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Enabling Community Energy Development for Electricity Generation in Bali, Indonesia

A Case Study Analysis Using Strategic Niche Management



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Enabling Community Energy Development for Electricity Generation in Bali, Indonesia

A Case Study Analysis Using Strategic Niche Management

By

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In the middle of 2016 summer, I squatted by the beach in rural Tasikmalaya, West Java while carving wind turbine blades from a wood slab to light up our new sheep pen. Two years later in 2018, I wiped the dust off photovoltaic (PV) panels on top of a barren hill that powered up a pump system providing fresh water to a village in Gunungkidul, Special Region of Yogyakarta. Years later, I wrote this piece as a tribute to all the people who trailblazed the path of renewable energy development all over Indonesia and the world—ensuring the right for all people to clean and accessible energy despite all the challenges and obstacles.

This also marks the end of my rocky journey at the TU Delft – a tough yet poetic depiction of the topic of community energy (CE) in Bali. It seems like a path with no end, yet we witness the movements flourishing in every corner of the island. It is a stubborn movement that defies all sociotechnical odds. Borrowing the words of James Baldwin, “The world is held together by the love and passion of a very few people.” It was such a privilege to spend the final months of my study talking for hours with those stubbornly passionate people who championed renewable energy development in Bali.

Therefore, I would like to express my gratitude to all the engineers, activists, hobbyists, and everyone else who dedicated their lives to community empowerment in renewable energy that inspired this research. Most importantly, my deepest appreciation to Dr. Ir. J.N. Quist and Dr. Udo Pesch who have not only provided me with guidance, feedback, and insights but also motivation and support to push through all the adversities I faced during the research. I also would like to thank all the interviewees for the eye-opening discussions and fellow colleagues at the TU Delft and beyond for their priceless inputs and support. Lastly, I would like to forward my gratitude to the Indonesia Endowment Fund for Education Agency (LPDP) for funding my education.

This thesis is a part of the Indonesia Regional Energy Transition Project by TU Delft. The project entails various research and publications aimed towards the development of strategic planning for sustainable energy implementation in the country. Co-creation with multiple actors and stakeholders as well as trans-/interdisciplinary approaches are the main building blocks of the project. Therefore, this thesis fits well within the initiative. More info about the project and other interesting publications related to Indonesia’s energy transition path can be found on the project’s [homepage](#).

For anyone who found this thesis (accidentally or not), I shall emphasize that this research is done with the intention of shedding more light on the rebels and mutineers who push through the challenges to solve societal problems. Whenever you finish reading it, get out of the room, witness the same sunlight that powers up the PV panels, feel the same gush of wind that keeps the wind turbines spinning, dip your feet into the same river that leads up to the micro-hydro power plants, and realize that renewable energy is a tangible manifestation of the harmony between *buana agung* (the environment) and *buana alit* (the people).

Warih Aji Pamungkas

Den Haag, June 2024

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Executive Summary

The development of Community Energy (CE) initiatives in Bali represents a critical step towards achieving sustainable energy goals and addressing energy access challenges. This report employs the Multi-Level Perspective (MLP) and Strategic Niche Management (SNM) frameworks to analyze the current state of CE in Bali, identify key stakeholders, and explore the factors influencing its growth. The research highlights the interplay between local cultural practices, government policies, and international pressures in shaping the landscape for renewable energy development in Bali.

Background and Societal Relevance

Bali, renowned for its cultural heritage and tourism industry, has committed to enhancing its renewable energy share amidst growing energy demand. The island's Regional General Energy Plan (RUED) sets targets for increasing the renewable energy mix, though these are lower than national targets. Bali's role as the host of international events like the G20 Summit has underscored its commitment to sustainable development, providing a platform for sharing best practices and fostering international collaborations.

Problem Statement and Research Questions

CE initiatives in Bali face numerous challenges, including regulatory barriers, limited financial resources, and technical capabilities. This research aims to identify the barriers and opportunities influencing CE development in Bali and provide strategic recommendations to foster its growth. The research questions guiding this study are:

1. What is the current stage of CE initiatives in Bali?
2. What are the roles of the stakeholders in the development of CE initiatives in Bali?
3. What are the factors that influence the development of CE initiatives in Bali?
4. How can Bali address the barriers and utilize the drivers of CE development to foster its growth?

Methodology

The research combines desk research, media analysis, and interviews with various stakeholders, including government entities, NGOs, local practitioners, and academics. This multi-faceted approach ensures a comprehensive understanding of the dynamics affecting CE initiatives. The MLP and SNM frameworks guide the investigation of niche nurturing, shielding, and empowerment processes.

Multi-Level Perspective (MLP)

The MLP framework views socio-technical transitions as processes occurring at three levels: the niche, regime, and landscape. Niches are protected spaces where radical innovations can develop, regimes are the dominant practices and rules that stabilize existing systems, and landscapes are the broader contextual factors such as cultural values and macro-economic trends. By analyzing interactions across these levels, the MLP framework helps to understand how CE initiatives can evolve and potentially transform the dominant energy regime in Bali.

Strategic Niche Management (SNM)

SNM focuses on the creation and nurturing of niches where sustainable innovations can grow. It emphasizes processes like shielding (protecting innovations from market pressures), nurturing (supporting the development and learning of innovations), and empowerment (strengthening niches to influence or replace the existing regime). This approach is particularly relevant for CE in Bali, as it involves fostering community-led renewable energy projects within a challenging socio-technical landscape.

Key Findings

CE initiatives benefit from strong local networks and cultural alignment with sustainable practices. The involvement of customary villages (*desa adat*) and the integration of traditional practices, such as the subak irrigation system, play a crucial role in supporting renewable energy projects. However, the economic viability of CE is challenged by the availability of cheap, subsidized electricity from the Java-Bali PLN grid, which discourages investment in local renewable energy infrastructure.

The Bali Department of Labor, Energy, and Mineral Resources, along with PLN, plays a pivotal role in shaping the regulatory environment for CE. Local NGOs and international organizations provide critical support in terms of funding, technical expertise, and community engagement. The tourism industry, as a major energy consumer, also has a significant impact on energy demand and sustainability efforts.

Key barriers include regulatory hurdles, insufficient funding mechanisms, and technical challenges in integrating variable renewable energy sources into the grid. Opportunities lie in leveraging Bali's international profile to attract investment, enhancing policy frameworks to support CE, and promoting community involvement through education and capacity-building initiatives.

The COVID-19 pandemic significantly affected Bali's economy, highlighting the island's dependence on tourism and underscoring the need for economic diversification. The reduction in energy demand during the pandemic provided an opportunity to reassess energy strategies and prioritize renewable energy integration. CE projects emerged as potential solutions for stimulating local economies, creating jobs, and enhancing energy resilience.

Recommendations

1. For policymakers:

- Streamline regulatory processes to facilitate CE project implementation.
- Establish dedicated funding mechanisms and financial incentives for renewable energy initiatives.
- Invest in capacity-building programs to enhance local technical expertise.

2. For researchers:

- Conduct comparative studies across different regions to identify universal and context-specific best practices.
- Engage in longitudinal studies to monitor the long-term viability of CE projects.
- Utilize mixed-methods approaches to capture the technical, social, and economic dimensions of CE initiatives.

Conclusion

Bali's unique cultural context, combined with international pressures and local policy initiatives, creates a complex but promising landscape for CE development. By addressing the identified barriers and leveraging existing opportunities, Bali can advance its energy transition, setting an example for other regions in Indonesia and beyond. This research contributes valuable insights into the institutional and socio-technical dynamics of CE, offering strategic guidance for future development.

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List of Abbreviations

AD	<i>Anno Domini</i>
ACE	ASEAN Centre for Energy
ADB	Asian Development Bank
APAEC	ASEAN Plan for Energy Cooperation
API	Application Programming Interface
ASEAN	Association of South East Asian Nations
BPS	<i>Badan Pusat Statistik/Statistics Indonesia</i>
BUMD	<i>Badan Usaha Milik Desa/Village-owned Enterprise</i>
CBR	Community-based Research
CE	Community Energy
CO ₂	Carbon Dioxide
CoE	Centre of Excellence
COVID-19	Coronavirus Disease 2019
CSR	Corporate Social Responsibility
DEN	<i>Dewan Energi Nasional/National Energy Council</i>
EPA	Engineering and Policy Analysis
ESDM	<i>Energi dan Sumber Daya Mineral (Energy and Mineral Resources)</i>
GW	Gigawatt
GWh	Gigawatt-hour
HTML	Hypertext Markup Language
IEA	International Energy Agency
IESR	Institute for Essential Service Reform
IRENA	International Renewable Energy Agency
JETP	Just Energy Transition Partnership
KEN	<i>Kebijakan Energi Nasional/National Energy Plan</i>
LEZ	Low Emission Zone
LREO	Local Renewable Energy Organization
MDS	Multi-dimensional Scaling
MLP	Multi-level Perspective
NDC	Nationally Determined Contribution
NZE	Net Zero Emission
NGO	Non-governmental Organization
PAMAS	Policy Analysis of Multi-actor Systems
Perda	<i>Peraturan Daerah/Regional Regulation</i>
Pergub	<i>Peraturan Gubernur/Governor Regulation</i>
Permen	<i>Peraturan Menteri/Ministry Regulation</i>
Perpres	<i>Peraturan Presiden/Presidential Regulation</i>
PESTLE	Political, Economic, Sociological, Technological, Legal and Environmental
PLN	<i>Perusahaan Listrik Negara/State Electricity Company</i>
PLTS	<i>Pembangkit Listrik Tenaga Surya/Solar Power Plant</i>
PP	<i>Peraturan Pemerintah/Government Regulation</i>
PT	<i>Perusahaan Terbuka/Public Enterprise</i>
PV	Photovoltaic
RE	Renewable Energy
Renstra	<i>Rencana Strategis/Strategic Plan</i>
RUED	<i>Rencana Umum Energi Daerah/Regional General Energy Plan</i>
RUEN	<i>Rencana Umum Energi Nasional/National General Energy Plan</i>
RUKD	<i>Rencana Umum Kelistrikan Daerah/Regional General Energy Plan</i>
RUKN	<i>Rencana Umum Kelistrikan Nasional/National General Energy Plan</i>
RUPTL	<i>Rencana Usaha Pengadaan Tenaga Listrik/Electricity Supply Business Plan</i>
SNM	Strategic Niche Management
STEEP	Social, Technical, Economic, Environment, Policy
SWPS	Solar Water Pumping System
TWh	Terawatt-hour
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
URL	Uniform Resource Locator
UU	<i>Undang-undang/Law</i>
WRI	World Resources Institute
YRE	<i>Yayasan Rumah Energi/Energy Home Foundation</i>

1 Introduction

Indonesia is currently at a crossroads in its energy transition ambition. On one hand, the country's economic growth leads to ever-increasing energy demand. In 2020, electricity consumption in Indonesia reached 242 TWh and is expected to be multiplied five-fold by 2050 (IRENA, 2022). Skyrocketing gas prices amidst the global energy crisis and unbalanced coal export and supply, among others, are hurting the country's energy security (IESR, 2022). On the other hand, complying with the Nationally Determined Contribution (NDC), Indonesia is in urgent need to push the renewable energy (RE) mix to a minimum of 23% by 2030 and 31% by 2050 (Government of Indonesia, 2022). As of now, Indonesia is still highly dependent on fossil fuels with only 10.4% shares of renewables (IESR, 2022). Indonesia has a huge potential in RE sources (approximately 3,643 GW for power plants), yet only 0.3% is already utilized (National Energy Council, 2022).

Indonesia has always been dealing with bottlenecks in energy transition, particularly in the policy arena. Indonesia's electricity market is a natural monopoly with State Electricity Company (PLN) as the sole retailer carrying the (partial) generation, transmission, and distribution role (Setyawan, 2015; Vagliasindi & Besant-Jones, 2013). Grassroots RE initiatives, commonly referred to as Community Energy (CE), have been long scattered around the country covering energy needs in rural areas (Gui & MacGill, 2018; Marianti, Permatasari, Manurung, wardhana, et al., 2023). Yet, they have to deal with the strict limitations of local content obligations, non-competitive regulated prices, and on-grid connectivity approval bureaucracies that deem the sustainability and scalability of their operation stalled (R. Fathoni, 2023; International Energy Agency, 2022a).

Bali is one of the first provinces in Indonesia to publish the Regional General Energy Plan (*Rencana Umum Energi Daerah/RUED*). The region set a target of 11.5% and 20.1% of the minimum RE mix by 2025 and 2050, respectively. The number is considerably lower than the national target (Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020). At the same time, electricity demand has spiked by 16.2% in 2022 compared to the previous year. The jump is caused by the rapid growth of Bali's industrial sector in recent years, along with the constant rise of electricity demand from the household sector (BPS-Statistics Indonesia, 2023b). This by no means needs to consider the fact that Bali is also the most impacted region during the COVID-19 crisis in Indonesia (Hartono et al., 2021).

As the host of the G20 Meeting in 2022, Bali has committed to champion the clean energy development in Indonesia. The meeting comprised sharing sessions and discussions to learn from different Bali energy stakeholders and resulted in several key takeaways: (1) The massive COVID-19 impact on the province of Bali opened the opportunity for sustainable economic recovery through energy transition; (2) The energy transition needs both technological innovation and socio-cultural landscape understanding, and; (3) Community empowerment is as important as national and local government action (Harsanto, 2022).

1.1. Problem Statement

CE entails citizen-led RE projects across multiple kinds and forms of technological and management practices. It is considered as a form of social innovation (SI) considering that CE is built upon under mutually-experienced social challenges and addressed through community participation (Creamer et al., 2019; Hewitt et al., 2019). In Indonesia, these initiatives played a critical role in addressing energy access challenges, particularly in remote areas, by utilizing local RE potential and therefore contributing for rural electrification or simpler form of energy production i.e. clean cooking. CE often seen as a catalyst for economic development in rural regions, creating jobs and fostering energy independence (Budiarto et al., 2019). Yet, at the same time, there are evident cases of the lack of community involvement in some projects, causing distrust between project stakeholders and the society the project is intended to serve (Pratiwi & Juerges, 2022; Shofiyah et al.,

2023). CE initiatives in Indonesia have been stuck in a nascent stage due to a lack of government attention worsened by the presence of policy bottlenecks (Sekaringtias et al., 2023). The projects—both government and grassroots-initiated—are no stranger to abandonment due to insufficient local technical capability, social disruption, or financial resources (Thomas et al., 2018).

Amidst the less-than-ideal situation, there are growing CE projects across the nation. In Bali, the local government has initiated several enablers such as incentives for solar rooftop users and legal support for local enterprises to develop RE infrastructures (Setyowati & Quist, 2022; Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021). Establishing a healthy policy and financing environment for CE projects can help Bali ensure resilience in electricity supply, explore new economic potential in RE, and progress to a more just and sustainable energy source (Guerreiro & Botetzagias, 2018; E. S. Wahyuni et al., 2020; N. S. Wahyuni et al., 2015). There are only a few studies that have been published on CE in Indonesia, particularly on the technical feasibility of RE technologies and the sociocultural dynamics of it. Strategic niche management (SNM) will be used to observe CE as a niche and what can be done to foster its growth in the current landscape of Bali (Hakim, 2021; Sirait, 2022).

1.2. Societal Relevance

The topic tackles issues regarding Goal 7 of the Sustainable Development Goals (SDGs), which aims to ensure access to affordable, reliable, sustainable, and modern energy for all (Transforming Our World: The 2030 Agenda for Sustainable Development, 2015). An adequate implementation of CE in Bali could address energy access issues, thus advancing the just energy transition goal by the regional government. The collective nature of CE is also relevant to Goal 11, which focuses on making cities and human settlements inclusive, safe, resilient, and sustainable. CE has the potential to enhance the sustainability and resilience of communities in Bali in the energy sector, which ultimately leads to more sustainable urban and rural development. Moreover, a better CE implementation framework for Bali means a blueprint for other provinces to follow.

In the regional context, research on CE holds significant societal relevance in the context of the ASEAN Plan of Action for Energy Cooperation (APAEC). APAEC is a regional framework aimed at enhancing energy security, sustainability, and accessibility in Southeast Asia. RE is among the seven pillars of APAEC, in its outcome-based strategies include (1) enhancing awareness of RE among policymakers, private sectors and the public and (2) enhancing the R&D network on RE technology development and utilisation within the region (ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 Phase II: 2021-2025, 2019). The result of this research has the potential to inform policymakers on the untapped potential of thriving CE initiatives in Indonesia waiting to be supported.

Indonesia has also submitted the Enhanced Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2021 aimed towards a net-zero emission target by 2060. In order to achieve the goal, the government set several targets in the energy sector, including a national share of RE of 23% by 2025 and at least 31% by 2030 (Government of Indonesia, 2022). Therefore, Indonesia launched the Just Energy Transition Partnership (JETP) program during the G20 summit in Bali, Indonesia. The program accounts for a \$20 billion initial investment from various partnerships and is maintained through the Comprehensive Investment and Policy Plan (CIPP) as a living document that will be regularly evaluated and updated throughout the program period (JETP Indonesia, 2023). The document mentioned an even more ambitious target of 34% RE share by 2030.

In response to that, Bali has also enacted regional policies to support the national target, namely the Regional General Energy Plan (*Rencana Umum Energi Daerah/RUED*) under the National General Energy Plan (*Rencana Umum Energi Nasional/RUEN*). The statute includes a projection of RE share target of 11.15% by 2025 and 20.10% by 2050—which is below the national target (Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020). The government is putting RE development as their third priority under the statute, supported by various regional policies under

the Bali Clean Energy (*Bali Energi Bersih*) plan—ranging from RE infrastructure development, energy storage management, internet of things (IoT) implementation in the context of energy, energy conservation plan, green building, and energy-related business regulation (Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali Energi Bersih, 2019). The research delves into community-led RE initiatives. Bottom-up perspective on Bali energy transition can inform the stakeholders on the challenges and opportunities faced by the “needle-movers” within the Bali community, therefore allowing cooperation between the government and their people.

1.3. Engineering and Policy Analysis (EPA) Relevance

This topic is highly relevant to this program as it requires an interdisciplinary approach that is integral to the EPA curriculum. It examines the sociotechnical dimensions of CE initiatives, reflecting the program's nature in exploring multi-faceted problems that span technical, societal, and policy domains. This research aligns with this objective by trying to explore the policy recommendations critical to the development of CE projects to catalyse energy transition in Bali. It explores the interplay between governmental and non-governmental actors, as well as their power and interest dynamics. Such multifaceted policy analysis resonates with the policy and political analysis components of the EPA curriculum.

This research examines the matter using actor analysis and policy analysis frameworks, which were learned in the courses EPA1144 Actor and Strategy Models and EPA1124 Policy Analysis of Multi-Actor Systems (Enserink et al., 2022; Hermans et al., 2018). Strategic Niche Management (SNM) and the Multi-Level Perspective (MLP) frameworks are not directly integrated within the EPA curriculum, yet are considered instrumental in the research of sociotechnical analysis (Geels & Schot, 2007; Schot & Geels, 2008).

Moreover, the focus on sustainability and energy transitions in the research resonates with the EPA program's emphasis on wicked problems within the environment and sustainability realms. By investigating the implementation of CE projects in Bali, the research provides valuable insights into real-world applications of RE technologies and their societal impacts. EPA curriculum prioritises hands-on, real-world problem-solving experiences which aligns with this research. Furthermore, the international context of the research aligns with the program's goal of enhancing proximity towards managing and analysing complex issues across different cultural and socio-political landscapes.

1.4. Research Objectives

SNM framework is particularly suitable for studying CE development in Bali, Indonesia, due to the unique characteristics of grassroots RE initiatives and the socio-cultural context of Bali which fits the niche perspective. CE projects represent niche innovations in which they involve decentralized and community-driven approaches to energy production and consumption (Seyfang et al., 2014; A. Smith et al., 2016). Bali is a unique region in Indonesia with strong community ties and cultural values, providing an interesting context for studying how such niche innovations can interact with existing energy regimes and navigate the local landscape. In Bali community and sustainability are integral to the culture. Therefore, CE initiatives align with the values of Balinese society (Harsamto, 2022).

To conduct research using the SNM framework on CE initiatives in Bali, a multi-faceted approach is recommended. The first step is the identification of existing CE initiatives in Bali and multiple factors regarding their establishment and operation, such as motivations, milestones, organizational structures, and interactions with the local community (Seyfang et al., 2014). Externally, existing regime identification and actor analysis can further contextualize the niche with related factors surrounding it. The landscape can be assessed by examining the regulatory environment, cultural attitudes towards energy, and economic factors influencing energy choices, among others (Boon & Dieperink, 2014; A. Smith et al., 2016).

Necessary data is acquired through interviews and literature reviews. Works of literature that are covered in this research include academic publications, governmental documents, news articles, and non-academic reports from reputable energy- and research-led institutions/entities. Interviews are gathered to gain insights into the dynamics between the CE initiatives and the broader energy regime and landscape.

The goal of this research is to provide strategic interventions or policy recommendations based on the SNM framework to support the successful integration of CE initiatives into the broader energy system in Bali.

1.5. Research Question

The purpose of this research is to fill the gap in the institutional context of CE development in Indonesia to address electricity access in rural areas. Bali is chosen as a case study considering its unique situation as an independent island connected to the Java grid and leading the country in terms of RE initiatives and policies. Based on that notion, a research question is formulated as follows:

“What are the barriers and opportunities that influence the establishment and operation of community energy (CE) initiatives in Bali, Indonesia and what can be done to foster the growth of CE development on the island?”

To address this, the research adopts a multi-faceted approach using the SNM framework to explore how institutional frameworks, stakeholder engagement, and community involvement can shape and support the development of CE. Therefore, to support the main overarching question, research sub-questions are formulated as follows:

1. What is the current stage of CE initiatives in Bali?
2. What are the roles of the stakeholders in the development of CE initiatives in Bali?
3. What are the factors that influence the development of CE initiatives in Bali?
4. How can Bali address the barriers and utilize the drivers of CE development to foster its growth?

1.6. Research Outline

Chapter 2 of this thesis explains each concept and theory used in this research, as well as the preliminary knowledge gap discovery through a literature review. The third chapter consists of explanation of the research methodology stages, including data collection and analysis, elaboration on the used analytical framework, overall research flow, and the validity and reliability aspect of the research. This part explains the basic principle of niche innovation analysis (including niche nurturing, shielding, and empowerment), regime analysis, landscape analysis, actor analysis, and choice of geographical boundary.

Chapter 4 is the beginning of the analysis parts of the research, in which the chapter consists of policy analysis of CE in Bali within the MLP framework. Therefore, the chapter contains a sociotechnical landscape, technological map, actor analysis, and a deeper dig into the matter under PESTLE elements. Chapter 5 uses SNM framework to analyse CE in Bali, therefore diving in the shielding, nurturing, empowerment, barriers, and opportunities aspects of CE as a niche. Lastly, the discussion section dissects interesting findings on CE initiatives in Bali such as the challenges and opportunities of Bali as an international hub in Indonesia with its tourism-led economy and frequent role contesting interest between Bali CE practitioners and the government, the unique role and power of “customary village”, and the possibility for Bali to become a blueprint for the nation’s CE development.

2 Theory and Literature Review

2.1. Overview of Community Energy (CE) in Bali

2.1.1. Community Energy (CE)

CE refers to the generation, distribution, and often ownership of energy resources at a local or community level (Creamer et al., 2019; Thomas et al., 2018). It involves active participation by community members in developing and managing energy projects, with the aim of providing clean and sustainable energy to meet local needs while promoting economic and social benefits. CE projects can encompass various RE sources and they are typically driven by shared objectives, including reducing carbon emissions, enhancing energy resilience, and fostering a sense of ownership and empowerment within the community (Bauwens, 2016).

CE plays a pivotal role in the energy transition because it empowers local communities to actively participate in and benefit from the shift to cleaner and more sustainable energy sources (Bauwens et al., 2016). By fostering ownership, control, and engagement at the grassroots level, CE initiatives not only reduce carbon emissions and promote the use of RE but also enhance energy resilience, stimulate local economic development, and strengthen social cohesion (Mohammadi, 2023). These projects serve as a crucial driver for a successful and inclusive energy transition that addresses both environmental and societal needs.

