugarcane, paddy, palm, cassava, maize, bamboo, and fast-growing acacia. A fuel-purchasing contract guarantees prices with community enterprises and networks in the form of contract farming, specifying purchase amount, period, qualifications, and energy crop pricing included in the agreement. At least 80 percent of energy crops for production use must originate in community enterprises, networks, or nearby farms, and the remainder may be supplied by power plants. As for electricity distribution, community power plants will sell electricity to the Metropolitan Electricity Authority (MEA).

A case study of basic economy community power plants, Mae Chaem District, Chiang Mai Province, Northern Thailand

The first model community power plant operated by the Electricity Generating Authority of Thailand (EGAT) is located in Mae Chaem District, Chiang Mai Province. Its business model allows the community to participate in three main aspects: shareholding; agricultural material sales by the community for fuel in the production process; and the community power plant fund.

This community power plant is managed by two groups: (1) EGAT, a state enterprise; and (2) a community enterprise group (at least 200 household members). When the project began, EGAT held at least 90 percent of community power plants, with the remainder held by community enterprises. However, the ratio may be adjusted in future by providing opportunities for community enterprises to boost shareholding by up to 40 percent (not less than 10 percent of preferred shares and an opportunity to purchase additional shares not exceeding 40 percent in total).

The Mae Chaem District community power plant is considered a model, integrating local energy, water, and food. Energy crops used derive from corncobs, bamboo, and fast-growing acacia plants. Community power plants undertake contract farming to purchase fuel used to generate electricity from community enterprises and pay community enterprises for fuel. The sale of agricultural waste as fuel to generate electricity has increased farming income by 18,966 baht per household annually, representing an annual increase of 11.61 percent. Community power plants may sell electricity to EGAT, whereupon EGAT pays community power plants by a feed-in tariff (FiT) price-driven policy mechanism divided into two parts: paying community power plants and using the community power plant fund at a ratio of at least 0.25–0.50 baht per unit with funds used for local rehabilitation within a one kilometer radius of the power plant.

A case study of Khun Tad Wai Power Plant, Khun Tad Wai Subdistrict, Chana District, Songkhla Province, Southern Thailand

Khun Tad Wai Power Plant originated from a governmental policy promoting and supporting renewable energy usage as the main national energy. The goal was to increase the proportion of renewable energy from 15 percent to 20 percent by 2022, and governmental investment promotion policy in the three southernmost provinces, including four districts in Songkhla province (Chana, Thepha, Na Thawi, and Saba Yoi) by according special privileges to private power producers from renewable energy.

This community power plant with a 9.9 megawatt electricity capacity is owned by three capital groups through Songkhla Biomass Company Limited, a joint venture between Ratchaburi Electricity Generating Holding Public Company Limited, a subsidiary of a Thai state-owned enterprise (40%), Precise Power Producer Co., Ltd., a local private company (40%), and Assiddeek Cooperative Ltd., representatives of local communities (20%). Assiddeek Cooperative Ltd. participates significantly in coordinating between the project developer and community, as well as in brainstorming solutions to diverse problems occurring during project development and building community confidence through an opportunity for investment participation as a project owner. Khun Tad Wai Power Plant received an award for outstanding renewable energy as a project with on-grid connection at the 2020 Thailand Energy Awards.

Main energy crops used as fuel to generate electricity include tree stumps, roots, wood slabs, and rubber scraps, purchased from communities surrounding the power plant. In terms of electricity distribution, Khun Tad Wai Power Plant is prepared to sell electricity to the Provincial Electricity Authority (PEA). Khun Tad Wai Power Plant schedules corporate social responsibility (CSR) activities to care for the community, society, and environment, such as generating direct income by purchasing rubber wood scraps from communities surrounding the power plant as fuel material for generating electricity, as well as organizing public relations activities in local customs, religion, and culture. These include organizing charity football matches to raise income to purchase public land for the community, donating equipment to improve the mosque, and donating money for diverse community activities.

Draft a social innovation model to drive community biomass power plants

Study results indicated that social innovation was suitable for propelling SEZ biomass power plants. A power plant should be established for management in a social business approach by allowing the community to participate in three main aspects: co-ownership, contributing to social impact through, and after, the business process. To ensure that the main objective of the power plant is to resolve community economic, social, and environmental issues, composition details are shown in Table 2.

Regionally, one private biomass power plant is accepted by local residents due to its CSR activities featuring community participation in social and environmental activities, including religious and community lifestyle activities. By contrast, government-initiated community power plants aim to boost grassroots economies two ways: (1) communities are allowed to hold shares of up to 10 percent; and (2) energy crop input is purchased from local communities. However, there is no mention of profit sharing in social and environmental development activities with community participation. Consequently, the government model appears impractical for expanding biomass power plants in the Chana area due to regional vulnerability and concerns that returns may go to external capital sources rather than benefiting the local community. In response to these challenges, a business model for biomass power plants merging strengths of both models gained acceptance among local residents. This evolved from focus group deliberations and a growing community conviction that most benefits will remain in the community.