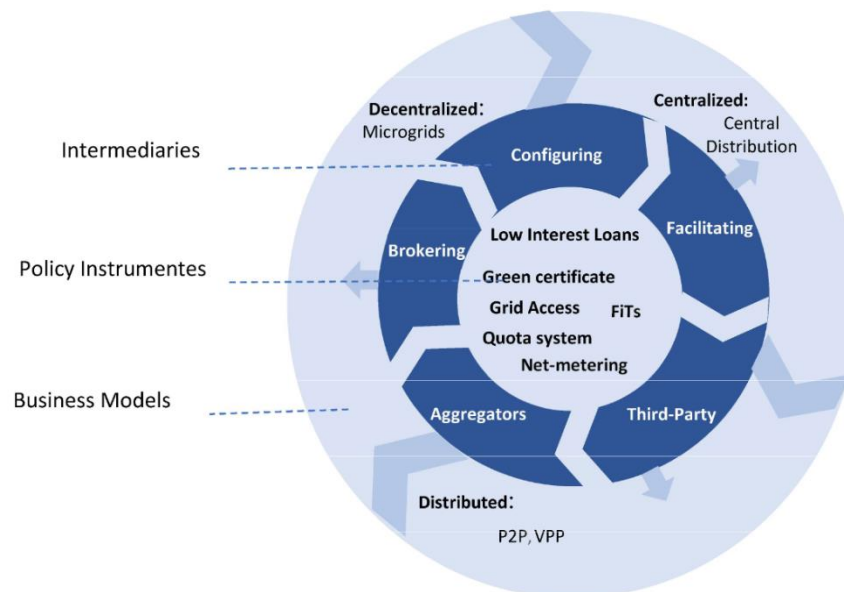


Figure 1. Conceptual framework of CE (Mohammadi, 2023)

2.1.2. Bali Energy Status

Indonesia is one of the fastest-growing economies in the world. It is now has established itself as the seventh-largest economy in the world and is projected to become the fourth-largest by 2050. Hence, the country is in dire need of increasing energy supply while at the same time having committed to achieving net-zero emissions by 2060. It means that the country needs to find a way to detach itself from its current dependence on coal-powered electricity—which accounts for around 60% of total electricity output and 224

million tonnes of CO₂ emission in 2019 (International Energy Agency, 2022a). The electricity demand in Indonesia is solely provided by Perusahaan Listrik Negara (PLN), a state-owned electricity company which controls all transmission and distribution networks in Indonesia, as well as more than two-thirds of electricity generation (Asian Development Bank, 2019). Despite there is more flexibility for the private sector to participate in the exploration and production streams, PT Pertamina, a state-owned oil and gas enterprise, still dominates the market (Asian Development Bank, 2021).

As an archipelago, Indonesia's power system is not entirely connected and comprises several major grid systems. Bali is in the same grid system as Madura and Java—the most populous island in the country—which accounts for 64% of the nation's installed capacity. Coal dominates 70% of its power mix and only 8% of it is from renewables (International Energy Agency, 2023).

Table 1. Electricity consumption and access rate of selected major Indonesian power grids (International Energy Agency, 2022a)

	Population (million)	Consumption (GWh)	Electricity access rate (%)
Java-Madura-Bali	156	175,035	99,60
Sumatra	58	38,111	99,69
Kalimantan	16	11,352	98,86
Sulawesi	20	11,423	99,23
Maluku, Papua, Nusa Tenggara	18	6,192	94,13
Total	268	242,113	96,7

2.1.3. Bali Energy Policy

All policies and strategies related to the energy sector in Indonesia are constituted under the National General Energy Plan (Rencana Umum Energi Nasional/RUEN) (Peraturan Presiden Republik Indonesia Nomor 22 Tahun 2017 Tentang Rencana Umum Energi Nasional, 2017). RUEN serves as a reference document (blueprint) for strategic regional planning below it based on the milestones of Kebijakan Energi Nasional (National Energy Policy/KEN). KEN is a policy framework designed to guide energy development and ensure a stable, secure, and sustainable energy supply which encompasses various aspects of energy policy, including energy security, affordability, and sustainability (Peraturan Pemerintah Republik Indonesia Nomor 79 Tahun 2014 Tentang Kebijakan Energi Nasional, 2014). The Regional General Energy Plan (Rencana Umum Energi Daerah/RUED) is a more localised energy plan that focuses on energy development goals and strategies for specific regions or provinces within Indonesia. It should align with the broader goals set in RUEN but can have region-specific strategies (Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020).

On the other side, there is also the National General Electricity Plan (Rencana Umum Kelistrikan Nasional/RUKN). RUKN focuses specifically on the planning and development of the electricity sector in Indonesia through the development of power generation, transmission, and distribution systems. Regional General Electricity Plan (Rencana Umum Kelistrikan Daerah/RUKD) serves as an interpretation of RUKN in the local contexts and needs of specific regions or provinces. It entails a plan for the development of the electricity sector tailored to the local area's unique needs, resources, and goals (National Energy Council, 2022).

Bali has its own RUED and RUKD, as well as several other supporting policy instruments on the energy sector such as Governor's Regulation No. 45/2019 on Bali Clean Energy and Circular Letter No. 5/2022 on Rooftop Solar Panel Implementation (Keputusan Gubernur Bali Nomor 879/03-M/HK/2022 Pedoman Teknis Penyelenggaraan Bangunan Gedung Hijau Dalam Rangka Penyelenggaraan Bali Energi Bersih Di Provinsi Bali, 2022; Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali Energi Bersih, 2019; Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021).

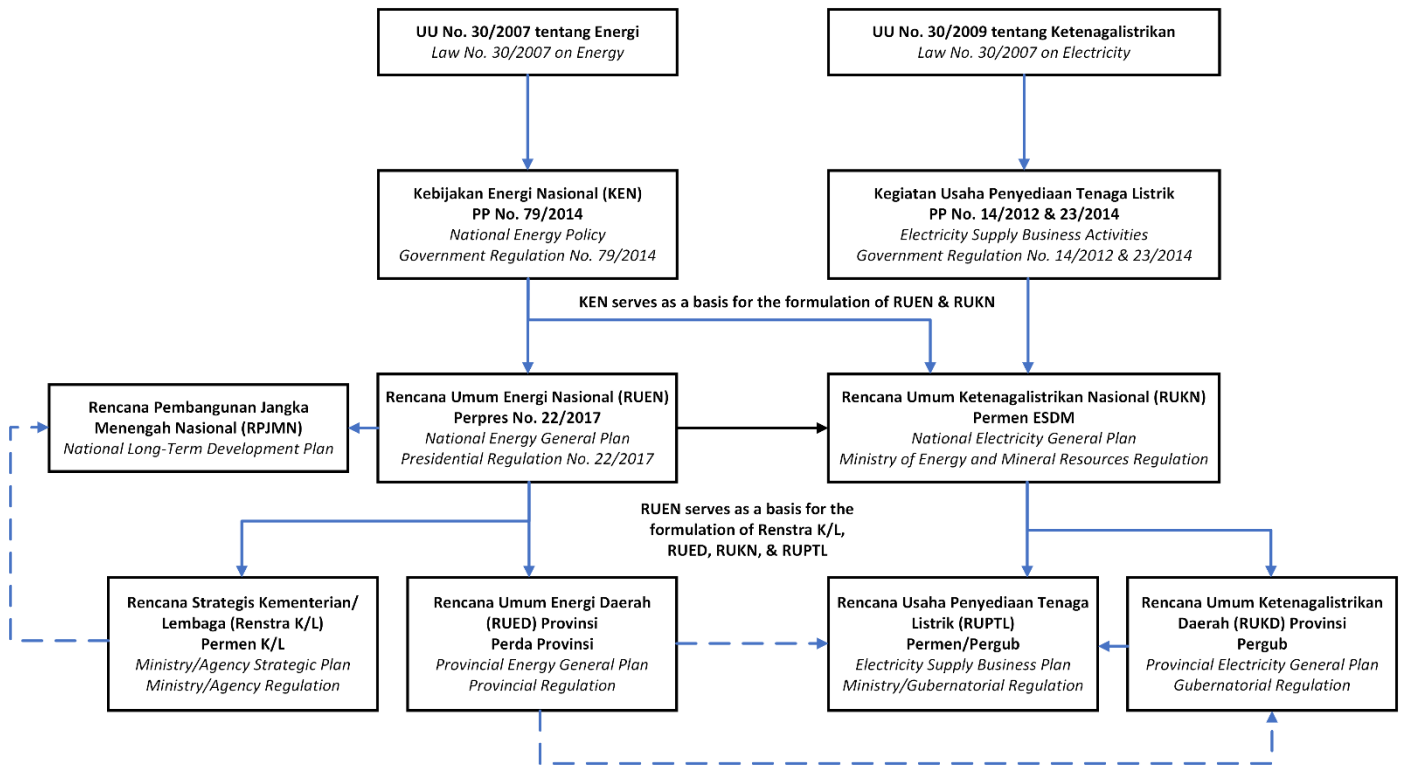


Figure 2. Policy instruments on energy in Indonesia (National Energy Council, 2022)

2.2. Theory

2.2.1. Multi-level Perspective (MLP)

The Multi-Level Perspective (MLP) framework is a theoretical approach used to understand the dynamics of socio-technical transitions, which are complex processes through which societies shift from one socio-technical system to another. These systems encompass the technical, social, and institutional structures that define how societies meet their needs, such as energy supply, transportation, or communication. The MLP framework is particularly used in the study of sustainability transitions, aiming to understand how technological, social, and environmental systems can be transformed towards more sustainable modes of operation (Riddell, 2015).

The MLP framework stands on an understanding that transitions occur through interactions between three analytical levels. First, niche innovation represents the emergence of radical innovations. Niches are protected spaces where new technologies, practices, or ideas can develop without immediate pressure from mainstream markets or regulatory forces. These innovations can be technological, but they can also include new business models, practices, or social arrangements. Second, socio-technical regime encompasses the dominant social, technical, institutional, and regulatory structures that stabilize existing systems. Regimes are deeply embedded in society and represent the status quo, including established technologies, user practices, regulations, and industry standards. Last, socio-technical landscapes represent the broad and relatively stable social, political, cultural, and environmental backdrop including macroeconomic trends, deep-seated cultural patterns, and large-scale political developments. The degree of difficulty of changes at each level gets higher, therefore explaining windows of opportunity for niche innovations to break through and potentially destabilize existing regimes (Dóci et al., 2015; Mah & Cheung, 2020).

2.2.2. Strategic Niche Management (SNM)

Strategic Niche Management (SNM) is a theoretical and practical framework built upon MLP used to understand and facilitate the development and diffusion of sustainable innovations (Seyfang et al., 2014). It focuses on the creation, development, and scaling up of niches where novel socio-technical practices can

emerge and evolve away from the immediate pressures of mainstream markets and established regimes. SNM is often discussed in the context of sustainability transitions, aiming to guide the process through which new technologies, systems, or practices can contribute to a more sustainable future. However, the SNM framework focuses on the core idea of protected spaces created by stakeholders that allow for the experimentation with, and nurturing of, radical innovations (Geels, 2005). These innovations can potentially challenge and ultimately replace existing unsustainable practices and technologies within the broader socio-technical system.

There are three key elements of SNM framework: learning, network, and expectation. Experimentation and learning encourage a variety of experiments within niches to generate learning about the technical, social, and institutional conditions necessary for the innovation to succeed. This involves not just technological development but also learning about user preferences, regulatory requirements, and market dynamics. Network formation considers networks of actors who support the innovation that includes a range of stakeholders such as researchers, entrepreneurs, users, policymakers, and others who can contribute resources, knowledge, and legitimacy to the niche. Lastly, vision and expectation help to align stakeholders around common goals, attract interest and resources, and provide direction for niche development (A. Smith et al., 2016).

By focusing on these strategic elements, the SNM framework seeks to overcome the barriers that often prevent radical innovations from reaching their full potential, thereby contributing to systemic change toward sustainability. Such scaling-up and diffusion processes may involve leveraging windows of opportunity, aligning with broader market or regulatory trends, or engaging in strategic partnerships based on the three key elements of SNM (Schot & Geels, 2008).

2.2.3. Actor Analysis

Actor analysis helps to unravel the complex network of stakeholders involved in the energy transition and ensures that the perspectives, interests, and influence of different actors are properly understood and considered (Pouloudi et al., 2004). In the context of Bali, where community-driven energy initiatives are both pushed towards sustainability agenda and integrated within the belief of the people in the grassroots level, understanding the roles and interactions of various actors becomes essential. Bali's unique socio-cultural landscape is characterized by not only indigenous values but also traditional community structures, such as customary villages and irrigation cooperatives (*subak*). Those structures, among others, play pivotal roles in local decision-making processes. They often intersect with more modern governmental, private, and non-governmental organizations (NGOs), each with their own agendas and power dynamics (Dharmayasa et al., 2023; Zen et al., 2024). Actor analysis helps researchers identify how these different entities contribute to, or hinder, the development of CE projects. For example, while local government bodies might support RE initiatives in principle, their policies might not align with the community's needs or the cultural context, leading to resistance or inefficiency in implementation.

Actor analysis can also be used to observe power relations and potential conflicts between stakeholders. In Bali, the tourism industry is a dominant economic force that significantly impacts energy consumption patterns and environmental policies. Hospitality industries, for instance, may have different priorities compared to local communities, which can lead to conflicts over resource allocation, environmental impacts, and the direction of energy policy (Chevalier & Budarma, 2016; Colorni, 2018). Understanding the motivations and capacities of different stakeholders is also pivotal. CE projects rely on the active participation of local populations. It is essential to assess the level and difference of interest, motivation, and action that various actors can bring to the table. For instance, local NGOs might have a deep interest in sustainable energy due to environmental concerns, but the local community might lack the technical expertise or financial resources needed to initiate and maintain such projects (Ziozas, 2019). Conversely, private companies might be driven by profit motives that do not align with community goals, and when they actually do, the government does not have the political will to support it (Chelminski, 2015; Deendarlianto, 2024). Understanding these

motivations and capacities through actor analysis allows researchers to propose strategies that leverage the strengths of each actor while addressing their limitations.

2.3. Gap Analysis

2.3.1. Methodology

Scopus is used to explore published academic literatures related to the research topic of Indonesian CE. Therefore, the used search query is as follows:

("community energy" OR "community RE" OR "energy cooperatives") AND "indonesia"

There is definitely a stark difference between the definition of “community energy” and “energy cooperatives”. Cooperative is defined as “an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise” (International Labour Organization, 2013). Energy cooperative is a community-driven, grassroots initiative where members act as both producers and consumers (prosumers) to promote sustainable energy production and consumption (Heras-Saizarbitoria et al., 2018). Therefore, energy cooperative might be a model that is used in a CE, particularly in Indonesia where on-grid electricity is fully controlled by PLN. The search query resulted in 8 documents found in Table 2.

Table 2. Summary of English-written academic publications about CE in Indonesia

Author, Year	Title	Summary
Guerreiro & Botetzagias, 2018	Empowering communities—the role of intermediary organisations in community RE projects in Indonesia	Literature review and interviews on STEEP (Social, Technical, Economic, Environment, Policy) aspects are used on two CEs in Indonesia, resulting in the need for a meso-actor to bridge the gap between micro-level factors within the CE and macro-level factors such as policy and financing instruments.
Thomas et al., 2018	Transdisciplinary research methods in CE development and governance in Indonesia: Insights for sustainability science	Transdisciplinary analysis on respondents who are members of CEs in four different villages in Indonesia resulted in six methodological principles: preparations, common understandings, flexibility, shared responsibility, respect, and lightheartedness.
Akbar et al., 2019	Government's strategy in optimising RE programs through the participatory approach in Gorontalo, Indonesia	A mixed method of questionnaires and interviews to observe availability, acceptability, accessibility, affordability, and social participation in the implementation of solar and hydropower plants in Gorontalo, Indonesia, resulting in the lack of community participation evident in some of the power plant projects.
Rahmani et al., 2020	Review of community RE projects: The driving factors and their continuation in the upscaling process	Literature review of CE implementations on 9 case studies within 7 countries including Indonesia by observing the typologies of background setting, people's motivation, community social capital, external support, and experienced outcome during the upscaling process.
H. S. Fathoni et al., 2021	Is community RE always just? Examining energy injustices and inequalities in rural Indonesia	Research on CEs in Sumba Island, Indonesia by interviewing 8 government officials, 13 NGO and development organisation representatives, 2 academics, 5 private renewable developers, 3 officials from the state electricity company (PLN), 4 local project implementers, 13 village leaders and stakeholders, 4 cooperative staffs, 6 village-owned enterprises (BUMD) officials and 44 villagers/community members to observe the politics of energy distribution, the need for community involvement, and the influence of traditional social stratification.
Dwipayana et al., 2021	Sustainability Index of Solar Power Plants in Remote Areas in Indonesia	Analysis on solar power sustainability factor in Bogor, Indonesia, using Multi-Dimensional Scaling (MDS), resulting in the environmental dimension being the highest sustainability index followed by social, technical, and economic dimensions.
Rahmani et al., 2021	Socio-economic Impact of a Solar Water Pumping System in a Rural Community in Indonesia	Research on the social and economic impact of Solar Water Pumping Systems (SWPS) in Indonesian rural communities using questionnaires, found that an increase in satisfaction regarding knowledge gain and economic saving does not translate to increased welfare.
Mohammadi, 2023	Investigation of Community Energy Business Models from an Institutional Perspective: Intermediaries and Policy Instruments in Selected Cases of Developing and Developed Countries	Ostrom's institutional framework analysis on CE developments in developed and developing countries including Indonesia, resulted in the issue of top-down policies in developing countries that turned out to be the main bottleneck of participatory planning and development in the energy sector.

Due to the limitation in the number of published literatures on Indonesian CE in English, a further search is done in Bahasa Indonesia using Google Scholar. The following search query is used:

"komunitas" AND "energi"

The search query (direct translation: “community” AND “energy”) is considerably more straightforward compared to the previous one by assuming that most if not all CE-related publications in Bahasa Indonesia

should cover topics indigenous to Indonesian case studies. Relevant publications resulted from the search query can be found in Table 3.

Table 3. Summary of Bahasa Indonesia-written academic publications about CE in Indonesia

Author, Year	Title (Translated)	Summary
Setiawan et al., 2014	Development of a Solar Water Pumping System in Karsts Rural Area Tepus, Gunungkidul through Student Community Services	Case study on the implementation of Solar Water Pumping System (SWPS) to address energy and water scarcity problem in Purwodadi Village, Yogyakarta, Indonesia by the collaboration of university students and local community.
N. S. Wahyuni et al., 2015	Integrated Communities for the Sustainability of RE Application: Solar Water Pumping System in Banyumeneng Village, Indonesia	Sociotechnical case study on community empowerment in student-led CE initiatives in Banyumeneng Village, Yogyakarta, Indonesia.
Irfan, 2016	Crowdfunding in Collective RE	Assessment on the potential of crowdfunding as an alternative way for community-led RE financing.
Rumbayan, 2017	Biogas Technology Introductions as RE for Rural Communities	Questionnaire-based research to assess community participation in biogas CE initiative in Kosio Village, Bolaang Mongondow, North Sulawesi, Indonesia. Result shows that albeit the lack of knowledge on biogas, there are abundant resources in the village due to farming activities and huge interest from the community to participate.
Budiarto et al., 2019	(Book) Community-based Energy Transition in Islands and Remote Areas	A book that covers multidisciplinary and complex system aspects of energy transition in islands and rural areas in Indonesia. The book also covers several case studies in Nusa Penida Island, Semau Island, Wakatobi Island, and Gorontalo Province.
Khotimah, 2019	Maintaining Nation Solidities Through RE Management Based on Communities	Literature research and case studies on how CE aligns with the Indonesian government's goal of energy resilience. The case study covers CE initiatives in Singasari Village, Bangun Sari Village, and Krueng Kala Village.
E. S. Wahyuni et al., 2020	Utilization of RE for Community-Based Solar Power Generation: Towards an Energy Independent Village	Community-based Research (CBR) assessment in Wonosalam Village in Sleman, Indonesia. The assessment covers the community approach, feasibility study, installation, and evaluation of a community-led solar power plant.

2.3.2. Discussion

The limited number of literature found further proves the lack of research on CE in Indonesia, albeit the thriving existence of such initiatives. This research, however, does not incorporate publications that are specifically address the technical side of CE only. There are a number of academic papers that explain the technical design and implementation of various RE technologies in Indonesian CE, further proving that there are already plenty of movements, yet little documentation from the interdisciplinary perspective.

CE projects in Indonesia are the focus of several studies that highlight the roles of intermediaries, community involvement, and policy frameworks. Guerreiro & Botetzagias (2018) emphasize the importance of intermediary organizations in linking local initiatives to broader policy frameworks, facilitating community RE projects. These intermediaries play a vital role in overcoming barriers and ensuring the success of local energy initiatives. Mohammadi (2023) similarly explores the challenges posed by top-down policies in developing countries, identifying them as major bottlenecks for participatory planning. Both studies underscore the necessity of intermediaries and tailored policy instruments to support CE projects effectively.

Thomas et al. (2018) and Rahmani et al. (2020) focus on methodological approaches and factors influencing CE project success. Thomas et al. use a transdisciplinary approach to stress the importance of stakeholder collaboration and local knowledge integration, outlining six key methodological principles.

Rahmani et al., on the other hand, review multiple case studies to identify driving factors and challenges in the upscaling of community RE projects. Both studies highlight the critical role of community involvement and collaboration for successful energy project implementation.

Akbar et al. (2019) investigate the challenges related to community participation in RE projects in Gorontalo, Indonesia, noting a lack of engagement in some solar and hydropower projects. This highlights the need for more inclusive approaches to ensure project success. Meanwhile, H. S. Fathoni et al. (2021) examine energy injustices in rural Indonesia, finding that CE projects can perpetuate social inequalities due to existing power imbalances. Both studies call for increased community engagement and addressing socio-political challenges.

Dwipayana et al. (2021) assess the sustainability of solar power plants in remote Indonesian areas, using a multi-dimensional scaling approach to evaluate sustainability across environmental, technical, social, and economic dimensions. They emphasize the importance of effective management and community involvement in optimizing solar power performance. Rahmani et al. (2021) examine the socio-economic impacts of solar water pumping systems, finding that while there is satisfaction with cost savings, these do not always lead to welfare improvements. Both studies highlight the need for sustainability assessments and support mechanisms to maximize the benefits of RE projects. Setiawan et al. (2014) and N. S. Wahyuni et al. (2015) both also investigate solar water pumping systems in rural areas, with an emphasis on university student-led projects. Both studies demonstrate the effectiveness of combining academic resources with community engagement to promote sustainable development.

Irfan (2016) and Rumbayan (2017) examine alternative financing and technology adoption methods for RE. Irfan's study explores crowdfunding as a mechanism for financing community-led RE projects, highlighting its potential to embody the cultural value of "gotong royong," or mutual cooperation. This approach enables communities to collectively raise funds and increase investment in sustainable energy initiatives. On the other hand, Rumbayan focuses on the introduction of biogas technology in Kosio Village, North Sulawesi, using community engagement and questionnaires to assess interest and potential. Despite limited initial knowledge, the community's high interest and available resources indicate a promising avenue for biogas production, demonstrating how community participation can drive technology adoption in rural settings.

Khotimah (2019) explores how community-based RE initiatives contribute to national energy resilience in Indonesia in a bottom-up manner. This research underscores the importance of integrating grassroots efforts into national strategies to promote sustainable development. Meanwhile, E. S. Wahyuni et al. (2020) focus on community-based solar power generation for energy independence within the village itself. This study evaluates the feasibility and impact of community-led solar power installations, highlighting the potential for villages to become self-sufficient by utilizing local renewable resources. Both research projects demonstrate the significance of localized efforts to contribute to broader energy sustainability objectives.

Budiarto et al. (2019) provide a comprehensive overview of community-based energy transitions in Indonesian islands and remote areas through their book, "Community-based Energy Transition in Rural Islands and Areas". The authors highlight interdisciplinary efforts by Universitas Gadjah Mada in regions such as Nusa Penida, Semau Island, Wakatobi, and Gorontalo, showcasing how a combination of social and technical studies can facilitate sustainable energy development. The projects documented emphasize community engagement and multidisciplinary collaboration as key factors in achieving effective energy solutions in remote areas.

As an addition to the observed texts, Islam & Mamun (2017) emphasized the importance of PESTLE (Political, Economic, Social, Technological, Legal and Environmental) analysis in RE implementation in archipelagic countries. The geographical condition of such countries poses challenges in the context of grid connection, natural disasters, and policy/political coherence. Asian Development Bank (2020) further elaborated that Indonesia is currently facing a technological growth spurt, yet the government still has a huge task to catch up—as is apparent in the CE sector. Sekaringtias et al. (2023) listed some of the major bottlenecks of energy transition in Indonesia includes: (1) conflicting interests, (2) inconsistent regulation, and

(3) low capability at the implementation level. Hence, there is an urgent need to address the matter from the sociotechnical and policy perspective.

2.3.3. Additional Literature

To support the limited availability of literature on CE in Indonesia, additional documents are needed from various sources. In general, additional literature used in this research is classified as (1) grey literature such as reports from reputable organizations or institutions such as International Energy Agency (IEA) and International RE Agency (IRENA), to name a few and (2) official documents released by the government such as the KEN, RUEN, and RUED. Also not listed here are news articles that will be used to keep track of the most recent situation of energy transition in Bali and Indonesia. A complete list of official documents relevant to the topic can be found in Table 4.

Table 4. Relevant legal documents published by the national and local governments of Indonesia and Bali

Title, Year	Title (Translated, Shortened)	Note
National Level		
<i>Undang-Undang Republik Indonesia Nomor 30 Tahun 2007 Tentang Energi, 2007</i>	National Law on Energy	
<i>Peraturan Pemerintah Republik Indonesia Nomor 79 Tahun 2014 Tentang Kebijakan Energi Nasional, 2014</i>	National Energy Policy (Kebijakan Energi Nasional/KEN)	Academic manuscript is included
<i>Peraturan Presiden Republik Indonesia Nomor 22 Tahun 2017 Tentang Rencana Umum Energi Nasional, 2017</i>	National General Energy Plan (Rencana Umum Energi Nasional/RUEN)	Academic manuscript is included
Local Level		
<i>Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali Energi Bersih, 2019</i>	Bali Clean Energy	
<i>Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020</i>	Regional General Energy Plan (Rencana Umum Energi Daerah/RUED)	Academic manuscript is included
<i>Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021</i>	Rooftop Solar Panel Implementation	
<i>Keputusan Gubernur Bali Nomor 879/03-M/HK/2022 Pedoman Teknis Penyelenggaraan Bangunan Gedung Hijau Dalam Rangka Penyelenggaraan Bali Energi Bersih Di Provinsi Bali, 2022</i>	Green Building Implementation Technical Guidelines	

On the national level, *Undang-Undang Republik Indonesia Nomor 30 Tahun 2007 Tentang Energi* (National Law on Energy) is an umbrella framework for managing energy resources to enhance national energy resilience. It outlines the responsibilities of the government and local authorities in ensuring sustainable and equitable energy provision. The law emphasizes diversification of energy sources, efficient use, and public participation in energy management to ensure energy security and sustainable development. *Peraturan Pemerintah Republik Indonesia Nomor 79 Tahun 2014 Tentang Kebijakan Energi Nasional* (National Energy Policy/KEN) serves as Indonesia's strategic energy policy. It aims to achieve energy security and sustainability by increasing the use of RE and reducing reliance on fossil fuels. This regulation sets targets for energy mix diversification and promotes energy efficiency and conservation. *Peraturan Presiden Republik Indonesia Nomor 22 Tahun 2017 Tentang Rencana Umum Energi Nasional* (National General Energy Plan/RUEN) provides a comprehensive national energy plan up to 2050. It details strategies for achieving the goals set in the national energy policy, including diversification of energy sources, improving energy efficiency, and increasing the share of renewables in the energy mix. RUEN serves as a reference for

national and regional energy planning and emphasizes the need for coordinated cross-sectoral energy management.

The Government of Bali also enacted several supporting regional policies in accordance to the three national-level policies mentioned previously. *Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali Energi Bersih* (Bali Clean Energy) is an overarching plan to promote clean energy to reduce carbon emissions and enhance energy sustainability. It encourages the adoption of RE technologies and supports initiatives to improve energy efficiency across the island. *Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050* (Regional Plan for National Energy/RUED) outlines Bali's long-term energy strategy. It aims to increase the share of RE in the local energy mix and improve energy infrastructure to support the island's sustainable development goals. It is mandatory for every province in Indonesia to develop RUED as an actionable plan to support RUEN. There are also policies that catered towards more specific field of energy transition efforts such as *Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali* (Rooftop Solar Panel Implementation Plan) and *Keputusan Gubernur Bali Nomor 879/03-M/HK/2022 Pedoman Teknis Penyelenggaraan Bangunan Gedung Hijau* (Green Building Implementation Technical Guidelines).

2.3.4. Knowledge Gap

In the research on CE in Indonesia, several knowledge gaps become evident from the academic manuscripts reviewed. Studies like those by Setiawan et al. (2014) and N. S. Wahyuni et al. (2015) focus on specific technologies such as solar water pumping systems in rural areas and emphasise community involvement and student participation as key components of project success. These studies highlight the technical and social benefits of implementing RE projects at the village level. However, broader systemic interactions and interplays between a broader set of actors/stakeholders beyond local contexts are barely discussed within the papers and other related papers.

Irfan (2016) explores alternative financing methods such as crowdfunding for RE projects, illustrating the cultural resonance of collective financing in Indonesia. This approach is innovative but remains largely descriptive. It would also be interesting to observe the systemic barriers and enablers for the widespread adoption and success of CE. Similarly, Rumbayan (2017), E. S. Wahyuni et al. (2020), and other more technology-specific papers provide insights into community readiness and resource availability but do not address the policy and infrastructural challenges that could affect long-term sustainability and replication in a more general context of RE valorisation.

The existing body of research often remains siloed, with many studies focusing narrowly on specific technologies, financing methods, or project-specific cases without fully integrating these elements into a broader socio-technical and policy context. This fragmentation leads to a limited and case-specific understanding of how individual projects can contribute to larger energy transitions. Furthermore, while some studies touch on the importance of policy support and community involvement, there is a lack of comprehensive frameworks that tie these factors with technological innovation and landscape dynamics. Addressing these gaps is crucial for developing a cohesive strategy for CE in Indonesia that aligns local initiatives with national energy goals. Here, addressing CE as a niche within the multi-level perspective and strategic niche management framework serves as a connecting bridge of different aspects and multi-actor interplays of this grassroots energy transition effort.

3 Research Methodology

SNM framework is particularly suitable for studying CE in Bali, Indonesia, due to the unique characteristics of CE initiatives and the socio-cultural context of Bali which fits the niche perspective. CE projects represent niche innovations involving decentralized and community-driven approaches. The framework serves as the overarching method to answer the research question. Supporting frameworks are used for the sub-questions as a deeper understanding of certain elements (such as stakeholders and technological best practices) is needed.

3.1. Data Collection and Analysis

Data will be acquired mainly from desk research and interviews. The desk research will include a variety of written documents such as academic publications, government regulations, state/public reports, and news resources. The interviews will cover various stakeholders with different backgrounds and merits in line with the CE sector.

3.1.1. Desk Research

The desk research conducted using academic publications, government regulations, and state/public reports is aimed towards answering specific purposes (i.e. stakeholder and regulatory hierarchy, regulations in force, etc.). News resources data extraction will be carried out in order to explore the status quo of the CE sector which is not covered in grey literature and official documents. Event Registry is an API service that allows the user to acquire data from worldwide news sources, including Indonesia. The platform has its own analytical tools available that cover semantic analysis, network clustering, sentiment analysis, and correlational analysis, among others (Leban et al., 2014). Additional work, however, needs to be done to extract useful information on news sources that are written in Indonesia due to the platform limitation.

3.1.2. Media Analysis

News coverage related to CE initiatives in Bali is acquired within the specified period of ASEAN Plan of Action for Energy Cooperation Phase II (2020-2024). EventRegistry Python API is utilized for this purpose due to its robust data analysis and categorisation tools. This tool allows for comprehensive access to a global database of news articles and events, providing extensive filtering capabilities to target specific topics and regions. The API was selected due to its features and ease of integration with Python, which facilitates the automated retrieval and analysis of news data (*EventRegistry/Event-Registry-Python*, 2015/2024).

The query was constructed to filter news articles based on keywords such as "*komunitas*" or "*masyarakat*" (community) and "*desa*" or "*kampung*" (village) and "Bali" The date range was set from January 1, 2020, to June 31, 2024, to align with the second phase of the ASEAN Plan of Action for Energy Cooperation (APAEC), providing a relevant temporal context in regard to the push of energy transition agenda within the country and region (ACE, 2016, 2021). The query also filtered for English-language articles to ensure consistency in the data analysis.

3.1.3. Interview

Interviews are conducted in semi structural manner with multiple stakeholders to gain information that are not extracted during desk research due to the unavailability of published written documents. The data collection is done through semi-structured means. A semi-structured interview is conducted using open-ended questions to probe more in-depth answers from the interviewees and at the same time explore more possibilities of candid insights and 'uncharted territories' (Adams, 2015). In this case, the aim of the interview is to collect information in the case study on the development of CE in Bali.

Respondents from multiple backgrounds and merits will be reached through e-mails and LinkedIn messages to be further interviewed through online meetings. The interviews will be transcribed using the principles of denaturalization as a balancing act between transcription accuracy and contextuality (Azevedo et al., 2017). The list of potential interviewees are listed on Table 5. The interview was held according to TU Delft's ethical regulation and guidance, as the interview process requires human subjects as respondents (Appendix B).

Table 5. List of interviewees

Interviewee	Actor type	Sector
1	Private entity (financing)	Founder of an energy cooperative
2	Local NGO	Executive (data) of a local NGO
3	Local practitioner (biomass)	Founder of a biomass CE
4	Local practitioner (solar PV)	Founder of a solar PV CE
5	Academic researcher	Associate researcher in energy
6	Local NGO	Executive (creative) of a local NGO
7	Local practitioner (micro-hydro)	Founder of a micro hydro CE
8	International NGO	Executive (engagement) of an international NGO
9	Academic researcher	Professor of a national university
10	Academic researcher	Professor of a local university
11	Government entity	Executive of a government body
12	Government-owned enterprise entity	Executive of a government-owned enterprise

3.1.4. Data Cleaning and Preprocessing

As both acquired data from desk research and interviews are in Bahasa Indonesia, the text will be cleaned and pre-processed in Bahasa Indonesia. This approach is chosen instead of the translation-first method due to the cross-cultural context of the research. The aim of this approach is to extract as much local context and collective experiences of the interviewees, thus resulting in more representative information and easier data verification (Rebecca & Noble, 2004).

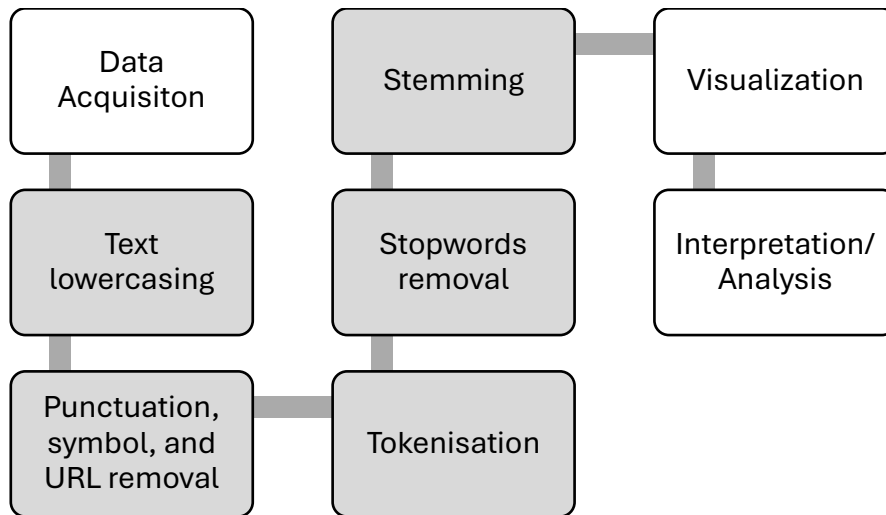


Figure 3. Text data analysis pipeline

The data is then pre-processed using a text processing pipeline: (1) lowercasing, (2) punctuation removal, (3) HTML/URL removal, (4) tokenization, (5) stop words removal, (6) normalization/stemming (Elghali, 2021; Elov et al., 2023). Text lowercasing is one of the initial steps in text preprocessing. Lowercasing all text ensures uniformity and prevents the same word in different cases from being treated as different entities by the algorithm (Hickman et al., 2022). For example, "Rumah", "rumah", and "RUMAH" (house) should all be recognized as the same word after lowercasing. punctuation marks such as commas, periods, exclamation marks, and question marks are used to structure sentences but do not carry meaning when analyzing text content. Similarly, symbols like hashtags, at-signs, and other non-alphanumeric characters often do not contribute to the semantic content of a sentence and can be removed to simplify the text (Etaawi & Naymat, 2017). URLs are typically irrelevant to text analysis, as they do not provide meaningful context related to the language or intent of the text.

Tokenisation is the process of splitting text into individual units, typically words or phrases. This step is fundamental as it converts text into a format that can be easily processed by algorithms. In Bahasa Indonesia, tokenisation needs to consider the language's structure, where some words might be compound or where prefixes and suffixes might influence meaning. Proper tokenisation ensures that words are accurately represented, instead of words without meaning or context. Stopwords removal is also significant in cleaning Bahasa Indonesia text. Stopwords are common words that do not carry substantial meaning and are often filtered out during preprocessing. In Bahasa Indonesia, words like "yang" (which), "di" (where), "dan" (and), "ini" (this), and "itu" (that) are examples of stopwords. Removing these words helps to reduce noise in the data and allows the model to focus on more informative content, which can lead to better analytical outcomes.

Stemming involves reducing words to their base or root form (Manning et al., 2009). In the context of Bahasa Indonesia, stemming is particularly important due to the language's morphological richness. Bahasa Indonesia frequently uses affixes—prefixes, suffixes, infixes, and confixes—to create different word forms that share a common root. For example, the words "bekerja" (works; prefix *-be*), "pekerjaan" (occupation; prefix *pe-*; suffix *-an*), "mengerjakan" (working; prefix *me-*; suffix *-kan*), and "dikerjakan" (worked; prefix *di-*; suffix *-kan*), all derive from the root word "kerja" (work), but each word has a different meaning depending on its affix. Stemming allows us to strip these affixes and reduce words to their root forms, which helps in normalizing the data and consolidating various word forms under a single term. This process is crucial for reducing the dimensionality of the text data, thereby improving the performance of NLP models by focusing on the core meaning of words rather than their morphological variations (Asian et al., 2005).

Stemming in Bahasa Indonesia can be complex due to the language's agglutinative nature. Traditional stemming algorithms like the Porter stemmer, which was initially developed for English, might not be sufficient for the purpose (Mustikasari et al., 2021). Therefore, specialized tools are required. Sastrawi is a Python library that implements a rule-based approach to remove affixes from words according to the specific

morphological rules of Bahasa Indonesia (Sastrawi/Sastrawi, 2014/2016). It uses a comprehensive dictionary of root words and applies a sequence of rules to strip off prefixes, suffixes, and infixes while considering potential exceptions. For example, when processing the word "mengerjakan", Sastrawi systematically removes the "me-" prefix and the "-kan" suffix to return the root word "kerja". The library is used for this research.

3.1.5. Data Analysis and Visualization

For the news data, the Eventregistry Python library already provides ample tools to gain information from. It aggregates and analyzes news articles, events, and related data from a wide variety of sources globally in a structured manner (EventRegistry/Event-Registry-Python, 2015/2024). One of the strengths of the library is its ability to conduct complex queries. For instance, users can search for articles that mention multiple entities simultaneously or filter news based on the co-occurrence of specific topics. In order to do that, the library implements a feature they called as "concepts". The "concept" feature in the library allows users to interact with and analyze the key ideas, entities, or themes present within news articles and events. A "concept" typically refers to a broad category that can include people, organisations, locations, or abstract ideas. These concepts are automatically identified and extracted from the text of news articles (Leban et al., 2014). This feature is helpful to observe certain important figures or stakeholders covered by the news regarding to CE. The more abstract concepts can be helpful to see in what context CE is being discussed in the media—whether it is in relation to the environment, economy, welfare, or other possible topics.

The more general visualization which applies to both news media data and interview data is word cloud. A word cloud is used to represent the frequency or significance of words within a given text dataset. It displays words in varying sizes, with the size of each word corresponding to its frequency or importance in the dataset: the more frequent or significant a word is, the larger and more prominently it is displayed in the cloud. This visual representation allows for a quick and intuitive understanding of the main themes or topics within a text. Word clouds are particularly useful in exploratory data analysis, where the goal is to gain an initial understanding of the data's content without delving into more complex statistical techniques. By visualizing the most frequent words, key terms and topics that dominate the text can be easily observed, which can guide further, more detailed analysis. Word cloud involves tokenizing the text into individual words, counting the frequency of each word, and then scaling the words' sizes according to these frequencies (Chandrapaul et al., 2019). This makes word clouds a versatile tool for summarizing and communicating the content of large text datasets in an accessible and visually appealing manner. Despite their simplicity and ease of use, word clouds do have limitations. The method is primarily descriptive, therefore for this context word cloud serves to also help identify the initial context for further phases of the research such as interviews.

3.2. Analytical Framework

Here the approach that will be used to explore each research question will be explained. The SNM framework serves as the overarching method to answer the research question. Supporting frameworks are used for the sub-questions as a deeper understanding of certain elements (such as stakeholders and technological best practices) are needed.

3.2.1. Niche Innovation Analysis

SNM framework will be used to investigate three important concepts in developing niche innovation, namely nurturing, shielding, and empowerment (Smith & Raven, 2012). In this case, CE serves as the niche innovation within the geographical boundary of the Bali region. Terminologies from Boon & Dieperink (2014) are integrated to specify the regime dimension within CE context in the framework. It serves to observe six aspects of the development of a CE initiative: macro developments, technological characteristics, economic

characteristics, governmental interventions, market and society, and organisational characteristics. This is meant to tackle the context of CE in Indonesia which is less developed in terms of business model as it is exclusively non-profit (and sometimes difficult to sustain due to heavy reliance towards external funding) – therefore not necessarily fitting with the conventional SNM framework that includes business model as one of its aspects of assessment (Irfan, 2016; Kamp & Vanheule, 2015).

3.2.1.1. Niche Nurturing

The nurturing process are distinguished into: articulation and shaping of expectation, social network formation, and learning process (Smith & Raven, 2012). The articulation and shaping of expectations will be assessed both from inside of the niche itself (internal) and the actors' expectations outside of the niche (external). The evaluation will be performed by interviewing the internal actors and external actors, and then investigating the power relation and interests between each other. Internal and external expectations as well as endogenous and exogenous factors will also be assessed through the interview process.

Lastly, the learning process aspects have been coined by Kamp and Vanheule (2015). Adjustments are needed to contextualize the matter with the CE development in Bali. For instance, business model is supposed to be included as part of the aspect, yet CE projects in Indonesia are generally non-profit. CE in Indonesia fits the term more as a social enterprise instead of business/corporate enterprise. Social enterprise does not mean that the initiative should devoid of any profitable activities, but align the financing side more towards sustaining its future and not personal/collective financial gain (Neessen et al., 2021). Most of CE projects in Indonesia are financed by donors and funding grants (Mohammadi, 2023). Moreover, private electricity producer cannot sell their excess to the grid regulatory-wise (Hamdi, 2019).

3.2.1.2. Niche Shielding

Both passive and active shielding can be evident in CE development. Passive shielding is relevant to analyze the development of CE as a solution for rural areas away from grid infrastructure access. Meanwhile, active shielding can be present in the form of local or national regulations that protect, incentivize, and/or encourage implementation of CE projects in the area.

3.2.1.3. Niche Empowerment

Niche empowerment might comes in a form of fit and conform and/or stretch and transform (A. Smith & Raven, 2012). The possibility of both will be explored through analysis of the regulations, policies and economic/organizational models. In fit and conform empowerment, CE might thrives in the current energy sector without changing the regime's selection pressures such as bureaucracies and social norms. A stretch and transform empowerment might be evident within the niche or spreading across multiple aspects of the regime (i.e. organizational model pivot of the CE or new enabling policies).

Table 6. Niche processes, aspects, and indicators

Niche process	Aspect	Specific indicator	Analysis
Nurturing	Network formation	Actors composition	Network analysis
		Actors alignment	Power-interest matrix
	Shaping expectation	Endogenous factors	Learning experiences and network composition within the niche
		Exogenous factors	Landscape and regime factors, the development and/or rise of other niches
		Internal expectations	Quality, robustness and specification of expectations of the current actors in the niche
		External expectations	Awareness and confidence level of actors outside the niche
	Learning process	Technical development and infrastructure	Design specifications, complementary technology and the required infrastructure needed for technology dissemination
		Industrial development	Suppliers and installers, knowledge provision/transfer
		Social and environmental impact	Social cohesion, green image, environmental awareness,
		Development of the user context	Independency from energy corporation, reliability, visibility/transparency, feedback possibilities, local oppositions
Government policy and regulatory framework		Energy policy consistence, dissatisfaction from inconsistent energy policy, incompetence of meeting environmental targets, bureaucratic procedures	
Resource potential and analysis		RE resource potential, local value/knowledge potential	
Shielding	Passive shielding	Energy prices, market entry barriers, level playing field, initial investment, payback period, division of ownership, division of benefits, local involvement	
	Active shielding	Development of CE through passive shielding	
Empowering	Fit and conform	Development of CE through active shielding	
	Stretch and conform	Competitiveness of CE in the current energy regime	
			Changes that are influenced by CE as a niche

3.2.2. Regime Analysis

The regime of energy transition in Bali will be observed using three dimensions of the regime elaborated by Bergh & Bruinsma (2008): actors network, rules, and technology. Actors' network and alignment will be assessed using network analysis and power-interest matrix, respectively (Chairahman et al., 2024; Yudha & Tjahjono, 2019). Rules and regulations will be analyzed based on the existing official regulatory documents currently enforced by the national and regional governments. The techno-economic elements of the CE concept that is applied in Bali will be observed more flexibly which not necessarily will have to include a robust business model system, but rather various financial stream based on Boon & Dieperink (2014).

3.2.3. Landscape Analysis

Conducting a landscape analysis for CE in Bali involves examining the external pressures and drivers that impact the development of this niche. The first step in this process is identifying relevant landscape factors that influence CE initiatives. These can include global trends such as international climate agreements, technological advancements in RE, and socio-economic shifts like the increasing demand for sustainable tourism.

3.2.4. Actor Analysis

The Actor Analysis within the Policy Analysis of Multi-Actor Systems (PAMAS) framework involves systematically identifying and analyzing the various stakeholders involved in community-based RE initiatives in Bali. This analysis aims to understand each actor's interests, objectives, existing situations, perceived causes of problems, and possible solutions. The methodology adopted for this Actor Analysis integrates both qualitative and quantitative approaches to capture a comprehensive view of the multi-actor landscape.

The initial step involves identifying all relevant actors involved in or affected by CE projects in Bali. For this study, the actors include the Bali Department of Energy, Perusahaan Listrik Negara (PLN), Pertamina, local NGOs, private companies, local initiatives, international NGOs, research entities, Customary Villages, the general community/people, project funders (cooperative/grant), and the hospitality/tourism industry. These actors were identified through a combination of literature review, stakeholder mapping, and consultations with local experts.

The PAMAS framework was employed to structure the actor analysis. This framework considers various dimensions including actors' interests, desired situations/objectives, existing or expected situations, perceived causes of problems, and possible solutions. The analysis was conducted in the following steps: (1) Interests and Objectives: Understanding what each actor aims to achieve. For example, while the Bali Department of Energy may prioritize sustainable energy development, private companies might focus on profitability and market growth; (2) Existing/Expected Situations: Assessing the current state or anticipated future conditions related to energy projects. This includes the current energy mix, infrastructure status, and community engagement levels; (3) Causes of Problems: Identifying factors perceived by each actor as barriers to achieving their objectives. These could range from regulatory barriers and high costs to lack of technical expertise and community resistance; (4) Possible Solutions: Exploring solutions proposed by each actor. For instance, government entities might suggest policy reforms and subsidies, while NGOs might advocate for increased community awareness and participation.

Data from interviews and surveys were coded and analyzed to identify recurring themes and patterns. This qualitative data was triangulated with quantitative survey results to ensure robustness. The analysis aimed to highlight convergences and divergences in actors' perspectives, providing a nuanced understanding of the multi-actor dynamics.

3.2.5. Geographical Boundary

The decision to focus on Bali for the development of community-based RE initiatives is driven by several compelling geographical, cultural, and economic factors. Bali, as a unique region of Indonesia, presents an ideal case for exploring the implementation of RE projects due to its distinctive grid connection, international significance, and rich cultural heritage.

Bali's electricity grid is interconnected with the Java-Bali grid, which is one of the most crucial electricity grids in Indonesia. This connection ensures a stable supply of electricity from the main island of Java, supporting Bali's energy needs. The Java-Bali grid, managed by Perusahaan Listrik Negara (PLN), is part of the larger interconnected grid system that supplies electricity to a significant portion of Indonesia's population. The interconnected nature of this grid facilitates the integration of RE sources, allowing for the balancing of supply and demand across regions. This infrastructure is crucial for accommodating the variability of RE sources such as solar and wind, making Bali a strategic location for pilot projects in RE.

Bali serves as an international hub for Indonesia, attracting millions of tourists annually. Its global recognition as a premier tourist destination brings both opportunities and challenges for energy management. The high demand for energy driven by tourism underscores the need for sustainable energy solutions to support the island's infrastructure without compromising its environmental integrity. Bali's role as an international hub also means that successful RE projects on the island can serve as high-visibility models for other regions, showcasing Indonesia's commitment to sustainable development to a global audience. This can attract international funding, partnerships, and technical expertise, further boosting the viability and scalability of RE projects on the island.

Bali is renowned for its strong cultural heritage, with deeply rooted traditions and community structures. The island's cultural uniqueness is preserved through institutions like the customary villages, which play a vital role in local governance and community decision-making. Integrating RE projects in Bali requires a culturally sensitive approach that respects and leverages these traditional structures. The involvement of local leaders and community members is essential for the acceptance and success of these projects. The strong community bonds and collective ethos in Bali provide a supportive environment for community-based initiatives, ensuring that projects are not only technically feasible but also socially sustainable.

Bali's strategic importance extends beyond its cultural and touristic appeal. The island is often seen as a gateway to Indonesia, influencing perceptions and trends across the country. By focusing on RE projects in Bali, there is an opportunity to set a precedent for sustainable energy practices that can be replicated in other parts of Indonesia. The island's visibility and influence make it an ideal location for initiating and demonstrating the benefits of RE, potentially driving broader policy changes and encouraging nationwide adoption of sustainable energy solutions.

3.3. Research Flow

Based on the previous section, a visual representation depicting the flow of the research is formulated below. As shown, each sub-question is rooted in SNM as its primary framework, with some other supporting frameworks that are necessary for the analysis.