Table 2 A biomass power plant business model

Community Participation	Key components
(1) Beneficiaries-ownership	Shareholding structure and proportion
	Benefit forms
(2) Social impact in business process	Purchasing community energy crops
	Employment of community residents
(3) Social impact after business process	Fund
	Fund committee
	Development activities

This includes sharing ownership up to 40 percent, selling energy crops to factories, and increasing local employment opportunities. Most significantly, a special fund was established to enable local residents to join committees and allocate community development activity budgets.

Validating a Social Innovation Model for Managing Community Biomass Power Plants

A literature review and analysis of the three aforementioned case studies operated through a focus group for content validation with stakeholders, was divided into two steps: For the first, the focus group featured practical discussions from 15 community representatives and stakeholders from three subdistricts in Chana SEZ, Songkhla Province (Sakom, Na Thap, and Taling Chan), each of whom had represented area residents for over 10 years uninterruptedly. They comprised presidents of the Community Organization Councils for Chana District, and Sakom, Na Thap, and Taling Chan subdistricts as well as the president of the People's Organization for Peace and Sufficiency Economy of Na Thap, Sakom, Taling Chan subdistricts and the Southern Border Provinces; in addition, also included were the president of the Coastal Fisheries Association of Taling Chan subdistrict/member of the Community Justice Center of Taling Chan subdistrict, and village headmen of Moo 8, Sakom subdistrict; Village Moo 14, Na Thap subdistrict; and Moo 8, Taling Chan subdistrict; the focus group also included the presidential secretary of the Subdistrict Administrative Organization, Sakom subdistrict, Na Thap subdistrict Inspector General, and members of the Community Cooperative Group. The second step for the focus group was policy discussion from the Southern Border Provinces Administration Center, the government agency overseeing development of the southern border area, including the Chana SEZ area. Five discussants included the deputy secretary-general of the Southern Border Provinces Administrative Center and personnel responsible for linking, and communicating with, communities from three SEZ area subdistricts.

An example of informant interview results:

The Na Thap subdistrict Community Organization Council chair, also known as village headman of Moo 14, stated: "The community supports the 9.9 MW biomass power plant. If such a plant is established, the group will prioritize community participation and benefits should be maximally returned to the community."

The chair of the People's Organization for Peace and Sufficiency Economy in Tambon Sakom proposed "a shareholding structure for biomass power plants as follows: (1) private companies holding 90 percent, and community enterprises holding 10 percent; (2) community enterprises holding 10 percent, with the potential to increase shareholding up to 40 percent based on community preparedness; (3) the private sector holding 40 percent of shares, with community enterprises holding 60 percent. However, this format or structure may still be adjusted."

Results of model validation are shown in Table 3.

Table 3 Validation results of the social business model for a biomass power plant

Participation dimension	Main compositions	Details
1. Beneficiaries-ownership	Capacity	- 9.9 megawatts.
	Licensee to build a power plant	- Government and/or private companies.
	Community equity participation	- Government and/or non-governmental companies joint ventures with community business (cooperatives, community enterprise).
	Community shareholding	- Government and/or non-governmental companies 60–90%. - Community business 10–40% (cooperatives, community enterprise).
	Benefits received by the community	- Dividends.
2. Social impacts in business processes	Energy plant types	- Para rubber, rubber wood scraps, and agricultural waste.
	Purchasing energy crops from the community	- The community was established as a business group for procuring and distributing biomass to power plants. - Communities that already have cooperatives or community enterprises may expand business by procuring and selling. - biomass to power plants.
	Employment of community residents	- At least 80%
3. Social impacts after business processes	Earmarked funding	- Establish a special community development fund to allocate income by determining a proportional rate according to power plant revenue.
	Fund committee	- Community representatives from each area are fund committee members.
	Community development plans/ activities	- The community participates in community economic, societal, and environmental care by participating in planning and scheduling annual activities.

Study results indicated that in addition to community participation in the three main social business steps, the community also offered dual track social innovations through (1) social business; and (2) community-developed activities. These two systems must work continuously to connect and transmit, resolving community problems and constantly upgrading. The key linkage point is community participation in creating social impacts after business processes. Raising the level by allowing the community to participate in determining criteria for using the fund and engaging members in decision-making with the committee will result in economic, social, and environmental development activity planning. This addresses community problems and needs as shown in detail in Table 4.

Discussion

Social enterprise builds social impact by using different business models. Previous studies suggest that organizations use social business models to address specific problems such as the social needs model, to help reduce pollution and environmental destruction by producing standardized environmentally friendly products and/or production processes; the cooperative model with beneficiaries owning the firm enables underprivileged target groups to become business owners and escape poverty to achieve sustainability; the work integration model sells products and provides regular services in the market system, focusing on hiring the disadvantaged as a principal organizational structure; the cross-subsidy model sells products and services in the conventional market to bring supporting profit to society's lower levels; and the plowback profit model creates a high-income business unit to facilitate helping labor and social activities unrelated with social enterprises.