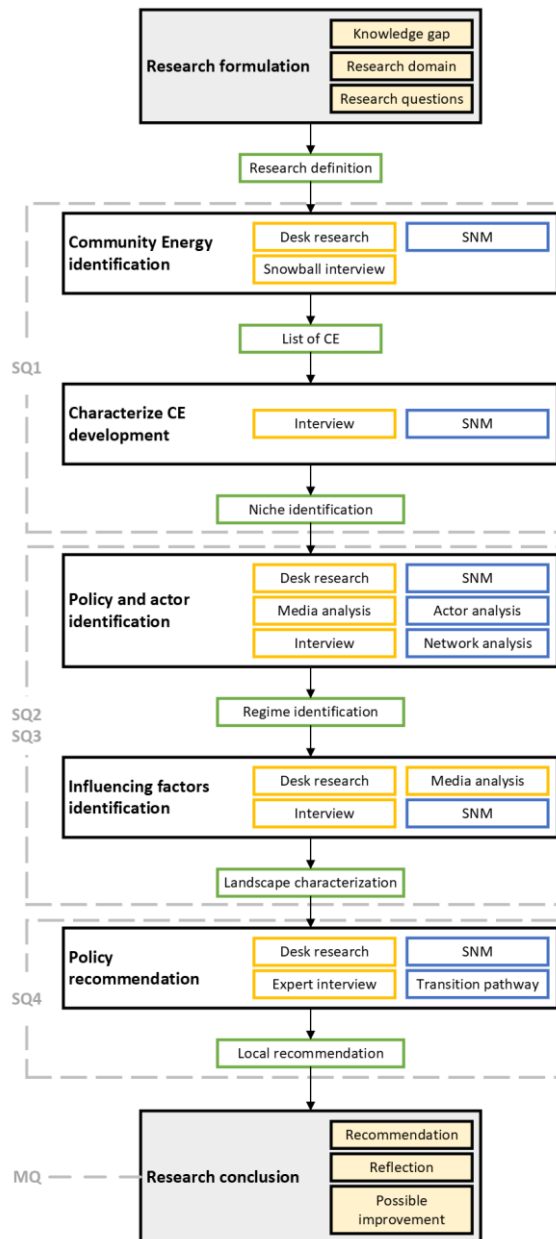


Figure 4. Research flow diagram

3.3.1. What are the CE initiatives in Bali and their current stage of development?

There isn't any available document that listed CE initiatives in Bali. PT Pertamina, a state-owned enterprise (Badan Usaha Milik Negara/BUMN) that is responsible for the upstream energy market in the country has corporate social responsibility (CSR) projects on community-based solar power plant in Keliki Village, Gianyar and Kedongan Village, Badung (CNBC Indonesia, 2023; Merdeka.com, 2022). In the biogas sector, there are at least four projects, each monitored by Bali Provincial Government, Agency of Public Works, West Bali National Park, and Yayasan Rumah Energi (YRE; Non-Governmental Organization) (Silaen et al., 2020). News articles search and snowball interviews will be the main sources to gain insight into those initiatives as well as to look for other initiatives that are less-known.

CE is perceived as niche. As such, the three niche processes—nurturing, shielding, empowerment—will be used to characterize its development. To characterize the establishment of CE, Boon and Dieperink (2014) proposed the Local RE Organization (LREO) development model. The terminologies used in the LREO model will be adapted as a foundation to formulate the interview question and answer the research sub-question under the SNM framework.

3.3.2. Which stakeholders play a role in the development of CE initiatives in Bali?

Actor analysis is implemented as a critical methodological approach for dissecting the complex dynamics in multi-actor systems. It aims to identify and understand the various stakeholders involved in the CE arena, including their interests, objectives, and the power that they wield. Different actors might influence policy outcomes and have their own roles and dynamics in potential conflicts and alliances. The identification of stakeholders will be done through a series of grey literature from national and local regulations and news resources. It ensures the consideration of diverse perspectives and influences of all stakeholders. In a situation in which the number of actors is statistically sufficient, an actor network analysis can be used to further identify the centrality of the network and look for important actors and clusters.

3.3.3. What are the factors that influence the development of CE initiatives in Bali?

As a niche, CE in Indonesia serves as a radical solution to the status quo of conventional on-grid electricity supply from PLN. In some cases, the CE initiative helps remote villages to gain their basic electricity needs. In other cases, it allows the society to gain control of their electricity consumption, therefore saving in financial expenses, among other possible reasons. Therefore, it is important to also explore the regime and landscape in which the niche itself is thriving.

Regime refers to the dominant system of rules, practices, and technologies that characterize the current state of a specific sector or area. The observed niche—in this case, the CE—is meant to challenge the regime as the status quo. A characterization is needed to determine its interaction, stability, and resistance to change in the context of the dominant technology, the established industry players, regulatory bodies, and consumer habits. Hence, there is also a need to explore the current landscape of energy transition in Bali, Indonesia. Landscape is defined as the broadest context within which both niches and regimes exist which accounts for multiple aspects such as macroeconomic trends, societal values, cultural trends, and existing regulations.

3.3.4. How can Bali and other provinces of Indonesia address the barriers and utilize the drivers of CE development to foster its growth?

The best-case scenario for CE as a niche is to mature and expand in a broader market. Exploring its transition pathway is necessary to map the route that innovations within niches can break through and replace or fundamentally alter the existing regimes in response to pressures from the landscape level (Riddell, 2015). As it stems from the community level—in which energy is co-governed and co-designed—but is bounded by external factors (such as policy and financing support schemes), transition pathways of CE in Indonesia are unique on their own and might differ from province to province (Koirala et al., 2021).

Therefore, a supporting framework of the Socio-Ecological System (SES) is required to explore how Bali compares with other provinces in Indonesia in terms of CE development. The framework is traditionally used to observe how humans interact with and depend on the natural environment, and how these interactions affect the sustainability and resilience of both systems (McGinnis & Ostrom, 2017). CE heavily interconnects with renewable sources, hence the consideration of natural potential and challenges within provinces, along with socio-cultural diversity are important. For this purpose, the data and information acquired from previous questions will be compared and analyzed in the context of preliminary data from another province in Indonesia based on desk research. South Kalimantan is going to be a comparative case study as it has a stark difference in terms of geographical and demographical situations, yet also in a stage of pursuing rapid energy transition for the near future (Setyowati, 2022). Bauwens et al. (2016) has formulated a specific use of SES in the context of energy transition by underlining four elements: (1) support mechanisms, (2) planning procedures, (3) attitudes towards the cooperative models, and (4) local energy activism.

3.4. Research Validity and Reliability

Ensuring the validity and reliability of this research on community-based RE initiatives in Bali is paramount for producing credible and actionable insights. Validity refers to the accuracy and truthfulness of the findings. To enhance validity, the study employs multiple data sources, including semi-structured interviews, surveys, and secondary data from policy documents and reports. Triangulating these data sources helps to cross-verify information and ensure that the conclusions drawn are well-supported by evidence. For instance, the integration of qualitative data from interviews with quantitative survey results allows for a more comprehensive understanding of the perspectives and behaviors of different stakeholders, reducing the risk of bias and increasing the robustness of the findings.

Reliability, on the other hand, pertains to the consistency and repeatability of the research results. To ensure reliability, the study follows standardized procedures for data collection and analysis. For example, the use of established tools such as the EventRegistry Python API for news data extraction ensures that the methods can be replicated by other researchers. Additionally, detailed documentation of the research process, including the coding scheme for thematic analysis and the parameters used in the sentiment and topic modeling algorithms, enhances the transparency and reproducibility of the study (Appendix C-F). This systematic approach helps to ensure that the findings are not influenced by random errors or researcher biases.

Moreover, the involvement of multiple stakeholders in the data collection process, such as local NGOs, government agencies, and community representatives, contributes to the external validity of the study. By capturing a wide range of perspectives, the research findings are more likely to be generalizable to other similar contexts. Regular feedback loops with stakeholders during the research process also help to validate the findings and ensure that they accurately reflect the realities on the ground. This collaborative approach not only strengthens the credibility of the research but also ensures that the recommendations derived from the study are practical and grounded in the local context.

4 Overview of CE in Bali

Indonesia is currently at a crossroads in its energy transition ambition. On one hand, the country's economic growth leads to ever-increasing energy demand. In 2020, electricity consumption in Indonesia reached 242 TWh and is expected to be multiplied five-fold by 2050 (IRENA, 2022). Skyrocketing gas prices amidst the global energy crisis and unbalanced coal export and supply, among others, are hurting the country's energy security (IESR, 2022).

On the other hand, complying with the Nationally Determined Contribution (NDC), Indonesia is in urgent need to push the RE mix to a minimum of 23% by 2030 and 31% by 2050 (Government of Indonesia, 2022). As of now, Indonesia is still highly dependent on fossil fuels with only 10.4% shares of renewables (IESR, 2022). Indonesia has a huge potential in RE sources (approximately 3,643 GW for power plants), yet only 0.3% is already utilized (National Energy Council, 2022).

4.1. Historical Context

Bali has always been touted as the pioneer of region-wide RE development. The region was the first province to declare a plan to fully commit in transitioning to clean energy marked by the signing of a memorandum of understanding (MoU) between the Indonesian Ministry of Energy and Natural Resources with the Asian Development Bank (ADB) in 2015 (Gunawan, 2015). The Government of Bali was also the first to formulate and enact RUED in 2020. It was even preceded by the governor-initiated Bali Clean Energy policy in 2019 (Dinata, 2020).

However, the establishment of early CE in Bali can be traced further back to the 1960s in Banyuwatis, Buleleng, in the form of a village-led micro-hydro power plant according to I Putu Budiana, former head of Bali Energy and Mineral Resource Department (Fajar, 2017). The culture of Balinese has always been tightly knitted with the management of water resources. *Subak* is a complex water irrigation system for agricultural purposes that has been practised as a form of Indigenous knowledge in Bali. The earliest evidence of *subak* practice can be traced back to 800 AD from the year 800 of the ancient Saka calendar (Gany, 2001). It is necessary for every activity that requires the use of water resources in Bali to consult and ask for permission from the local organisation that manages the subak system. Nowadays, every hydropower initiative needs to be approved by the local subak organisation where the project is stationed (Interviewee 7).

Biomass, in its most fundamental definition as the act of using energy from organic materials, has been not only a part of Balinese people's daily lives but also integrated into their cultural ceremony since a long time ago (Mohammed Salih, 2021; Interviewee 5). During the annual Nyepi Holiday, Balinese Hindus perform a series of rituals spanning several days. In some parts of Bali, one of the mandatory rituals is "*Nyakan Diwang*", where people gather to cook together outside of their homes using traditional cooking methods involving firewood (Widarini, 2016). A pivotal momentum that actually kickstarted biomass CE started in 2009 when the Governor of Bali introduced SIMANTRI. The program provided incentives for farmers to integrate biodigester systems into their farm (Bößner et al., 2019). The program was considered a success as it was able to reach the target of 1000 recipients by 2018 and introduce circular farming to the region (Sudita et al., 2018). In the context of biomass-based CE in Bali, circular farming is considered the most important driver considering its financial benefits (Interviewee 2; Interviewee 5).

The adoption of solar PV technology by the local people of Bali started in the early 2000s, when an architect and local champion, I Gusti Agung Putradhyana, began his active campaign to promote the technology for personal/community use (Saturi, 2014). He advocates the use of solar PV technology for personal and community purposes, therefore starting the mushrooming adaptation of solar PV in the private and household sectors (Interviewee 1). Bali later became the first province to regulate region-wide solar

rooftop implementation, particularly on legal permission that has been a major hindrance in other provinces (Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021; Interviewee 12). Since then, at least six local private businesses are operating in solar PV provision, installation, and financing (Udayana & Kumara, 2020).

Established in 2005, Amoghasiddhi Cooperative in Bali became the first energy cooperative in Bali. Its members comprise individuals and business entities that are integrating solar PV technology into their homes or offices (Interviewee 1). Amoghasiddhi provides an energy credit program as a financing option to afford initial investment in solar PV. The establishment of Amoghasiddhi was later followed by other energy financing cooperatives such as Kopetindo and Program BIRU in other parts of the nation, as well as became an exemplary alternative financing scheme for CE projects in Bali—among other more conventional schemes such as CSR, open grants, crowdfunding, and philanthropy (Adhinegara et al., 2024).

4.2. Sociotechnical Landscape

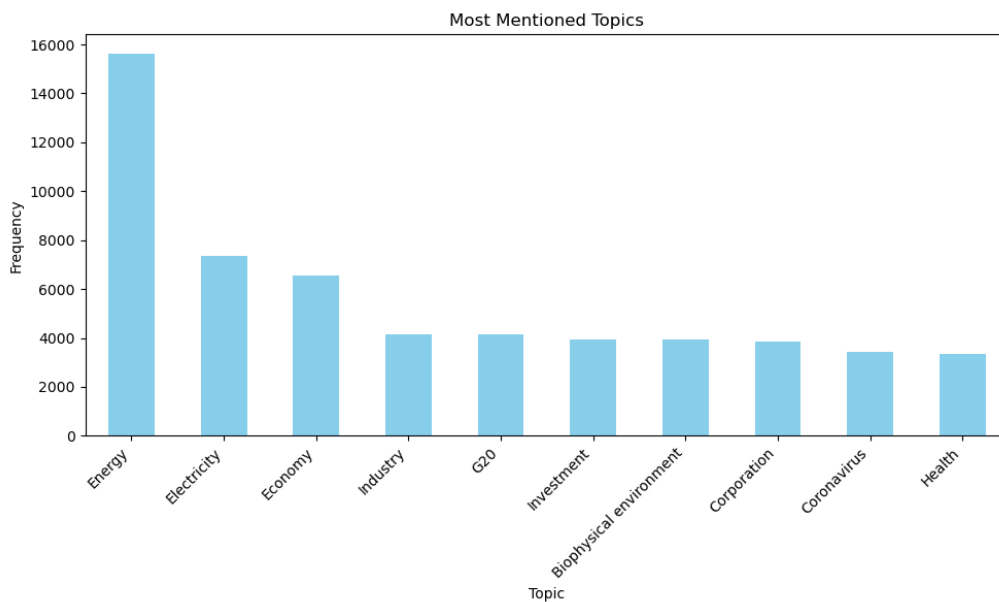


Figure 5. Most mentioned topics related to CE in news articles

Based on the media analysis in Figure 5, CE is predominantly discussed within the bigger topics of energy, electricity, and economy. This shows how energy (electricity in particular) as a primary need is still a major discussion in Bali, as can be seen in a few samples of data in Table 7. There is also a dominant discussion on the G20 event, which was one of the biggest events held in Bali in 2022 and tightly connected to the issue of energy transition (Guzman, 2022). Environmental concern is right in between the topics of investment and corporation, which might suggest a larger general interest towards pragmatic aspects of the energy industry. There are also some articles related to COVID-19 and health issues considering Bali is one of the most impacted provinces in Indonesia by the pandemic – including in the context of energy (Harianja, 2020; Interviewee 1).

“Initially, there was a lot of interest in solar PV adoption. It ended because of the pandemic. Not only suffered from zero demand, we also had to deal with our current partners’ default on solar PV debt.” (Interviewee 1)

Table 7. News samples based on topics

No	Title	News Source	Topic
1	Reflection on the Clean Energy Project Failures in Bali (Suriyani, 2020)	Mongabay.co.id	energy, biophysical environment, investment
2	Jokowi Enthusiastic about COP26, but Why are Solar Power Plants Left Abandoned? (Prabowo, 2021)	Tirto.id	energy, investment
3	Titab Mini-hydro Power Plant is Pioneering Mini-hydro Electricity Generation in Bali (H. N. Saputra, 2022)	Bisnis.com	energy, electricity
4	Community in Badung, Bali Utilizes Solar Power Plant to Process Waste (Anggita, 2023)	Detik.com	energy, electricity
5	Pertamina Partners with Miss Indonesia Bali 2024 to Introduce Keliki Energy (Wiguna, 2024)	Antaraneews.com	energy, industry, corporation

Bali is at the forefront of Indonesia's energy transition framework, leveraging its unique socio-technical systems to drive a sustainable energy transition (Interviewee 8). Whether top-down or bottom-up efforts, there are already evidences of effort to optimize local RE sources through community-based management practices. These systems align with the island's cultural and social structures, particularly the customary villages, which play a crucial role in their establishment and operation. Customary villages, with their deep-rooted communal traditions, provide a robust framework for collective energy initiatives, fostering local ownership, social cohesion, and sustainable resource management through cultural means.

Bali has committed to ambitious energy and environmental targets, including the Bali Low Emission Zone (LEZ) and the 2045 net-zero emissions goal. The LEZ aims to reduce greenhouse gas emissions significantly by promoting clean energy and reducing reliance on fossil fuels within designated areas (Rizki et al., 2021). This initiative complements Bali's broader energy strategy, which emphasizes the integration of RE sources like solar and wind. The provincial government is actively supporting these efforts through policies and incentives that encourage the development and adoption of CE projects. These projects not only help in achieving the LEZ goals but also contribute to the provincial target of reaching net-zero emissions by 2045 (IESR, 2021; Interviewee 2, Interviewee 8).

Local governance structures, particularly the customary villages, are instrumental in the success of CE projects in Bali. These customary villages have historically managed communal resources and social affairs, making them well-suited to oversee local energy initiatives. By integrating modern RE technologies within these traditional governance frameworks, Bali is able to enhance community engagement and ensure the sustainable management of energy resources. The collaboration between local communities, and customary village leaders is pivotal in driving Bali's energy transition, setting a model for decentralized and community-driven RE development (Interviewee 3, Interviewee 7).

Financing CE projects in Bali involves a combination of local, national, and international funding sources (Interviewee 2). Local financing often comes from the communities themselves, particularly through the customary villages, which can pool resources and investments from residents (Interviewee 7). National support includes grants and subsidies from the Indonesian government, particularly through the Ministry of Energy and Mineral Resources, which provides incentives for RE projects (Interviewee 1, Interviewee 4). Internationally, NGOs contribute by offering technical assistance and funding for sustainable energy initiatives (Interviewee 2, Interviewee 8). Additionally, private investors and green financing mechanisms, such as cooperative-based energy credits, play a significant role in mobilizing capital for these projects (Interviewee 1). Albeit the number of opportunities, it is still considerably difficult to sustain a CE initiative financially due to the uncompetitive nature of RE electricity generation in Indonesia (Interviewee 5).

4.2.1. Religion and Indigenous Wisdom

The integration of indigenous knowledge and religious values in Bali fosters a deep connection between humans and nature, underpinning sustainable lifestyles and communal living. This holistic approach is pivotal in the development of CE projects, as it aligns with the cultural ethos and environmental practices prevalent on the island. Indigenous knowledge in Bali encompasses traditional ecological wisdom passed down through generations. This knowledge includes sustainable agricultural practices, water management systems, and natural resource conservation techniques. For instance, the subak system, a traditional method of cooperative water management for rice cultivation, exemplifies how Balinese communities have long practiced sustainability. This system is based on a communal approach to water distribution, ensuring equitable access and maintaining ecological balance.

The subak system, recognized by UNESCO as a World Heritage site, highlights the effectiveness of indigenous practices in resource management (UNESCO World Heritage Centre, 2012). It demonstrates how community-led management of natural resources can lead to sustainable outcomes, providing a model for CE projects that require communal participation and stewardship. The principles underlying subak can be adapted to manage RE resources, promoting a community-based approach to energy production and consumption. Sustainable living and communal practices are intrinsic to Balinese culture. Villages are organized around communal principles, with decisions made collectively and resources managed for the common good. This communal ethos extends to environmental stewardship, where community members collectively manage agricultural land, water resources, and forests (Zen et al., 2024).

Hinduism in Bali, deeply rooted in local culture, promotes values that emphasize the interconnectedness of all life forms and the sanctity of the natural world. This worldview fosters a sense of responsibility towards maintaining ecological balance and respecting the environment. Rituals and ceremonies are integral to Balinese Hinduism, often centered around natural elements like sun and water, reinforcing the sacred relationship between humans and nature (Interviewee 4). The concept that actions have consequences encourages environmentally responsible behavior. Balinese are motivated to engage in sustainable practices to avoid negative repercussions for themselves and future generations. This spiritual and ethical framework supports the adoption of RE technologies, as it aligns with the moral imperative to protect and preserve the environment.

The communal lifestyle in Bali fosters strong social cohesion and mutual support, which are critical for the success of CE projects. CE initiatives require collective action and shared responsibility, making Bali's social structure highly conducive to such projects. The tradition of *gotong royong* (mutual cooperation) exemplifies how Balinese communities work together to achieve common goals, a principle that can be harnessed to develop and maintain CE systems (Harsamto, 2022). For example, the cooperative nature of the *subak* system has been mirrored in the management of communal solar or micro-hydro power systems. Community members can collectively invest in and manage these systems, ensuring equitable access to clean energy and sharing the benefits (Interviewee 7).

Educational initiatives that integrate traditional knowledge with modern RE technologies can empower local communities to take ownership of CE projects. Workshops and training sessions can be designed to teach community members about RE, drawing parallels with traditional practices to facilitate understanding and acceptance (Interviewee 3). Furthermore, the ethical and spiritual dimensions can be leveraged to promote the adoption of RE (Interviewee 4). Religious leaders and ceremonies can play a role in advocating for environmental stewardship and the use of clean energy, reinforcing the cultural and moral imperatives for sustainability (J. Smith, 2018).

4.2.2. Climate Change and Sustainability Issue

Climate change and sustainability have emerged as critical issues facing the world today. The evidence of climate change is unequivocal, with significant impacts already being observed globally. The primary driver of climate change is the increase in greenhouse gases (GHGs) in the atmosphere, particularly carbon dioxide (CO₂) from burning fossil fuels, deforestation, and various industrial processes. According to the IPCC, CO₂ levels have risen by more than 40% since pre-industrial times, primarily due to human activities. The enhanced greenhouse effect resulting from these increased GHGs is the main cause of global warming and the associated climate disruptions.

Addressing climate change requires a multi-faceted approach involving mitigation and adaptation strategies. Mitigation efforts focus on reducing GHG emissions through transitioning to RE sources, enhancing energy efficiency, and implementing sustainable land use practices. RE technologies such as solar, wind, hydro, and geothermal play a critical role in reducing reliance on fossil fuels and decreasing carbon emissions. Adaptation strategies are essential to cope with the changes that are already happening and those that are inevitable. These strategies involve modifying infrastructure, adopting new agricultural practices, managing water resources efficiently, and enhancing disaster preparedness and response. Effective adaptation requires integrating climate risks into planning and decision-making processes at all levels, from local to global.

Sustainability is intrinsically linked to climate change mitigation and adaptation. It encompasses the idea of meeting present needs without compromising the ability of future generations to meet their own. Sustainable development focuses on balancing economic growth, social inclusion, and environmental protection. The Stern Review on the Economics of Climate Change highlighted that the costs of inaction far exceed the costs of taking proactive measures to combat climate change. Investing in sustainable infrastructure, RE, and climate resilience can create jobs, stimulate economic growth, and reduce the long-term economic risks associated with climate change impacts. However, achieving these goals is challenging due to political, social, and economic barriers. There is often resistance to change from established industries and political entities, as well as a lack of awareness and understanding among the general public. Additionally, the upfront costs of transitioning to sustainable practices can be a significant barrier, especially for developing countries that may lack the necessary financial resources and technological capabilities.

The urgency of addressing climate change has driven a concerted effort to transition away from fossil fuels and towards RE sources. The Intergovernmental Panel on Climate Change (IPCC) has highlighted the need for rapid and far-reaching transitions in energy, land, urban, and industrial systems to limit global warming to 1.5°C above pre-industrial levels. This global push has led to the development of international frameworks such as the Paris Agreement, which commits countries to reduce their greenhouse gas emissions and increase the share of renewables in their energy mix. Regionally, different areas face unique challenges and opportunities in their energy transitions. In Southeast Asia, for instance, the Association of Southeast Asian Nations (ASEAN) has recognized the importance of RE in achieving energy security and reducing emissions. The ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 aims to increase the share of renewables in the region's energy mix to 23% by 2025 (ASEAN Centre for Energy, 2017). This regional framework supports CE initiatives by providing.

Nationally, Indonesia has made significant strides towards integrating RE into its energy system. The country's National Energy Policy (KEN) targets 23% of its primary energy mix to come from renewable sources by 2025. In the context of Bali, the island's unique cultural and environmental landscape plays a crucial role in shaping its approach to CE development. Bali's heavy reliance on tourism makes it particularly vulnerable to the impacts of climate change, such as rising sea levels and extreme weather events. This vulnerability has spurred local efforts to adopt more sustainable practices, including the promotion of RE. Bali's Provincial Regulation No. 45/2019 on Clean Energy aims to reduce the island's carbon footprint by promoting the use of RE sources and enhancing energy efficiency. The sociotechnical landscape of CE in Bali is also influenced by the island's participation in global and regional sustainability initiatives. Hosting

international climate and sustainability conferences has positioned Bali as a leader in environmental stewardship, attracting global attention and resources to support local CE projects. These events facilitate knowledge exchange, foster international partnerships, and secure funding for RE initiatives.

4.2.3. International Pressure

The international community has increasingly exerted influence and pressure on Bali to transition towards sustainable energy practices, driven by global climate commitments and the island's unique status as a major tourist destination with significant environmental impacts. The Paris Agreement, which aims to limit global temperature rise to well below 2°C above pre-industrial levels, has galvanized countries worldwide, including Indonesia, to commit to reducing greenhouse gas emissions (Government of Indonesia, 2022). As part of Indonesia, Bali is subject to these national commitments, which involve a substantial shift towards RE sources and sustainable practices (Dewi, 2022).

International pressure also comes from global environmental organizations and development agencies that emphasize the importance of sustainable tourism. Bali's role in hosting international sustainability and climate change conferences has heightened its visibility and accountability in the global arena. Events like the UN Climate Change Conference (COP13) held in Bali in 2007 and G20 Meeting in 2022 brought significant international attention to the island's environmental policies and practices (*Bali Declaration the Alliance for Industry Decarbonization*, 2022; Christoff, 2008). Such high-profile events place Bali under the scrutiny of international observers, compelling local authorities to demonstrate progress in their energy transition efforts and commitment to sustainability goals.

CE projects, which involve local communities in the production and management of RE, align well with the principles of sustainability and decentralised energy systems promoted by international agencies. These initiatives not only contribute to reducing greenhouse gas emissions but also empower local communities and enhance energy security. The international focus on sustainable development and climate resilience provides both financial and technical support for CE projects in Bali, helping to overcome barriers such as funding shortages and lack of technical expertise.

4.2.4. Bali Electrification Rate

Bali has a 100% electrification rate, ensuring that all households on the island have access to electricity (BPS-Statistics Indonesia, 2023a). This milestone is a significant indicator of the island's development and commitment to improving the quality of life for its residents. The high electrification rate has been made possible by the State Electricity Company. A critical component of Bali's electricity infrastructure is its connection to the Java-Bali grid. This grid interconnection links Bali with Java, Indonesia's most populous island and a major economic hub, allowing for the efficient distribution of electricity across the regions. The Java-Bali grid ensures a stable and reliable power supply by balancing the generation and demand across both islands. This interconnected system supports the growing energy needs of Bali's tourism and residential sectors. The Java-Bali grid connection is facilitated by several undersea cables that transmit electricity between the islands (Tambunan et al., 2020).

However, the integration of Bali into the Java-Bali grid poses substantial challenges for the adoption of RE sources. One of the primary issues is the availability of cheap, subsidized electricity from the grid, which can undermine the economic viability of local RE projects. The subsidized rates make it difficult for RE sources, such as solar and wind power, to compete with the lower costs of grid electricity. This situation can discourage investment in RE infrastructure and slow the transition to a more sustainable energy system. Moreover, the dependency on the Java-Bali grid can create complacency regarding the urgency of developing local RE capacities. Since the grid provides a reliable and constant supply of electricity, there is less immediate pressure to invest in renewable alternatives. This reliance on fossil-fuel-based grid electricity

conflicts with Bali's long-term sustainability goals and its commitment to reducing greenhouse gas emissions (International Energy Agency, 2022b).

4.2.5. Tourism Sector Growth

Bali's tourism sector has experienced significant growth over the past few decades, transforming the island into one of the most popular tourist destinations globally. This rapid expansion has had profound implications for the local economy, infrastructure, and environment, particularly in terms of energy demand. The island's ability to attract a large number of tourists is a major economic boon, contributing significantly to local GDP and providing employment opportunities across various sectors, including hospitality, transportation, and retail. The surge in tourist numbers has led to a corresponding increase in energy demand. Hotels, resorts, restaurants, and other tourism-related businesses consume large amounts of electricity for lighting, air conditioning, heating, and other amenities to cater to the needs of visitors. The energy consumption of the hospitality sector in tourist hotspots like Bali can be significantly higher compared to other areas due to the intensive use of energy-dependent services.

The reliance on the Java-Bali PLN grid for electricity supply presents both opportunities and challenges for managing this increased energy demand. While the grid connection ensures a stable electricity supply, it predominantly relies on fossil fuels, which are not sustainable in the long term. The availability of cheap, subsidized electricity from the grid can also deter investments in RE sources, making it challenging to transition towards a more sustainable energy system.

4.2.6. COVID-19 and Post-pandemic Recovery

The COVID-19 pandemic had a profound impact on Bali's economy and energy situation, creating both challenges and opportunities for CE initiatives. Bali's economy, heavily reliant on tourism, experienced a significant downturn due to global travel restrictions and lockdown measures. The drastic reduction in tourist arrivals led to widespread job losses and business closures, severely affecting the livelihoods of many residents. The economic contraction underscored the vulnerability of Bali's tourism-dependent economy and highlighted the urgent need for diversification and resilience (Subadra & Hughes, 2021). The pandemic-induced economic crisis also had implications for the island's energy consumption. With the decline in tourism, overall energy demand decreased as hotels, resorts, restaurants, and other tourism-related facilities scaled back operations or temporarily shut down. This reduction in energy demand provided a unique opportunity to reassess Bali's energy strategy and prioritize the integration of RE sources to enhance sustainability and resilience (Hartono et al., 2021; Utama et al., 2023).

The economic strain caused by the pandemic has also posed challenges for CE development. Funding for RE projects has become more competitive, with limited financial resources available for new initiatives. The reliance on subsidies and external funding has highlighted the need for sustainable financial models that can support the long-term viability of CE projects. Policymakers are encouraged to create incentives and support mechanisms that facilitate investment in RE, even in times of economic uncertainty. The pandemic has underscored the importance of building resilient energy systems that can withstand external shocks. The disruptions caused by COVID-19 have demonstrated the need for decentralized energy solutions that are less vulnerable to global supply chain interruptions.

4.3. Technological Map and Resource Potential

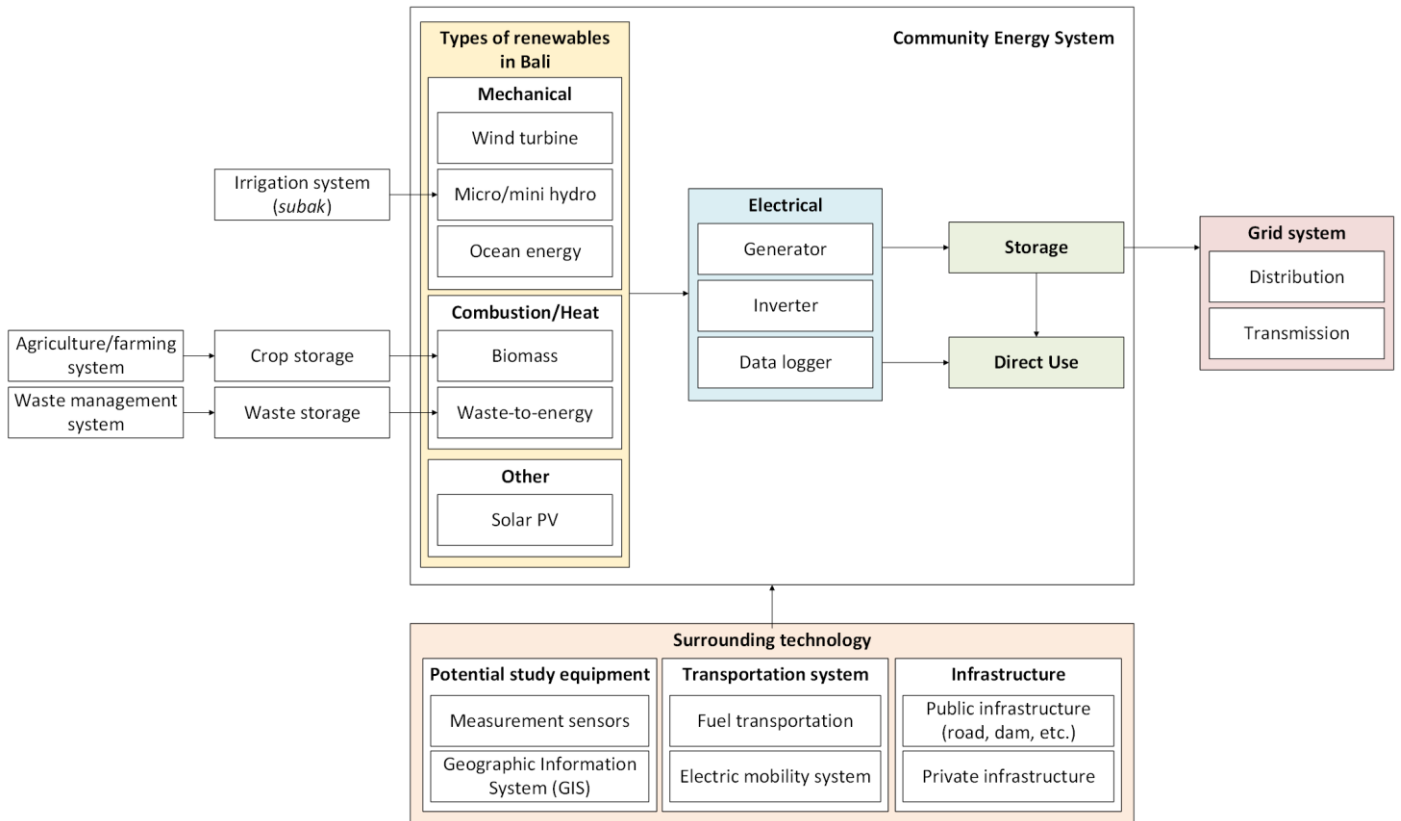


Figure 6. Technological Map of Bali CE system

CE refers more to the collectively owned and/or managed RE project of any kind (IRENA, 2018). Therefore, this technological map comprises a broad range of RE forms. In order to make the analysis concise and focused within the context of CE in Bali, a more general explanation of each RE form implemented in Bali is provided. There are also a brief explanation on Bali on-grid distribution and transmission which are provided by PLN within its Java-Bali network.

4.3.1. Wind Energy

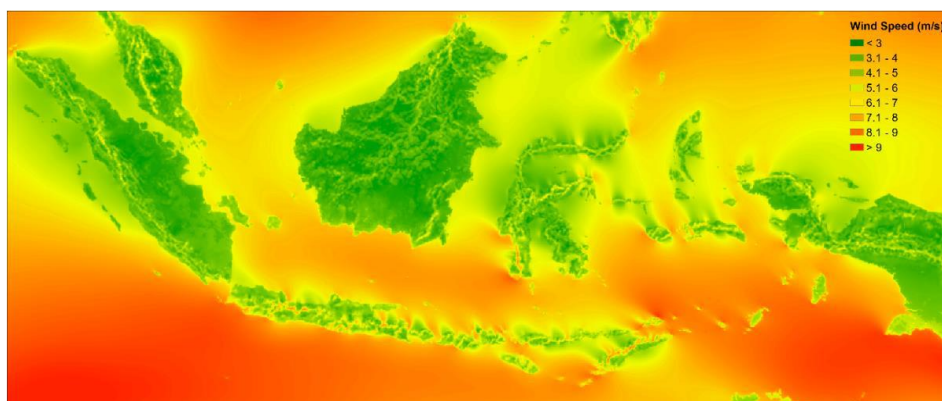


Figure 7. Technical potential of wind energy in Indonesia at 50 m height (Hesty et al., 2021)

Indonesia has a very long coastline of more than 81,000 km thanks to its archipelagic geographical condition that consists of more than 17,000 islands (Martosaputro & Murti, 2014). Despite the number, the country is lacking in wind energy potential with only a recorded mean wind speed of 3-6 m/s over the year. This is due to the archipelago spanning across the equator with warm air temperatures and low air pressure (Hidayat, 2022). The limited potential is reflected in the low number of installed wind turbine capacity in Indonesia which amounts to a mere 154 MW (IRENA, 2022).



Figure 8. Abandoned wind and solar farm site in Puncak Mundi Village, Bali (Suriyani, 2020)

In the context of Bali, the island is home to 1,019 MW cumulative wind energy potential (Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020). However, the technical potential is much lower with only 71.5 MW at 50 m hub height and 20.9 MW at 100 m hub height (Hidayat, 2022). Prior to the UNFCCC Bali Climate Change Conference in 2007, Indonesia launched a wind farm comprised of nine wind turbines with a planned capacity of 855 kW (6×80 kW and 3×85 kW). The site is located in Puncak Mundi Village, Nusa Penida, at the highest point of the region (Kementerian Energi dan Sumber Daya Mineral, 2007). It took less than two years until the project was completely abandoned (Suriyani, 2020). In 2022, Pertamina and Pondera Development BV signed a joint agreement to develop an offshore wind farm and green hydrogen production site in Nusa Dua, Bali (Putri, 2022). In 2024, another wind farm plan is announced by PLN for the island of Nusa Penida (Resources Asia, 2024).

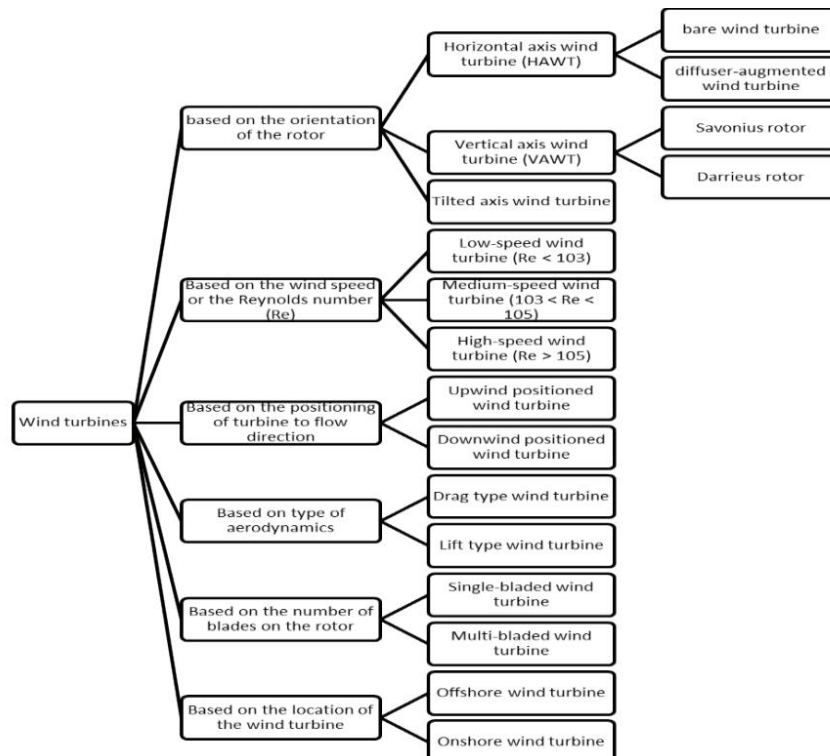


Figure 9. Wind turbine classification (Hidayat, 2022)

Wind turbines, in general, can be categorized as horizontal-axis wind turbines (HAWT) and vertical-axis wind turbines (VAWT). VAWT is considered more suitable in locations with low wind speed, although small-

scale HAWT has been proven to be functional as well (Purba et al., 2024). Other adjustments that can be made in a wind turbine to achieve optimal performance in a low wind speed condition other than rotor orientation include blade design choice, use of a low-actuation generator, and use of furling tail system (Alwanahda, 2022).

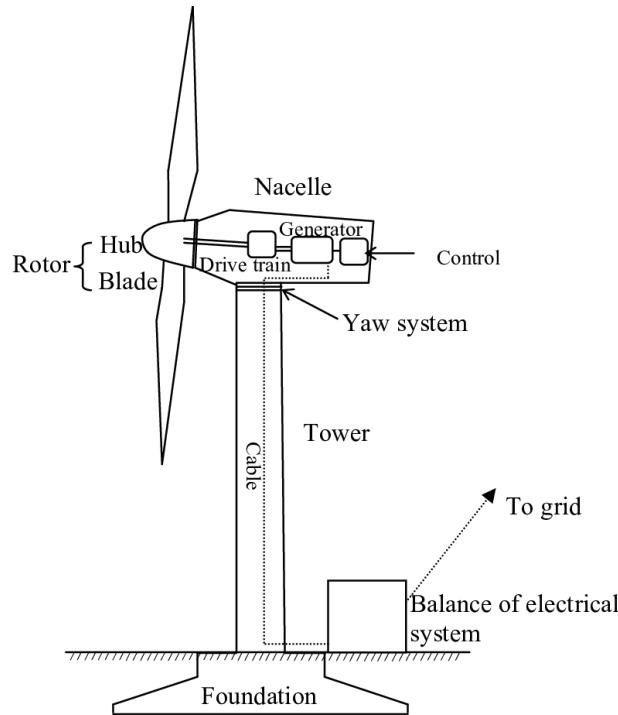


Figure 10. Components of a wind turbine (Albadi, 2010)

4.3.2. Hydropower Energy

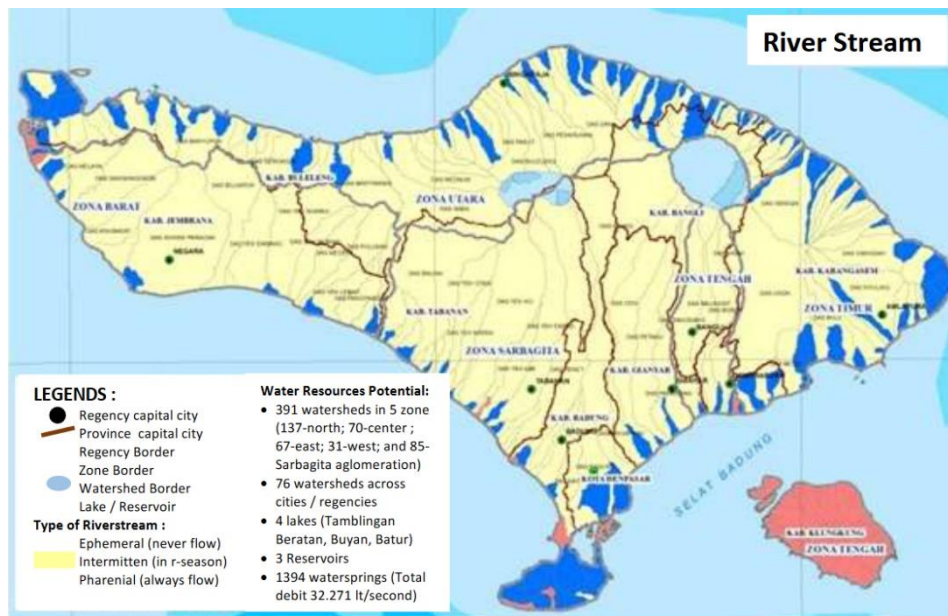


Figure 11. Water stream & Water resources potential in Bali (Green Building Council Indonesia, Bali & Setiawan, 2020)

Unlike wind energy, Indonesia has a plentiful water resource potential thanks to numerous river streams. From a total of 95 GW hydropower potential, Indonesia has a chance to utilize around 34 GW of its technical potential to generate electricity. Hydropower becomes one of the most prominent RE sources in Indonesia alongside geothermal energy with a total installed capacity of 6.6 GW (Ardiansyah, 2022; National Energy Council, 2022). In the CE context, the true potential of hydropower plants lies in the possibility of developing a smaller-scale system. Small hydropower plant (SHP) is a category assigned to hydropower

plants with a capacity of 10 MW and lower (IEA-ETSAP, 2005). Within the SHP categorization, Indonesia has 12,800 MW of potential capacity and already installed 403 MW (Liu et al., 2019a).

In Bali, there are at least two operational SHPs that kickstarted hydropower development in Bali: (1) 25 kW grid-connected plant in Karangasem and (2) 20 kW off-grid plant in Buleleng (Kumara et al., 2014). Muara Panji micro hydropower plant in Sambangan Village, Buleleng with a capacity of 2.3 MW was later launched in 2016 (Dzulfiqar, 2023). Recently-finished Titab micro hydropower plant has a capacity of 1.4 MW and located in Buleleng (Kusuma, 2024). One successful CE hydropower project is a 13 kW turbulent SHP to power the Green School on the riverside of Ayung River, Bali (Liu et al., 2019b).

Although might be varied in shapes and design, the basic components of a hydropower plant include a dam, reservoir, intake, penstock, turbine, generator, and outflow. Water stored in the reservoir behind the dam is released through the intake, where it flows into the penstock, a large pipe that directs the water to the turbine. The force of the water spins the turbine's blades, converting the water's kinetic energy into mechanical energy. The turbine is connected to a generator, which converts this mechanical energy into electrical energy through electromagnetic induction (Kundu et al., 2022).

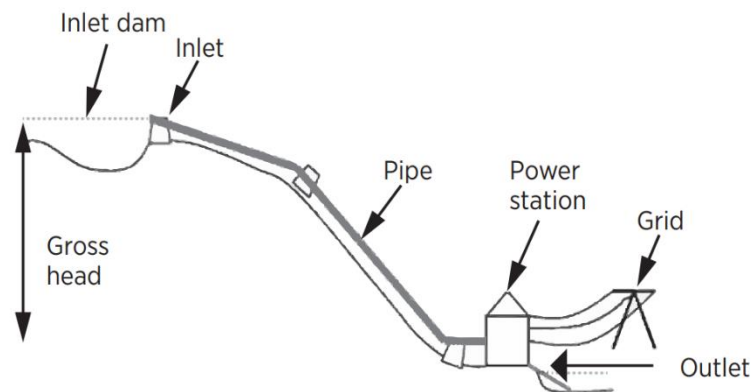


Figure 12. General schematic of a hydropower plant (IEA-ETSAP, 2005)

4.3.3. Ocean Energy

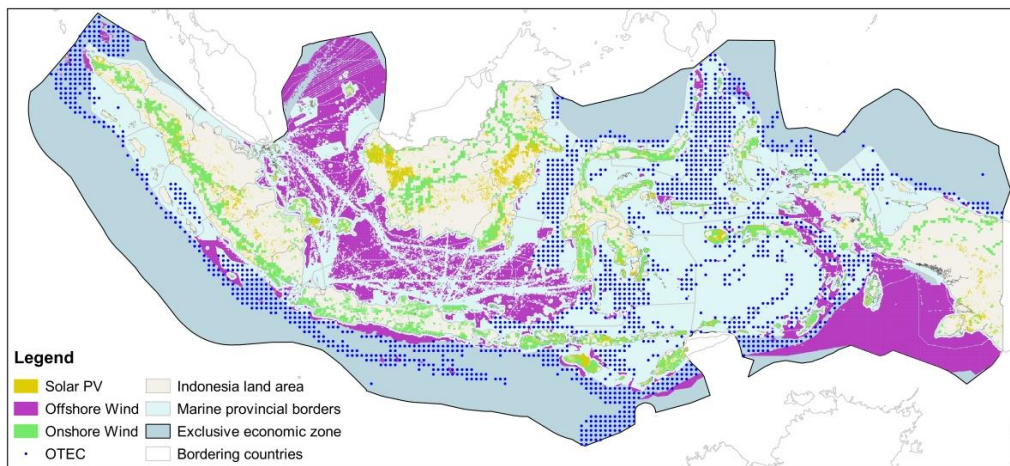


Figure 13. Map of ocean energy potential in Indonesia (Langer, 2023)

As an archipelagic country, it is no surprise that Indonesia has a plentiful untapped potential in ocean energy. Theoretically, Indonesia has a total ocean energy potential of 288 GW, with a technical potential of 18-72 GW (Adiputra et al., 2023). However, due to its nature of operating on a generally untouched area of nature in the middle of an ocean water body, the potential assessment and technical implementation of ocean energy has to consider limitations such as marine habitat, blue carbon habitat (mangrove) and protected area (Anggraini & Santoso, 2023). Bali Strait is one of the most researched part of Indonesia in terms of ocean energy potential, particularly wave, tidal, and current energy (Purba et al., 2024).



Figure 14. Map of potential wave energy sites in Indonesia (Adiputra et al., 2023)

A wave energy plant harnesses the energy from ocean waves to generate electricity. The primary components include wave energy converters (WECs), power take-off systems, electrical generators, and transmission systems. WECs are devices that capture and convert the kinetic and potential energy of waves into mechanical energy. These devices come in various forms, such as point absorbers, attenuators, oscillating water columns, and overtopping devices, each utilizing different methods to harness wave energy. The captured mechanical energy is then transferred to the power take-off system, which converts it into rotational energy suitable for driving an electrical generator (Weber, 2018).



Figure 15. Map of potential tidal energy sites in Indonesia (Adiputra et al., 2023)

A tidal energy plant converts the energy from tidal movements into electrical power, utilizing the predictable rise and fall of ocean tides. The primary components of a tidal energy plant include tidal turbines, barrages or tidal fences, sluice gates, and generators. Tidal turbines operate similarly to underwater wind turbines, capturing kinetic energy from tidal currents. These turbines are often installed in tidal streams where water flows swiftly during tidal changes. Barrages or tidal fences, on the other hand, are constructed across tidal estuaries or bays, trapping water during high tides and releasing it during low tides. The sluice gates in these structures control the flow of water to the turbines. As the tides ebb and flow, the movement of water spins the turbine blades, which are then transferred to the generators (Topper & Bryden, 2007).