However, the context of building a biomass power plant in Chana SEZ is multifaceted because the root issues are community lack of confidence, mistrust, and uncertainty that benefits will be worth the loss of area identity and valuable resources which are the bases for future careers for inhabitants. Constructing a biomass power plant will open an area for capitalists to seek benefits from natural resources and deliver rewards to investors outside the area, leaving potential social and environmental degradation for community residents. These findings suggest that the social business model for community biomass power plants in the SEZ should present community participation through three key elements: (1) co-ownership and receiving returns in the form of profit dividends; (2) participation in the production process, earning income by selling energy crops, and youth employment in a power plant offering stable careers, good salaries, and standardized, monitored work processes; and (3) participation in profit sharing from power plants to genuine community development activities.

Table 4 Dual track social innovation model for Chana SEZ

Social business		Social business through community development activities			
Business model for biomass power plant society	1. Beneficiaries-ownership	Structure and shareholding	Economic development	Social development	Environmental development
		Benefits received by the community	Community business development	Religions	Waste and industrial waste disposal
	2. Social impacts in business processes	Purchasing energy crops from the community	Agricultural career development	The underprivileged, old, disabled, and orphans	Waste water treatment
		Employment of people in the community	Create labor opportunities in the area	Health	Participate in environmental impact monitoring
	3. Social impacts after business processes	Fund		Education	
		Fund committee		Labor skill development	
		Development activities	1. Funding and criteria for capital fund usage	2. Fund management committee and community members	3. Economic, social, and environmental development plans/activities

In addition, previous studies have shown that the first challenge to social innovation is the ability to raise funds. The second is the knowledge gap, followed by opposition from political party shortage of experts, as well as lack of community participation (Schartinger, 2019). In addition, social innovation as a mechanism for continuously solving social problems requires dynamic competency, including the abilities to identify transitional social needs, convert social needs into innovative products and services, and integrate new knowledge and practices into culture (Kim et al., 2014, Vézina et al., 2019).

Conclusions and recommendations

This study concludes with industrial symbiosis as part of social innovation to mitigate conflicts between local communities and energy private sectors at Chana SEZ. Industrial symbiosis is a concept aimed at promoting sustainability and resource efficiency by establishing mutually beneficial relationships between different industries and businesses in a local community. It involves collaborative use of resources, materials, energy, and expertise to minimize waste generation, reduce environmental impact, and create new economic opportunities. The core idea of industrial symbiosis is to view one industry's waste or byproduct as a valuable resource for another industry. Instead of treating waste as a liability and disposing of it, industrial symbiosis seeks to identify opportunities where waste materials or energy from one industrial process may be used as input and energy sources for another process, thereby creating a closed-loop system. In the context of promoting industrial waste usage for local community energy generation, industrial symbiosis may take several forms: (1) waste-to-energy; industries generating organic waste such as agricultural residue or food processing byproducts may partner with energy producers or biofuel manufacturers. Waste materials may be converted into biogas to generate heat or electricity; (2) heat recovery; industries producing excess heat as a byproduct of processes may supply it to neighboring industries or residential areas for space heating or other purposes to reduces the need for individual industries to generate heat, saving energy; (3) co-generation; also known as combined heat and power (CHP), involves simultaneous production of electricity and useful heat from a single energy source. Industries with CHP systems may supply excess electricity to the local grid or neighboring businesses, while using waste heat for their own processes or nearby facilities; and (4) material exchange; industries producing waste materials such as scrap metal, plastic, or wood, can collaborate with other industries requiring these materials as input, reducing the demand for virgin resources and promoting community material recycling and reuse.

To facilitate industrial symbiosis, local governments, industry associations, and other stakeholders may establish platforms or networks where industries may identify potential synergies for interconnecting. These platforms can also provide technical assistance, financial incentives, and regulatory support to encourage and facilitate implementation of industrial symbiosis initiatives. By promoting industrial waste usage for energy generation through industrial symbiosis, local communities may achieve benefits including reduced waste generation, lower environmental impact, increased resource efficiency, enhanced economic development, and improved energy resilience.

Therefore, to overcome limitations and to build community dynamic competency, social innovations persuading sensitive areas to accept community energy usage must feature dual track social innovations through: (1) social business, and (2) community-developed activities working in tandem as social business models for biomass power plants and social innovation through community-based development activities. The connection point is the third sector: participation in profit sharing from power plants towards real community development: (1) overcoming funding capability challenges by creating earmarked funds to allocate profits from the power plant for community development at a certain rate; (2) mitigating the lack of knowledge and political resistance by appointing fund committees comprising pan-regional representatives with qualified members to share knowledge and advice on planning and deciding to work/develop activities in diverse fields; and (3) opening channels and opportunities for communities to participate in planning and achievement. With these three mechanisms, the community should be able to allocate money to community development activities covering all three areas, including social (educational and labor skill development), economic (agricultural skill) and community business development. This will allow community residents to earn more and increase shareholding in the future power plant business and obtain sufficient knowledge and skills to work in power plants at different positions.

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