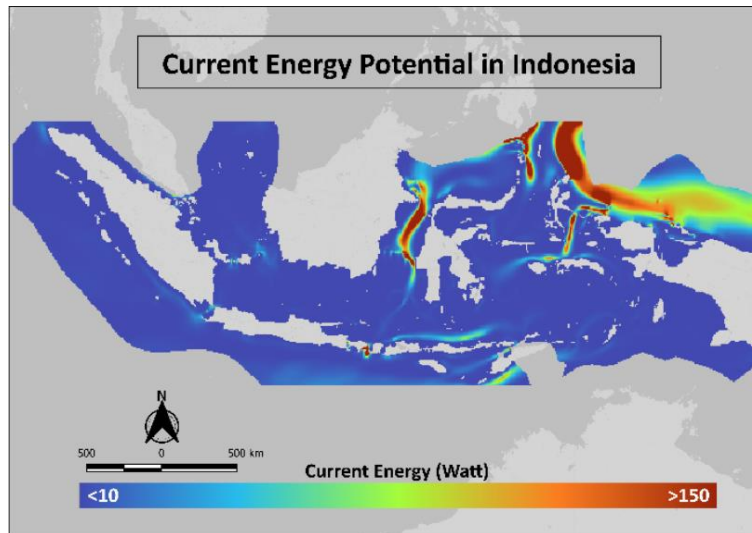


Figure 16. Map of potential tidal energy sites in Indonesia (Anggraini & Santoso, 2023)

An ocean current energy plant harnesses the kinetic energy from ocean currents. The primary components include underwater turbines, mooring systems, power take-off systems, generators, and transmission cables. Underwater turbines are placed in locations with strong, consistent ocean currents. These turbines function similarly to wind turbines, but they are designed to operate underwater, capturing the steady flow of ocean currents to spin their blades. The turbines are connected to the seabed using mooring systems that ensure stability and optimal positioning in the current flow. The rotating blades of the turbines transfer mechanical energy to the power take-off system, which converts it into rotational energy suitable for driving an electrical generator (Nugraha & Rijanto, 2012).

4.3.4. Biomass Energy

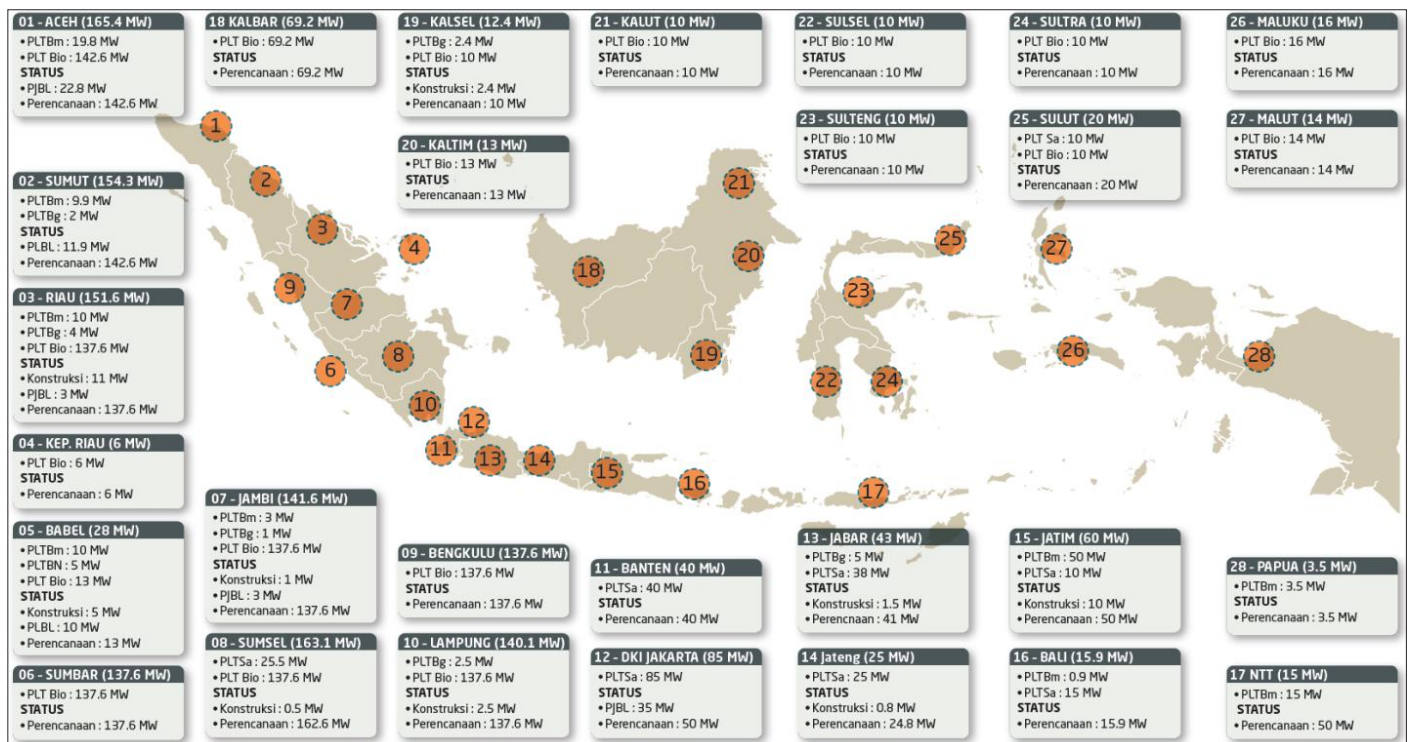


Figure 17. Sites of biomass energy power plants in Indonesia (Hardhi, 2022)

Despite the recent growth in the manufacturing industry and modernization, Indonesia is still considered as an agricultural country. The sector contributes 12.53% of national income, third behind manufacturing and wholesale/retail (Statista, 2023). Because of that, the country also has a plenty of biomass energy potential. In fact, biomass has been the main priority of Indonesia's energy transition plan, accounting for 1,890 MW of national energy capacity. It is still comparably low considering the country's biomass potential of 32 GW spanning 76.40 million hectares of potential land area (Hardhi, 2022).

Current biomass potential in Bali is projected at around 191.6 MW and is expected to grow to 263 MW in 2030 and later 453 MW in 2050 (Dewi et al., 2021; Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020). Biomass energy research and utilization in Bali has been growing at a rapid pace due to the continuous implementation of catalysing projects from its stakeholders. Four of the most important ones namely SIMANTRI in 2009, BIRU in 2009, West Bali National Park in 2013, and Public Works in 2015 (Bößner et al., 2019).

Table 8. List of government-initiated biomass projects

Name	Year	Description	Result
SIMANTRI	2009	The Bali Agricultural Agency subsidises integrated farming projects in the form of biogas digesters.	632 biodigesters installed
BIRU	2009	SNV Netherlands and HIVOS installed biogas digesters in farmers' households.	>1,000 biodigesters installed
West Bali National Park	2013	The Ministry of Environment and Forestry through The West Bali National Park authority provided livestock and bio digesters to farmers around the national park.	A few pilot projects have been implemented around the national park
Public Works	2015	Public Works utilized funding from the national government to install biogas digesters in farmer households that own livestock.	57 biodigesters installed

A biomass energy plant converts organic materials, such as agricultural residues, wood chips, and other biological waste, into electrical and thermal energy. The primary components of a biomass energy plant include a biomass feedstock handling system, a combustion or gasification chamber, a boiler, a steam turbine, and an electricity generator. Initially, the biomass feedstock is collected, processed, and transported to the plant. In the combustion chamber, the biomass is burned to produce heat, whereas in a gasification chamber, it is converted into syngas (a mixture of hydrogen and carbon monoxide) through a controlled process involving limited oxygen. The heat or syngas produced is then used to heat water in the boiler, generating steam. This high-pressure steam drives a steam turbine connected to an electricity generator (Mohammed Salih, 2021).

4.3.5. Waste-to-Energy

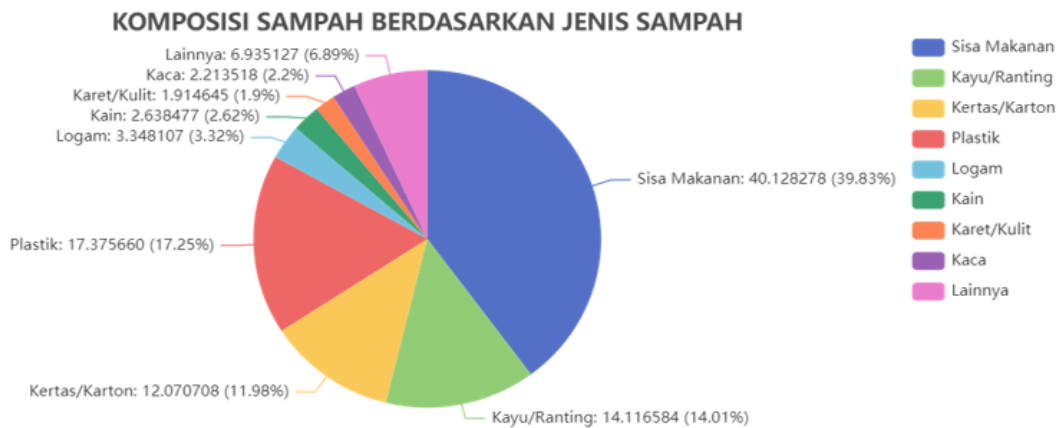


Figure 18. Indonesia solid waste composition (Romianingsih, 2023)

Indonesia produces around 91,324.49 tons of waste every day. The waste management, however, is mostly still carried out conventionally, using the open dumping method (60%) and the sanitary landfill (10%). Waste-to-energy technology can both solve waste management problems and provide energy supply with a theoretical potential capacity of 2,066 MW (Romianingsih, 2023). In 2021, Bali produced 263,410.27 tons of waste, with Denpasar as the highest emitter (Satu Data Indonesia, 2021). The waste is stored in 10 different landfills. Sarbagita regional landfill has the biggest land area of 5.5 ha (Agustina et al., 2019). This poses a great threat as well as energy generation potential to the island. Ironically, waste-to-energy is not even mentioned in the province's RUED. In 2007, Sarbagita regional landfill has planned for a waste-to-energy project which came short. The idea resurfaced in 2017 approaching the IMF and World Bank annual meeting in Bali but still yet to be realized. In 2021, the provincial government officially cancelled the plan altogether (Suriyani, 2021a). However, in 2024, the Government of Bali once again announced a plan to develop a 20 MW waste-to-energy plant in Denpasar (kgi-admin, 2023).

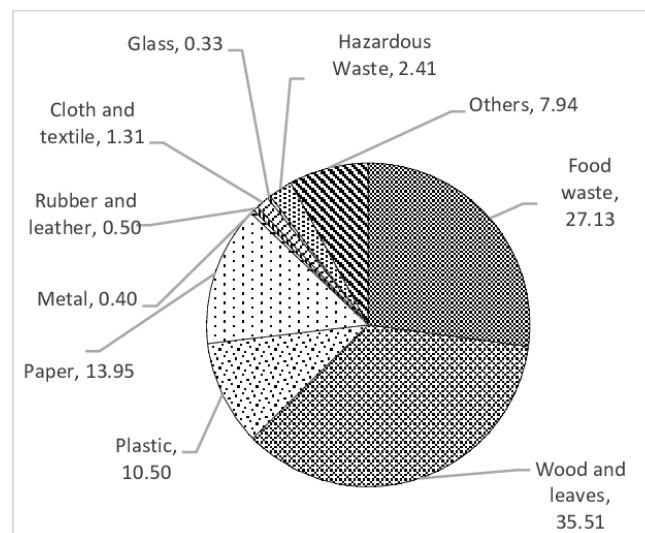


Figure 19. Bali solid waste composition (Agustina et al., 2019)

A waste-to-energy (WTE) plant converts municipal solid waste (MSW) into energy. The primary components of a WTE plant include waste collection and sorting systems, combustion chambers or gasifiers, boilers, steam turbines, and electricity generators. MSW is collected and delivered to the plant, where it undergoes sorting to remove recyclable and non-combustible materials. The remaining waste is then fed into a combustion chamber where it is incinerated at high temperatures, or into a gasifier where it is converted

into syngas through a controlled process with limited oxygen. The heat generated from the combustion produced from gasification is used to heat water in the boiler, creating steam. This high-pressure steam drives a steam turbine connected to an electricity generator (Klinghoffer et al., 2013).

4.3.5. Solar Energy

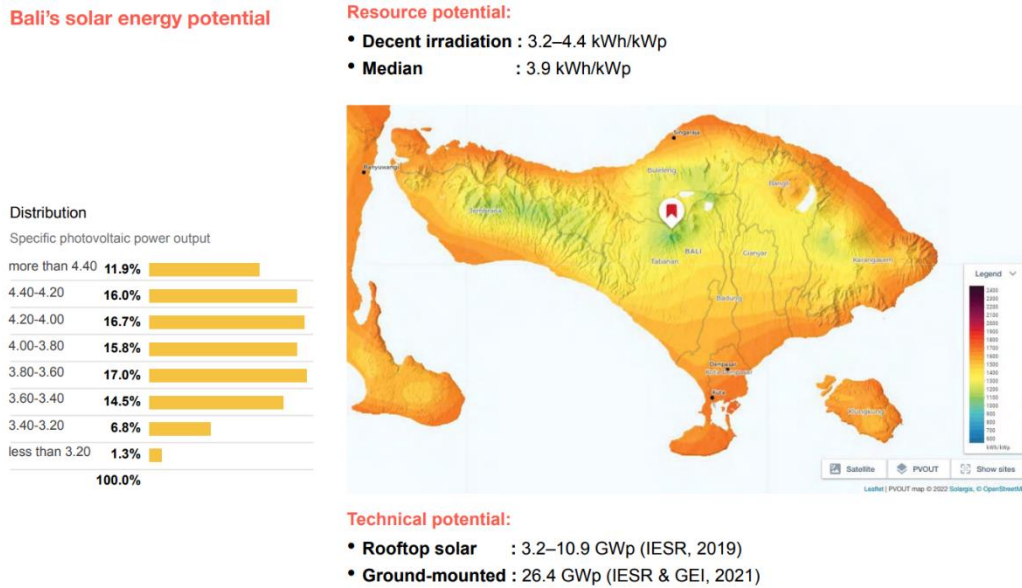


Figure 20. Solar energy potential in Bali (Harsamto, 2022)

Strategically located across the equatorial line, Indonesia has an abundance of solar energy potential all year long at around 207.8 GW (Agus Kiswanton, 2023; Pambudi et al., 2023). Bali, in particular, receives a consistent 12 hours of daylight throughout the year with an average solar irradiation of 5.3 kWh/m². In return, the small island has a huge technical potential of 10.9 GWp of rooftop solar panels and 26.4 GWp of ground-mounted solar panel (Harsamto, 2022). The regional government is aware of this untapped potential, thus became the first province to enact a region-wide regulation to encourage and catalyse solar PV adoption in the island (Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021).

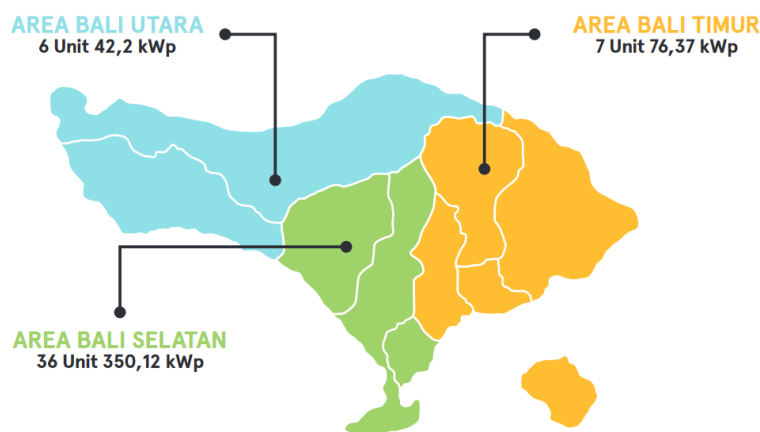


Figure 21. Installed capacity of solar rooftop in Bali (Udayana & Kumara, 2020)

In response to the opportunity, solar PV technology has become one of the most popular RE technologies in Bali (Interviewee 1; Interviewee 4). Solar PV in Bali has been getting cheaper and more efficient over time—and also easier to obtain as supply increases (Udayana & Kumara, 2020). It confirms Moore’s law equivalent of steady efficiency progress and lower cost but in the case of PV technology

(Hutchby, 2014). Solar PV currently accounts for 0.6% of the total operating capacity in Bali (around 7 MW), making it the largest contributor to RE share. There are at least 387 kW announced new projects and 50 MW in the pre-construction phase (Global Energy Monitor, 2023). The government has a plan to increase the capacity of ground-mounted PV system to 213 and 500 MW by 2025 and 2050, respectively and rooftop solar PV system to 10 and 20 MW by 2025 and 2050, respectively (Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020).

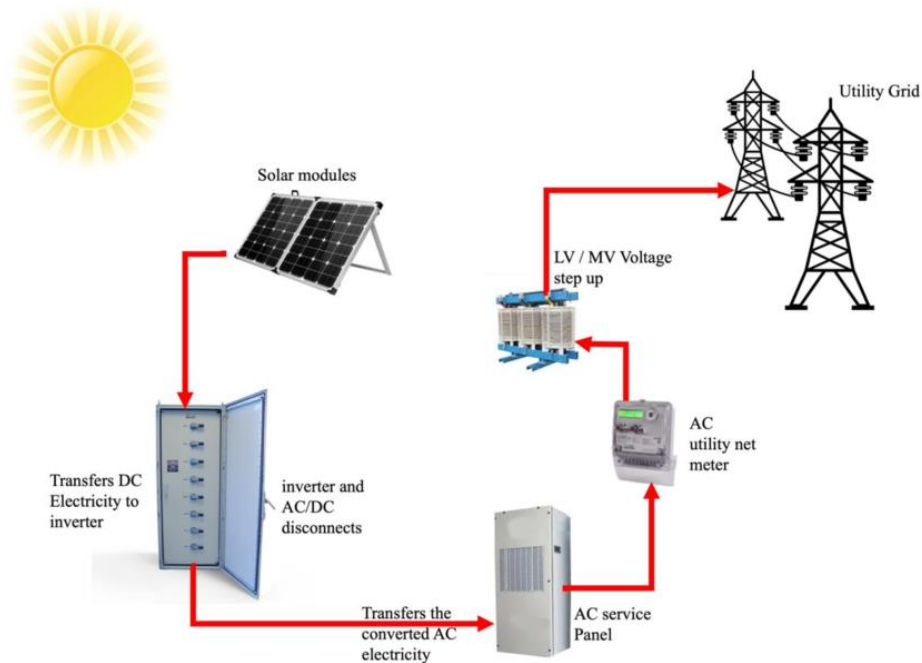


Figure 22. General schematics of an on-grid solar PV system (Obaideen et al., 2023)

A solar photovoltaic (PV) plant converts sunlight directly into electricity using solar panels made of semiconductor materials, typically silicon. The primary components of a solar PV plant include solar panels, inverters, a mounting system, and an electrical grid connection. Solar panels, which consist of numerous solar cells, capture sunlight and convert it into direct current (DC) electricity through the photovoltaic effect. The panels are mounted on structures that can be fixed or track the sun to maximize exposure. The mounting systems ensure that the panels are optimally angled and securely positioned to capture the maximum amount of solar energy. Once the solar panels generate DC electricity, inverters convert it into alternating current (AC) electricity, which is the standard used for most electrical appliances and for distribution through the electrical grid. The AC electricity is then transmitted through wiring and transformers to a substation so that it can integrate with the grid (Obaideen et al., 2023).

4.3.6. On-grid System

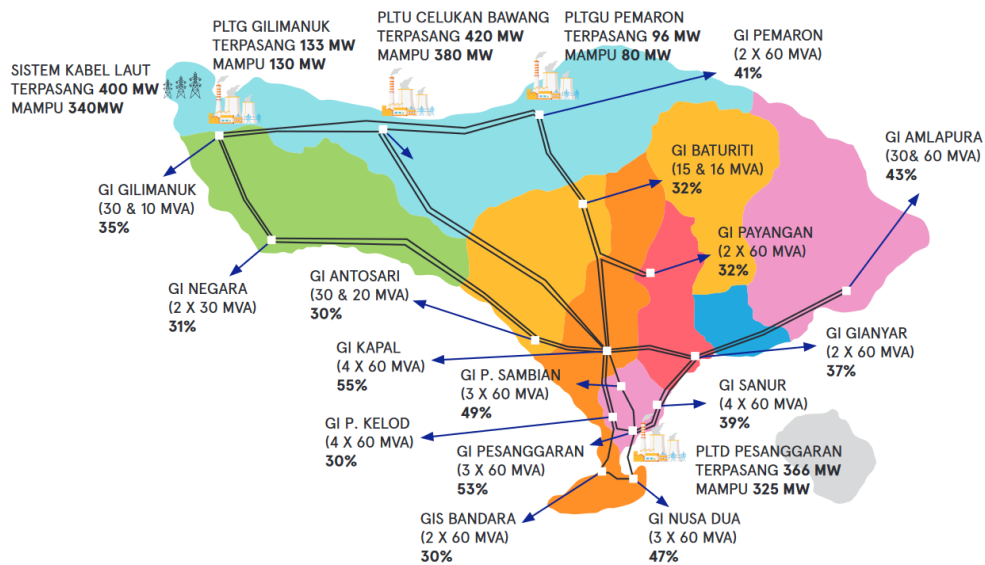


Figure 23. Bali on-grid electricity system (Udayana & Kumara, 2020)

Grid electricity supply in Bali is connected to the mainland of Java under the PLN Java-Bali grid system. The connection is established through an undersea cable system in Bali strait (Udayana & Kumara, 2020). The island is predominantly supplied by fossil-based electricity generation, particularly oil (75.71% in 2015) and coal (19.63% in 2015). Renewable only accounts for 0.27% of energy share. There are already some planned RE projects to achieve the future RE share target of 11.15% by 2025 and 20.10% by 2050 (Green Building Council Indonesia, Bali & Setiawan, 2020).

Table 9. Primary energy source (on grid) in Bali

Primary energy source	2015	2025	2050
Coal	19.63%	3.32%	0%
Gas	4.39%	56.23%	34.85%
Oil	75.71%	29.30%	45.05%
Renewables	0.27%	11.15%	20.10%

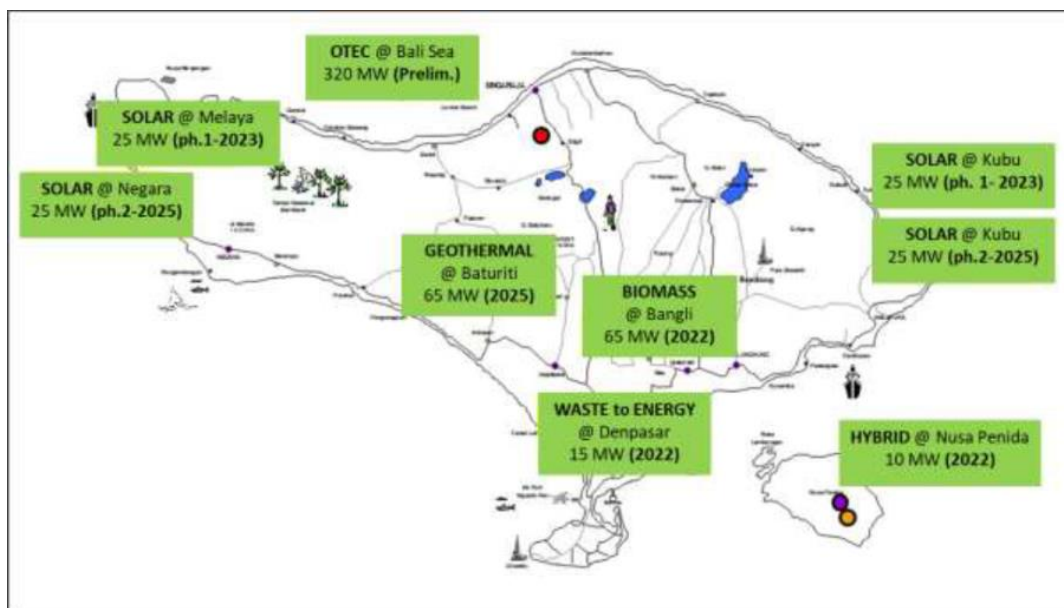


Figure 24. Map of newly-planned RE projects in Bali (Green Building Council Indonesia, Bali & Setiawan, 2020)

4.4. Actor Analysis

Initial actor identification is done using media analysis to observe which organizations are the most mentioned in articles discussing about the topic of CE in Bali. From the observation, it is found that State Electricity Company and Pertamina are two leading entities due to their influence in both regional and national energy landscape. Pertamina serves more on the extraction part of energy production, yet they also have several RE-related CSR projects – including in Bali (World Bank, 2000). State Electricity Company, meanwhile, operates within regulated monopolistic electricity market in Indonesia, therefore both crucial and powerful in the context of CE (Asian Development Bank, 2019). Government of Indonesia is a very general term that, for the context of Bali, will be narrowed down to Bali Department of Energy as the government body that regulates energy transition in the province. United Nations, Bank Indonesia, and Bank Rakyat Indonesia generally have a similar role as project funders for CE. G20 is again mentioned in relation to its presidency, which has negligible context to CE. University of Indonesia is mentioned as one of the research entities with interest to Bali CE. Indonesian Democratic Party of Struggle and Golkar are both political parties in Indonesia, but the interviews found no correlation between both parties and any of the stakeholders in Bali CE landscape, therefore both are excluded from the analysis.

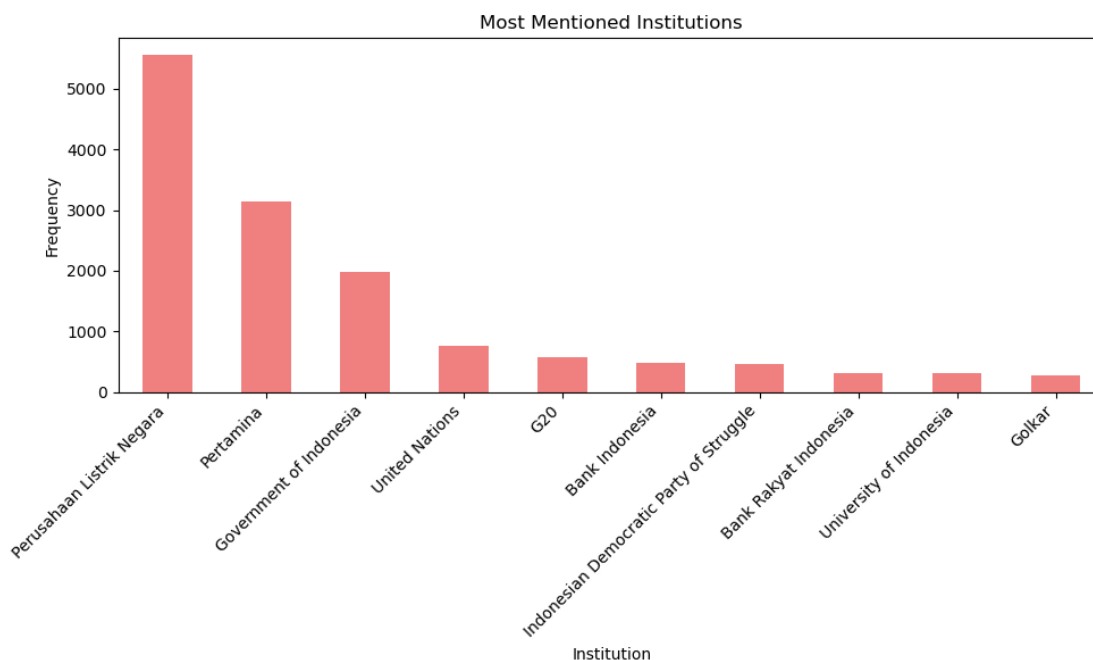


Figure 25. Most mentioned institutions related to CE in news articles

The interview in itself involves local initiatives, government entities, NGOs, project funders, state-owned enterprises, and research entities. Upon further discussion, the interviewees also mentioned the importance of customary village as the prominent village-level governing body and cultural value gatekeeper. Two major private entities are also included: Private companies which include RE-related enterprises operating in Bali and tourism industries which refer to enterprises working in tourism and hospitality sectors as the backbone of Bali economy. A more general context of people of Bali is also included as they represent the crowds that would directly or indirectly affected by the development of CE.

4.4.1. Bali Department of Labour, Energy, and Mineral Resources

Bali Department of Labor, Energy, and Mineral Resources is responsible for managing and executing provincial-level governmental affairs in the field of labour, energy, mineral resources, and transmigration – including policymaking and collaborating with CE within the Province of Bali (Disnaker ESDM Bali, n.d.-b). In the particular context of CE, the department serves as a regulator and facilitator of local projects (Interviewee 11). The department is responsible in the formulation and implementation of several regional policies on energy transition such as the Governor’s Regulation (Peraturan Gubernur/Pergub) No. 45/2019 on Bali Clean Energy, Local Regulation (Peraturan Daerah/Perda) No. 9/2020 on Regional General Energy Plan, Circular Letter (Surat Edaran) No. 5/2022 on Rooftop Solar Panel Implementation, and Governor’s Mandate No. 879/03-M/HK/2022 on Green Building Implementation (Keputusan Gubernur Bali Nomor 879/03-M/HK/2022 Pedoman Teknis Penyelenggaraan Bangunan Gedung Hijau Dalam Rangka Penyelenggaraan Bali Energi Bersih Di Provinsi Bali, 2022; Peraturan Daerah Provinsi Bali Nomor 9 Tahun 2020 Tentang Rencana Umum Energi Daerah Provinsi Bali Tahun 2020-2050, 2020; Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali Energi Bersih, 2019; Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021).

The department is led by a Department Head and divided into several key divisions and units focusing on different aspects of its mandate. These divisions include the Training and Productivity Division, Labour Opportunity and Transmigration Division, Corporate Relation and Labor Inspection Division, and the Energy and Mineral Resource Department. The last division is directly involved and engaging with CE initiatives in Bali and other energy transition stakeholders in the province. The department is directly responsible to the Governor of Bali—and adheres to the central government in accordance with RUEN, among other regulatory instruments (Disnaker ESDM Bali, n.d.-a).

One of the critical goals of the department is the transition to RE and achieving Net Zero Emissions by 2045. The department’s responsibilities also involve collaborating with various stakeholders, including local communities, non-governmental organizations, and international partners, to promote sustainable development and clean energy initiatives across the province (WRI Indonesia, n.d.). There is also some evidence of direct engagement and facilitation between the department with academia, local champions, and NGOs in the establishment and development of CE projects in Bali (Interviewee 2, Interviewee 6, Interviewee 9, Interviewee 11).

4.4.2. State Electricity Company (Perusahaan Listrik Negara/PLN)



Figure 26. Power Plants Operated by PLN under Its Subsidiary (Indonesia Power) (zonaebt, 2022)

Perusahaan Listrik Negara (PLN) is Indonesia's state-owned electricity company, responsible for generating, transmitting, and distributing electricity throughout the country. It plays a critical role in managing Indonesia's electricity infrastructure and ensuring the supply of electrical power to residential, commercial, and industrial sectors. In its operation, PLN adheres to the RUKN, among other regulations on electricity and energy in Indonesia (Rencana Umum Ketenagalistrikan Nasional, 2019). PLN has a decentralized institutional structure in place with unit(s) responsible for social safeguard roles and functions set up at both central and regional/project levels. PLN's regional offices (Unit Induk Distribusi, or UID) are given the primary mandate to address social safeguard issues in projects (Asian Development Bank, 2019).

PLN Bali Distribution Unit (Unit Induk Distribusi/UID) is a regional unit of PLN that manages electricity distribution specifically within the Bali region. PLN Bali, NTB, and NTT Business Unit was established in 2001, and later restructured into PLN UID Bali in 2002. By 2008, PLN UID Bali launched the World Class Services (WCS) initiative, focusing on satisfying customers, enhancing life quality through electricity, promoting economic activities, and ensuring environmentally friendly operations. The commitment is measured through several parameters and standards on electrical distribution company performance (Area, 2014).

PLN has implemented the Bali Eco Smart Grid to enhance electricity supply reliability, increase energy efficiency, and reduce CO₂ emissions in Bali. The smart grid integrates RE sources such as solar power into the existing grid, supporting Bali's clean energy regulations. This initiative involves partnerships with local governments and developers, aiming to boost RE use to 23% by 2025. Additionally, PLN promotes the installation of photovoltaic systems on buildings and ensures energy reliability through backup power and storage solutions (Dukung Energi Bersih, PLN Terapkan Bali Eco Smart Grid, 2021).

4.4.3. Pertamina

Pertamina is Indonesia's state-owned oil and gas corporation, responsible for the exploration, production, refining, and distribution of petroleum and natural gas products. It plays a crucial role in the country's energy sector, ensuring the availability of energy resources—in this case from the upstream side of electricity generation. Pertamina's organizational structure includes various directorates and subsidiaries focusing on different aspects of the energy sector, such as upstream and downstream operations, gas, and

RE. The company is directly accountable to the Indonesian Ministry of State-Owned Enterprises, ensuring alignment with national energy policies and regulations (P. T. Pertamina (Persero), n.d.).

In Bali, Pertamina operates through various subsidiaries and units to manage fuel distribution, gas supply, and energy infrastructure projects. Key activities include operating fuel stations, LPG distribution centers, and supporting the region's energy needs by ensuring a steady supply of fuels and other energy products. Pertamina has also actively involved in CE projects under its Corporate Social Responsibility (CSR) program. A notable project is the Desa Energi Berdikari program in Keliki Village, Ubud, where Pertamina has installed solar PV systems to power local households and community facilities. This project aims to reduce carbon emissions and foster sustainable energy practices by using RE sources for various applications, including agriculture and waste management (CNBC Indonesia, 2023).

4.4.4. Private Companies

RE is an emerging sector in Bali. Within the province alone, six solar PV contractors were identified in 2019. These private companies sell RE technologies to the masses as well as service and after-sales support. CEs and independent adopters rely on these private companies in the adoption and maintenance of RE systems (Interviewee 4; Interviewee 8).

Table 10. Solar PV Contractors in Bali (Udayana & Kumara, 2020)

Name	District	Year of establishment
PT Contained Energy Indonesia	Kuta	2004
PT Solar Power Indonesia	Nusa Dua	2007
Solar Energi Solusi	Denpasar	2017
Ineco Solar	Kuta Utara	2018
PT Negeri Matahari Mandiri	Denpasar Timur	2019

There are also several other companies headquartered in other cities such as Jakarta, or even international companies with branches and/or local projects in Bali.

Table 11. Non-Bali-Based Private RE Companies with Project(s) in Bali

Name	Headquarter	Note
Bali Energy Limited	Jakarta	Operating the Bedugul geothermal power plant in Tabanan (Bali Energy Limited, n.d.)
PT Medco Power Indonesia	Jakarta	Currently developing solar farm projects in Bali Barat and Bali Timur (Medco Power Indonesia, 2021)
PT Indo Energi Masa Depan	Jakarta	Developing a floating solar farm in Muara Nusa (PT Indo Energi Masa Depan, n.d.)

4.4.5. Local NGO

Local non-governmental organizations (NGOs) play a pivotal role in Bali's energy transition and the promotion of CE initiatives. These organizations are crucial in advocating for sustainable energy practices, educating communities, and facilitating village-led RE projects. These NGOs play vital roles by engaging local communities, providing technical expertise, and advocating for policy changes that support RE adoption (Interviewee 2; Interviewee 3; Interviewee 4). Organizations within this group tend to have a better understanding of local community development dynamics and practices.

Institute for Essential Services Reform (IESR) actively supports the development of community-based RE projects. IESR's involvement includes conducting research, providing policy recommendations, and

facilitating the implementation of RE solutions at the community level. They emphasize the importance of local involvement and the benefits of decentralized energy systems, which can lead to more resilient and self-sufficient communities (G. Saputra, 2019). Similarly, Wisnu Foundation addresses environmental issues in Bali, focusing on waste management and community empowerment. Since 1999, the foundation has concentrated on environmental management, community resource management, and sustainable development. They have implemented various programs, including optimizing village potential through natural soap production and developing eco-tourism villages. Wisnu Foundation's initiatives aim to foster sustainable development and empower local communities through RE projects and environmental education (Interviewee 2).

Yayasan Rumah Energi is a significant player in promoting RE and sustainable agriculture through its BIRU (Biogas Rumah) program. The BIRU program focuses on the installation of household biogas digesters, which convert livestock manure into biogas for cooking and lighting, and bio-slurry for organic fertilizer. This initiative not only reduces reliance on non-RE sources but also supports organic farming, enhancing agricultural productivity and sustainability (Eco-Business, 2013). Bali New RE Foundation works on grassroots projects like installing solar PV systems in villages to provide reliable and sustainable energy sources, reduce carbon emissions, and boost local economic activities (Simanjuntak, 2023).

4.4.6. International NGO

International NGOs play critical roles in Bali's energy transition by providing expertise, funding, and advocacy. Their collaborative efforts with local NGOs and communities help to promote RE, particularly in relation with the SDGs. International NGOs work closely with global funding bodies, international organizations, and private donors to secure financial resources for RE projects. For example, the UNDP's Just Energy Transition Partnership (JETP) mobilizes significant public and private financing to support energy transitions in Indonesia, including Bali.

These organizations engage with national and regional governments to develop and advocate for policies that support RE adoption. They provide research, policy recommendations, and technical guidelines to help shape an enabling environment for sustainable energy initiatives. WRI Indonesia's work in supporting Bali's Net Zero Emissions 2045 vision through policy frameworks is a notable example. Other than that, international NGOs also often offer technical assistance and capacity-building programs to local stakeholders, ensuring that they have the expertise needed to implement and manage RE projects, as well as monitoring and evaluating the impact of RE projects, ensuring that they meet their objectives and provide lessons learned for future initiatives.

4.4.7. Research Entities

Research entities and universities are crucial in advancing CE initiatives in Bali, serving as the backbone for innovation, knowledge dissemination, and policy advocacy. Both Udayana University and Bandung Institute of Technology play a significant role in driving research and development (R&D) in RE technologies as well as community development on the ground (Interviewee 9; Interviewee 10). They conduct extensive studies on various energy sources, such as solar PV, wind, and bioenergy, which help identify the most effective and suitable technologies for Bali's environmental conditions. Additionally, universities and research institutions serve as hubs for technical expertise and training. They offer essential programs that build the capacity of community members, local NGOs, and other stakeholders involved in CE initiatives. Technical workshops and certification courses on RE system installation and maintenance equip local technicians with the skills necessary to support and sustain CE projects effectively. Practically, these academic institutions have the opportunity to facilitate knowledge transfer and foster innovation by leveraging global best practices and cutting-edge technologies.

4.4.8. Local Initiatives

Local CE initiatives in Bali have seen a growing interest and development, although they still face numerous challenges. These initiatives are increasingly becoming vital in the push towards sustainable energy, driven by the island's substantial RE potential and the strong communal culture that supports collective efforts for environmental stewardship. Despite the hurdles, there are several successful examples of local CE initiatives making significant strides (Interviewee 2; Interviewee 3). The communal spirit and traditional governance structures, such as customary villages, play a crucial role in supporting these projects (Interviewee 7). These local governance systems ensure high levels of participation and commitment from community members.

4.4.9. Customary Villages (*Desa Adat*)

Customary villages, known as *desa adat* or *desa pakraman* in Bali, are traditional village institutions that operate based on indigenous laws and customs. These villages maintain their own governance structures and are integral to the cultural and social life of the Balinese people. They coexist with the administrative villages (*desa dinas*). Customary villages are regulated through both traditional laws and provincial regulations. The Village Law of 2014 provided a framework for villages in Indonesia to choose between becoming a customary village or continuing as an administrative village. In Bali, the local regulation further reinforced the authority of customary villages, granting them legal recognition and autonomy over their customary lands and internal affairs. This regulation ensures that the cultural heritage and traditional governance of Bali's communities are preserved and respected (Peraturan Daerah Provinsi Bali Nomor 4 Tahun 2019 Tentang Desa Adat Di Bali, 2019; Peraturan Daerah Provinsi Bali Nomor 4 Tahun 2022 Tentang Pedoman, Mekanisme, Dan Pendirian Baga Usaha Padruwen Desa Adat, 2022).

The societal activities within customary villages are characterized by strong communal bonds and a collective approach to decision-making. The customary institution at the hamlet level within villages plays a central role in organizing and managing community activities, including religious ceremonies, cultural events, and social welfare (Purnamawati, 2021). The customary villages operate under the leadership of the village leaders/elders, who are highly respected and hold significant influence over community decisions. This traditional governance structure ensures high levels of participation and compliance with communal norms and regulations (Interviewee 7).

The strong communal ties and governance structures of customary villages present significant opportunities for the growth of CE initiatives in Bali. The collective nature of these villages means that CE projects can leverage the existing social cohesion and organizational framework to mobilize community members effectively. The alignment of RE initiatives with the environmental values and sustainability principles embedded in Balinese culture further enhances community support for these projects. Customary villages can play a pivotal role in implementing and managing CE initiatives, ensuring that they are culturally appropriate and community-driven. By integrating RE projects within the traditional governance framework, these initiatives can benefit from the strong local leadership and collective action that characterize Balinese society. This approach not only supports the technical and financial viability of CE projects but also reinforces the cultural and social fabric of the communities.

4.4.10. Project Funders (*Cooperatives/Grants*)

CE initiatives in Bali are funded by various financial schemes. These schemes ensure the development of the CE amid the current situation that is not ideal for a CE model to survive due to lack of competitiveness with the highly subsidized electricity price and complicated RE adoption bureaucracy (International Energy Agency, 2023). Some of those relatively newly-established schemes are cooperatives—both that are managed privately and by customary villages. Energy cooperatives in Bali are community-driven organizations that

focus on developing and managing RE projects collectively. These cooperatives pool financial resources from their members to invest in RE systems such as solar panels and micro-hydro plants (Heras-Saizarbitoria et al., 2018). One notable example is the Amoghasiddhi Energy Cooperative, which facilitates the installation and maintenance of RE projects in rural areas, promoting local energy independence and sustainability. By leveraging collective financial power and local engagement, these cooperatives ensure that the benefits of RE are equitably distributed among community members (Interviewee 1).

Customary village cooperatives, or *koperasi desa adat*, operate within Bali's customary village. These cooperatives are regulated by provincial laws such as the Peraturan Daerah Provinsi Bali Nomor 4 Tahun 2022 Tentang Pedoman, Mekanisme, Dan Pendirian Baga Usaha Padruwen Desa Adat (2022). They focus on economic and social initiatives, including the management of community funds through customary village-owned enterprise (*BUPDA/Badan Usaha Milik Desa Adat*), a network of savings-driven financial institutions. The BUPDAs are owned and governed by the customary villages, fully integrating into Balinese culture and supporting local development. These cooperatives play a critical role in mobilizing local resources for community projects, including RE initiatives, by fostering a sense of ownership and responsibility among community members.

Energy cooperatives and customary village cooperatives hold significant leverage in the development of CE initiatives in Bali. By pooling resources and fostering collective decision-making, these cooperatives can overcome initial capital barriers and ensure that RE projects are community-driven and aligned with local needs. The strong organizational structures and cultural integration of customary village cooperatives provide a robust framework for managing CE projects. These cooperatives can facilitate the implementation of RE systems, ensuring their long-term sustainability through regular maintenance and community engagement. Additionally, their deep-rooted presence in the community allows them to navigate local regulatory landscapes effectively, making them ideal vehicles for promoting and sustaining CE initiatives.

4.4.11. Tourism Industries

Economically, Bali is heavily dependent on tourism, which accounts for nearly 80% of its GDP. In 2019, before the COVID-19 pandemic, Bali attracted over 6.3 million international visitors and 10 million domestic tourists. However, the pandemic severely impacted this sector, leading to a contraction in the economy by over 9% in 2020 (BPS-Statistics Bali, 2024c). In response, significant efforts have been made to diversify the economy. Agriculture, particularly rice and coffee production, still plays a crucial role, contributing around 14% to the GDP (BPS-Statistics Bali, 2024a). There is also a growing emphasis on sustainable tourism and RE sources to ensure long-term economic resilience and environmental sustainability. The provincial government aims to increase the contribution of small and medium enterprises to the economy by 10% over the next five years, reducing reliance on tourism (BPS-Statistics Bali, 2024b).

4.4.12. People of Bali

Bali's population, estimated at around 4.3 million, is predominantly Balinese Hindu, making up about 83% of the population, with the remaining 17% consisting of Muslims, Christians, and Buddhists. The demographic profile is youthful, with a median age of approximately 30 years, indicating a dynamic and growing workforce (BPS-Statistics Bali, 2024b). Energy consumption in Bali is rising, driven by population growth and tourism development. The island relies on a mix of energy sources, with around 65% of its energy needs met by imported fossil fuels and the rest by locally produced energy including renewables (BPS-Statistics Indonesia, 2023a). The government is investing IDR 1.5 trillion (approximately USD 100 million) in RE projects, such as solar and wind, to reduce carbon emissions and achieve energy self-sufficiency (Global Energy Monitor, 2023). These efforts are part of a broader strategy to address climate change and ensure sustainable development.

4.4.13. Power-Interest Matrix

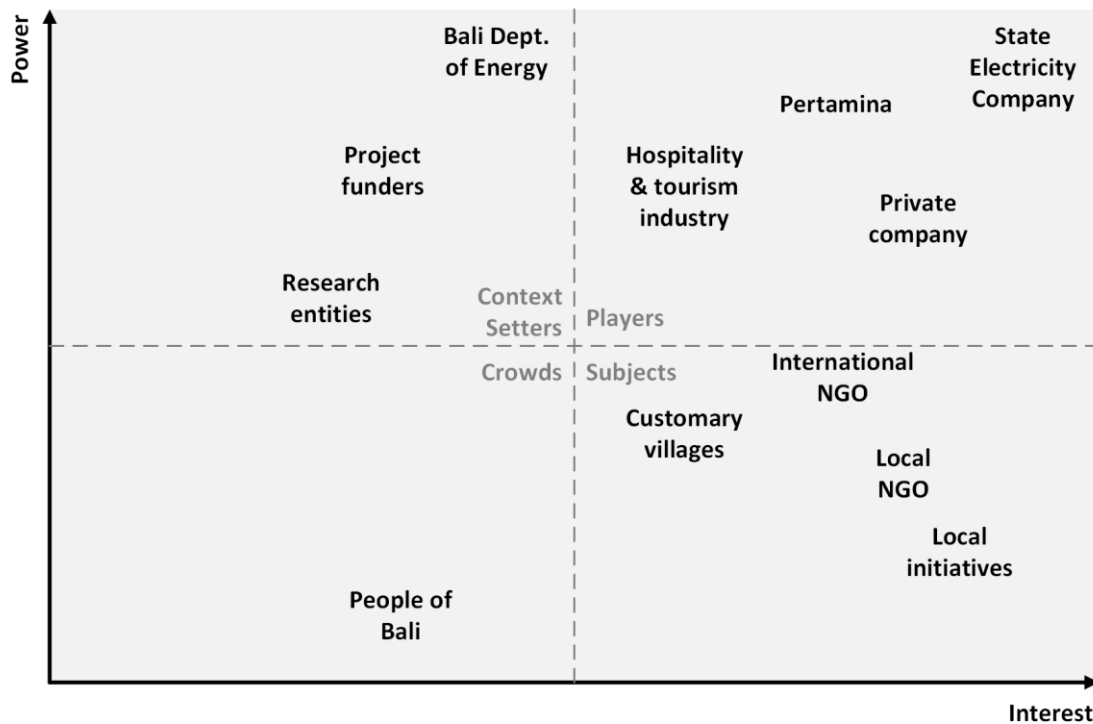


Figure 27. Power-interest matrix of actors in Bali CE

Based on the elaboration of each actor in prior subsections and Appendix G, a power-interest matrix is developed. A Power-Interest Matrix is a strategic tool used to map out the influence and interest of different stakeholders in a certain context. It categorizes stakeholders based on two key dimensions: their level of power (influence or ability to affect the outcome of the project) and their level of interest (concern or involvement in the project's outcomes). The matrix typically divides stakeholders into four quadrants: (1) Players (high power, high interest), who are key stakeholders that should be actively engaged and managed closely; (2) Context Setters (high power, low interest), who can influence the project significantly but may require less intensive management; (3) Subjects (low power, high interest), who are interested in the project but have limited influence and should be kept informed and involved; and (4) Crowds (low power, low interest), who have minimal influence and interest and require minimal management effort. This matrix helps project managers prioritize their efforts and resources towards engaging stakeholders effectively, ensuring that those with the most influence and interest are appropriately managed to achieve project success (Ackermann & Eden, 2011).

The hospitality and tourism industries in Bali have emerged as key players in the CE niche, shown by the growing demand for eco-conscious tourism in a province heavily reliant on the tourism industry. These industries recognize that integrating RE solutions into their operations not only provides an opportunity to reduce costs but also enhances their appeal to environmentally aware tourists. Hotels, resorts, and other tourism-related businesses have the financial resources, market influence, and even political bargaining power to invest in and promote sustainable energy practices (Colorni, 2018; Kharisma, 2024). Similarly, Pertamina, Indonesia's state-owned oil and gas company, and the State Electricity Company (PLN) are significant players in Bali's energy landscape. Both entities have a vested interest in the energy transition due to their roles in energy production and distribution. While traditionally focused on fossil fuels, these companies are increasingly exploring RE as part of their diversification strategies as well as CSR channels (JETP Indonesia, 2023; Interviewee 8; Interviewee 12). Private companies, particularly those involved in RE technologies, are also critical players. They bring innovation, technical expertise, and investment capital to

the CE niche, driving the adoption of solar panels, wind turbines, and other sustainable energy solutions (Udayana & Kumara, 2020; Interviewee 1; Interviewee 6).

The Bali Department of Energy, while possessing considerable regulatory power, has less interest in acquiring profit off CE initiatives and more about serving as a regulatory and supporting platform. Its decisions and policies are crucial in shaping the environment in which these projects operate (Interviewee 11). As a context setter, the Department's support or lack thereof can significantly influence the success of CE projects. Project funders, including development banks, cooperatives, and philanthropic entities, also play a crucial role in the CE landscape. Although their primary interest may not be in RE per se, their funding decisions can enable or constrain the development of CE projects (Interviewee 1; Interviewee 8). Research entities, including universities and think tanks, provide the technical knowledge and mentorship for the design and implementation of CE projects. Their interest in CE is more academic or research-oriented, but their work sets the stage for practical applications in the field (Interviewee 5; Interviewee 9; Interviewee 10).

International and local NGOs are among the most active key figures of CE in Bali. They are deeply invested in promoting sustainable energy practices but often lack the power to drive large-scale change on their own. These organizations play a vital role in advocating for CE, raising awareness, and providing technical assistance and capacity-building to local communities (Interviewee 2; Interviewee 6; Interviewee 8). Customary villages also fall into the category of subjects. These villages have a strong cultural and social interest in sustainability, rooted in traditional values of living in harmony with nature (Dharmayasa et al., 2023; Marianti, Permatasari, Manurung, Wardhana, et al., 2023). Although they have limited power in the broader landscape, they have village-level leverage to enforce the adoption of CE solutions to preserve their environment and way of life (Interviewee 7). Local initiatives, often grassroots movements or community-based organizations, share this high interest in RE. These groups are driven by a desire to improve local resilience and work towards better environmental conditions. However, they often face challenges due to their limited influence and resources. Therefore, local initiatives almost always require help from other actors to execute their plans (Interviewee 2; Interviewee 3).

4.5. Conclusion

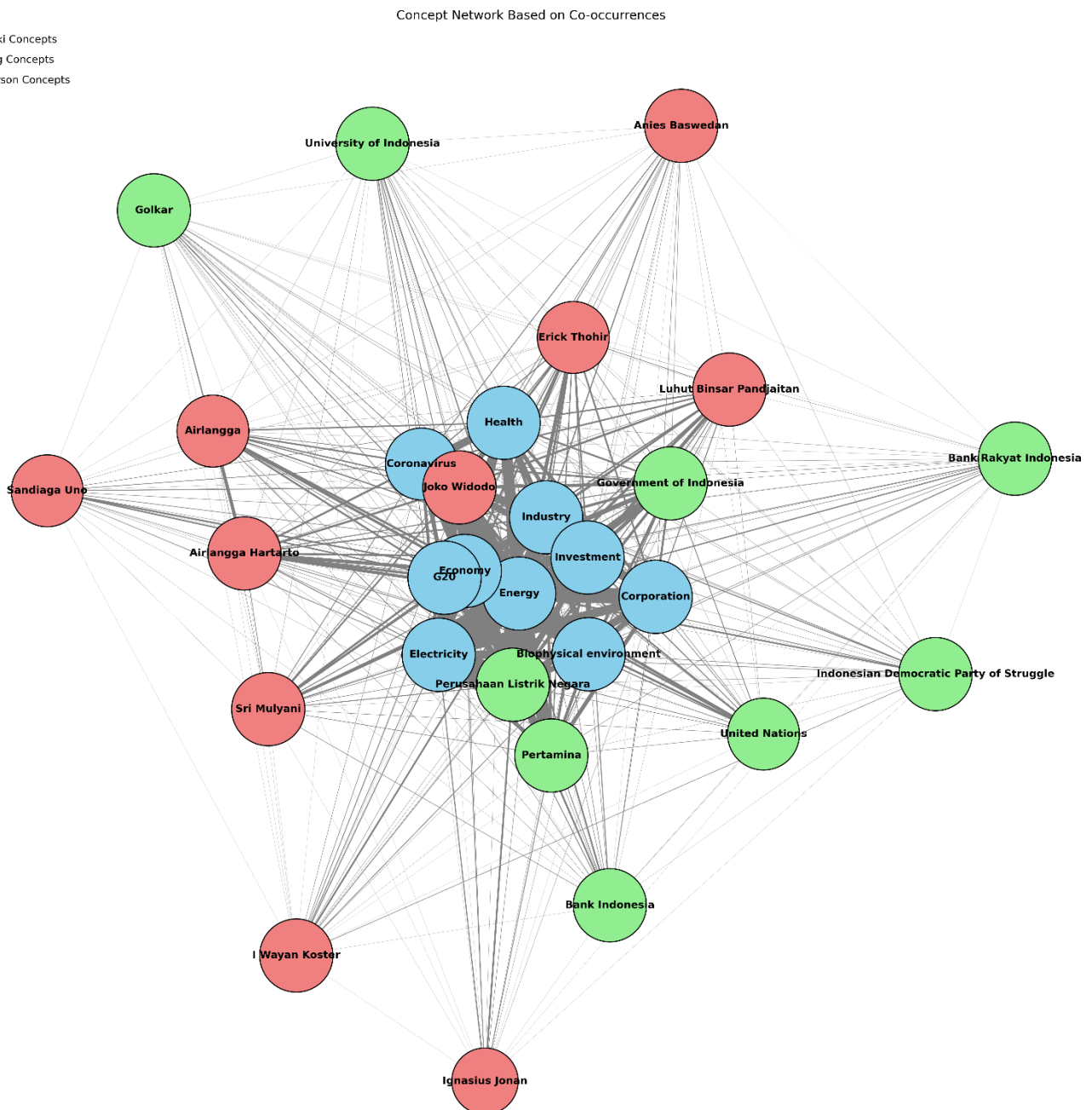


Figure 28. Concept network of topic/wiki, organizations, and individual figures mentioned on news related to Bali CE

The evolution of CE initiatives in Bali is deeply rooted in the island's historical context and cultural practices, which have significantly shaped its approach to RE development. Bali has been a pioneer in RE within Indonesia, marked by its early commitment to clean energy through regional- and national-scale policies and developments. The history of CE in Bali can be traced back to village-led initiatives in the 1960s and even earlier through traditional practices like the *subak* water irrigation system, reflecting a longstanding integration of sustainable resource management into Balinese culture. These foundational elements have laid the groundwork for Bali's contemporary energy transition efforts. However, as depicted from Figure 28, discourse on Bali CE can not be separated from its role as the spearhead of national energy transition agenda albeit its distinctive local characteristics.

Therefore, the socio-technical landscape in Bali is characterized by a strong interplay between local cultural practices, governance structures, and the broader national and international pressures to transition to RE. As shown in Figure 29, news media discourses on Bali CE still circle around the centralised topic of the government and state-owned enterprises. In fact, Bali's unique cultural framework, particularly through the role of customary villages, provides a robust foundation for community-based energy projects. These initiatives are supported by the island's commitment to ambitious environmental targets, such as the Bali LEZ and the 2045 net-zero emissions goal. The integration of RE technologies within these traditional governance frameworks has facilitated local ownership and social cohesion, which are critical to the success of CE projects.

Bali's RE potential is vast, spanning solar, wind, hydropower, and biomass. However, realizing this potential faces challenges due to the island's reliance on fossil fuels, particularly through its connection to the Java-Bali grid. Despite this, the provincial government, supported by international NGOs and local organizations, has been active in promoting RE projects, particularly solar energy, which is becoming increasingly popular and economically viable. The involvement of private companies and the establishment of energy cooperatives have further accelerated the adoption of RE technologies across the island.



Figure 29. Word cloud of news related to Bali CE

In conclusion, Bali's approach to RE is a blend of traditional wisdom, modern technological adoption, and strategic policy-making. The island's historical context, coupled with its socio-technical landscape, positions it as a leader in Indonesia's energy transition. However, to fully realize its RE potential, Bali must address the challenges posed by its current energy infrastructure and reliance on fossil fuels. By continuing to leverage its unique cultural practices and strong community governance structures, Bali can set a precedent for sustainable energy development that aligns with both national goals and global environmental commitments.

5 SNM Analysis of CE in Bali

This chapter aims to analyze niche processes using the concepts of Strategic Niche Management and present barriers and opportunities based on insights from niche development analysis. The analysis is derived mainly from the information collected through semi-structured interviews with diverse actors and stakeholders in Bali CE.

5.1. Network Formation

5.1.1. Composition

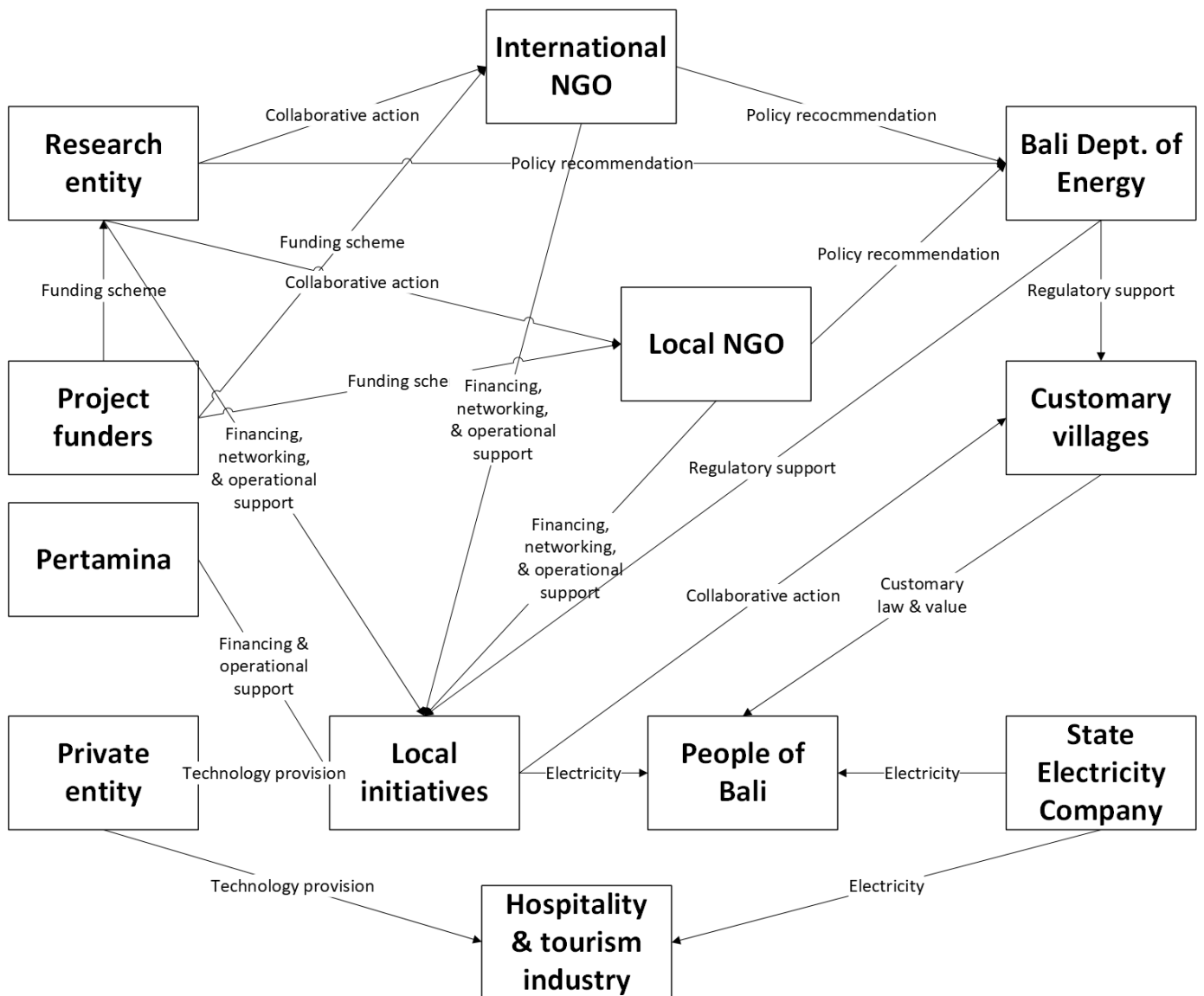


Figure 30. Actor network of CE in Bali

The embryo of the electricity company in Bali started in 1927 with the establishment of N.V. Electriciteit Bali-Lombok in Denpasar—the exact place where the current PLN UID Bali office is located. Albeit declaring its independence in 1945, the Government of Indonesia was only able to fully take ownership of the electricity company in around 1956-1957 and changed the name to PLN. The company was initially operating under the management of PLN Surabaya in the mainland of Java. Only then in 1965, PLN Exploitasi VIII – Nusra

was founded. During this time, the management of electricity distribution in Bali is merged with the provinces of West Nusa Tenggara and East Nusa Tenggara. After several restructuring of PLN as a state-owned company, PLN UID Bali was established in 2002 (Area, 2014).

PLN UID Bali operates under the regulatory oversight of the central PLN organization, which in turn is overseen by the Ministry of State-Owned Enterprises and the Ministry of Energy and Mineral Resources. In Bali, PLN UID works closely with the Disnaker ESDM Bali, the regional government body responsible for labour, energy, and mineral resources. This collaboration ensures alignment with regional policies, such as the realization of a 100% electrification rate in Bali (Wiratmini, 2018). Bali's electricity network is connected to Java via the Java-Bali interconnection. This link allows Bali to import electricity from Java, ensuring a stable and sufficient power supply to meet the island's growing demand. The interconnection involves high-voltage submarine cables that transmit electricity from power plants in Java to Bali, providing a reliable backup and supporting the region's energy needs during peak demand periods (International Energy Agency, 2022b).

Disnaker ESDM Bali plays a key role in formulating and implementing energy policies, in which PLN UID Bali is obliged to support. There is also cooperation between PLN as a state-owned company in electricity distribution and Pertamina as a state-owned company that operates more in the production side of the electricity supply chain. Pertamina collaborates closely with the provincial government, particularly through the Disnaker ESDM Bali. This collaboration ensures alignment with regional energy policies and supports Bali's goals for sustainable energy and reduced carbon emissions. Pertamina also works with PLN to integrate RE solutions and improve energy infrastructure in Bali. This partnership is essential given its connection to the Java-Bali interconnection grid (Interviewee 11).

One of Pertamina's flagship CSR programs in Bali is the *Desa Energi Berdikari* (Self-Reliant Energy Village) project in Desa Keliki, Ubud, Gianyar. This project exemplifies Pertamina's commitment to RE and community development. In Keliki, Pertamina has installed solar PV systems with a capacity of 28 kWp, benefiting 1,200 households. These solar panels support various community needs, including waste management, eco-village development, and agricultural activities (CNBC Indonesia, 2023; Merdeka.com, 2022). In the execution process, Pertamina collaborates with NGOs and local universities to implement these projects in an effort to build a strong network of other key stakeholders (Interviewee 12).

Local NGOs and local universities/research entities in Bali play crucial roles as intermediaries between RE projects and funding providers. They facilitate connections between project developers and both national and international funders, ensuring that projects receive the necessary financial and technical support to succeed. Centre of Excellence Community-Based RE (CORE) at Udayana University conducts research and provides feasibility studies for RE projects and facilitates policy and strategic recommendations to the government, state-owned companies, and other primary stakeholders (Udayana & Kumara, 2020; Interviewee 10). Local NGOs such as Wisnu Foundation contribute by promoting sustainable practices and implementing community-based RE projects. These NGOs often collaborate with larger organizations and funders to bring financial resources and technical expertise to local communities (Interviewee 2; Interviewee 8).

These funding schemes are often provided by grants and/or projects from international organizations. international NGOs, such as the United Nations Development Programme (UNDP) and the World Resources Institute (WRI), play a crucial role in securing funding, providing technical expertise, and influencing policy at national and regional levels. These organizations work closely with global funding bodies and international donors to mobilize financial resources for RE projects. For example, UNDP's Just Energy Transition Partnership (JETP) mobilizes significant public and private financing to support energy transitions in Indonesia, including Bali (JETP Indonesia, 2023). Additionally, international NGOs engage in policy advocacy and development, offering research, policy recommendations, and technical guidelines to create an enabling environment for sustainable energy initiatives. WRI Indonesia, for instance, supports Bali's Net Zero Emissions 2045 vision by helping shape policy frameworks and providing technical support (WRI Indonesia, 2023). These organizations also provide technical assistance and capacity-building programs to local stakeholders, ensuring they have the expertise needed to implement and manage RE projects effectively.

On the other hand, local NGOs are deeply embedded within communities, working directly with residents to implement RE and sustainability projects. These NGOs focus on empowering communities through education and training, conducting needs assessments to tailor solutions that address specific local challenges. Local NGOs also oversee the installation and maintenance of RE systems, ensuring their long-term functionality and impact. By integrating RE projects with economic development initiatives, such as training customary village communities to utilize solar energy, and therefore establish their own CE, these NGOs help improve local livelihoods and promote sustainable practices. This close collaboration ensures that CE projects are community-driven, addressing specific local challenges and leveraging local resources effectively.

At the same time, Bali's unique customary village system allows these communities to govern their own initiatives independently. Customary villages operate based on customary laws and local governance structures, which are deeply rooted in Balinese culture. This system provides a framework for community autonomy, enabling villages to make independent decisions about their energy projects and other local matters. This autonomy allows them to tailor CE initiatives to their specific cultural and environmental contexts, ensuring that these projects align with local values and practices. The system fosters a strong sense of ownership and responsibility among community members, which is valuable in the context of the sustainable operation of a CE initiative.

These CEs source their technology and expertise from local private RE companies, ensuring that the solutions are both locally relevant and technically robust. These companies distribute RE products and provide essential services such as solar panel installation and maintenance. Additionally, some CE initiatives are tailored to support Bali's tourism and hospitality sectors. RE solutions are increasingly being utilized by hotels, resorts, and eco-tourism ventures to enhance sustainability and reduce operational costs. For example, solar panels are used to power eco-friendly accommodations and tourist attractions, aligning with the growing demand for sustainable travel options.

Overall, the dynamics between these actors in Bali's CE sector highlight the importance of collaboration, trust-building, and aligning diverse interests towards a common goal of sustainable energy development. Each actor interests and their interactions are further elaborated in Appendix G.

5.1.2. Alignment

The dynamic interplay between various actors in Bali's CE sector highlights a complex landscape of collaboration, trust issues, and diverse interests. Bali's energy landscape has seen numerous RE projects initiated by the government that were subsequently abandoned (Suriyani, 2021b). These projects often faltered due to a combination of bureaucratic inefficiencies, misalignment with local needs, and a lack of sustained engagement with the communities they were meant to serve (Interviewee 3; Interviewee 4). One of the academic researchers specifically mentioned the growing scepticism by the people on every RE-related project:

“The (central) government abandoned their project after G20, leading to public distrust. Now, even a CE initiative requires extra effort to convince the people that they will not abandon them and the project.” (Interviewee 5)

This history of abandoned projects has led to a deep-seated distrust among the Balinese people towards RE initiatives—particularly government-led ones, but not excluding the bottom-up projects as well. The scepticism extends to state-owned companies like PLN and Pertamina, which are seen as extensions of the central government's top-down approach to energy management.

In contrast, Bali's people exhibit a high level of trust and collective action within the framework of their customary villages. These villages operate under traditional governance structures that are deeply rooted in Balinese culture and social norms. Customary villages are not only administrative units but also centres of cultural and spiritual life, making them powerful entities in mobilizing community action and resources

(Interviewee 4). This strong internal cohesion and trust within them facilitate collective decision-making and action, which are critical for the success of community-based initiatives, including those in the RE sector (Guerreiro & Botetzagias, 2018; Sudibia et al., 2017).

Local NGOs leverage this strong communal fabric to implement and sustain CE projects. These organizations work directly with communities to identify their needs, provide education and training, and ensure the technical and operational success of RE installations (Interviewee 2). Such approaches are tailored to local conditions and rely on the active participation of community members, enhancing their sustainability and effectiveness. While local NGOs focus on ground-level engagement, international NGOs provide critical support in terms of funding, technical expertise, and policy advocacy. These organizations act as bridges between local initiatives and global funding sources, helping to secure the financial resources necessary for large-scale implementation of RE projects. They also play a crucial role in shaping policies that create an enabling environment for RE adoption. However, the priorities of international NGOs sometimes align more closely with the interests of their funding providers rather than the immediate needs of the local communities, which can lead to tensions and misalignments in project execution (Interviewee 7; Interviewee 8).

Research entities and universities strive to act as intermediaries between the government, state-owned companies, and local communities (Interviewee 9; Interviewee 10). They conduct essential research, provide feasibility studies, and offer technical training to support RE projects. Despite their efforts, these institutions sometimes struggle with on-ground communication and practical technical capabilities, which can hinder their ability to fully address the immediate needs of local communities and ensure the seamless implementation of projects (Interviewee 2; Interviewee 6).

Customary villages and local CE initiatives often rely on partnerships with the tourism and hospitality industries, which are significant drivers of Bali's economy. RE solutions, such as solar panels, are increasingly being integrated into hotels, resorts, and eco-tourism projects, aligning with the growing demand for sustainable travel options (Interviewee 1; Interviewee 6). Private RE companies provide the necessary technology and expertise, but there is a degree of scepticism among local communities about the profit-driven motives of these enterprises (Interviewee 3; Interviewee 4). This scepticism can create barriers to full acceptance and cooperation, even as these partnerships are crucial for the technical and financial viability of CE projects.

5.2. Shaping Expectations

5.2.1. Internal Expectation



Figure 31. Wordcloud of interview transcripts

Figure 31 shows the general idea of interviews conducted within the topics of CE in Bali. In terms of expectations, there are plentiful mentions of the government (*pemerintah*). Regional government is regarded as the closest state entity to the CE practitioners – providing policy and practical support – albeit in limited amounts. However, there are several statements that show disappointment towards how the national government treat RE projects as monuments and not a potential to increase the province's energy resilience.

There are also a high hopes in a further collaboration between the public mass (*masyarakat*) and the CE initiatives itself (*komunitas*), particularly in the exchange of knowledge and learning experiences.

The Bali Department of Energy (Disnaker ESDM Bali) expects to facilitate the transition to RE through supportive policies and regulatory frameworks. They aim to reduce Bali's reliance on fossil fuels, promote sustainable energy practices, and achieve the regional goal of Net Zero Emissions by 2045. Their expectation is to create an enabling environment that encourages the adoption of CE initiatives, ensuring that these projects align with broader provincial sustainability targets (Interviewee 11).

PLN's expectations are centered around maintaining grid stability and meeting the growing energy demand while integrating RE sources. PLN aims to balance the integration of decentralized CE projects with its existing centralized grid infrastructure. They seek to overcome regulatory and technical challenges to facilitate smoother adoption of RE technologies, ensuring that these projects do not compromise the reliability of the overall electricity supply (Interviewee 8). Pertamina, as a state-owned oil and gas company, is increasingly focusing on RE as part of its corporate strategy. Their expectation is to leverage their resources and infrastructure to support CE projects, particularly in rural areas where traditional energy access is limited. Pertamina aims to align its initiatives with national energy policies and corporate social responsibility (CSR) goals, thereby contributing to sustainable development and enhancing their corporate image (Merdeka.com, 2022).

Private RE companies expect to expand their market and drive innovation in the RE sector. They aim to provide technological solutions and expertise to support CE projects, fostering partnerships with local communities, NGOs, and government bodies. These companies anticipate that increasing demand for clean energy solutions will create business opportunities, enabling them to contribute to Bali's sustainable energy transition while achieving their commercial objectives (Udayana & Kumara, 2020).

Local NGOs expect to empower communities by providing education, technical support, and resources for implementing CE projects. They aim to foster sustainable practices and enhance local capacities to manage and maintain RE systems. NGOs anticipate that their efforts will lead to increased community resilience, improved livelihoods, and a significant reduction in carbon emissions (Interviewee 2; Interviewee 6). On the other hand, international NGOs expect to provide financial support, technical expertise, and policy advocacy to promote CE projects in Bali. Their goal is to align local initiatives with global sustainability targets, facilitating the exchange of knowledge and best practices. These organizations anticipate that their involvement will catalyze the scaling of successful CE models and influence regional and national energy policies (Interviewee 8).

Research entities and universities, such as Udayana University's Center of Excellence Community-Based RE (CORE), expect to bridge the gap between theory and practice by providing research, feasibility studies, and technical training. They aim to support the implementation and optimization of CE projects, ensuring that these initiatives are scientifically sound and technically feasible. Their expectation is to contribute to knowledge dissemination and capacity building within local communities and stakeholders (Interviewee 9; Interviewee 10).

Local CE initiatives expect to harness RE resources to meet their energy needs sustainably. These projects aim to reduce dependency on external energy supplies, lower energy costs, and improve local environmental conditions. By implementing community-driven energy solutions, local initiatives anticipate fostering greater energy independence, community cohesion, and resilience against energy market fluctuations (Interviewee 3; Interviewee 4). Customary villages expect to integrate CE projects within their traditional governance and cultural practices. They aim to use RE to enhance local development while preserving their cultural heritage and natural environment. The customary villages anticipate that these projects will strengthen community bonds and provide sustainable economic opportunities, aligning with their values of environmental stewardship and collective well-being (Interviewee 7).

Project funders, including cooperatives and grant providers, expect to support innovative and impactful CE projects that demonstrate scalability and sustainability. They aim to invest in initiatives that provide tangible environmental and social benefits, ensuring accountability and effective use of funds. Funders

anticipate that their contributions will catalyze broader adoption of RE solutions and contribute to global sustainability goals (Interviewee 1). The hospitality and tourism industry in Bali expects to incorporate RE solutions to enhance their sustainability credentials and reduce operational costs. These businesses aim to meet the increasing demand for eco-friendly tourism options, attract environmentally conscious visitors, and reduce their carbon footprint. The industry anticipates that integrating CE projects will not only support local economies but also enhance the overall attractiveness and competitiveness of Bali as a sustainable tourism destination (Interviewee 6).

The people of Bali expect CE projects to provide reliable, affordable, and sustainable energy solutions. They aim to benefit from reduced energy costs, improved energy security, and enhanced environmental quality. Balinese communities anticipate that these initiatives will support local development, create job opportunities, and preserve their cultural and natural heritage, aligning with their long-standing values of sustainability and collective action (Interviewee 5).

5.2.2. External Expectation

From the national government's perspective, Bali is strategically positioned as a leading region in Indonesia's broader sustainability and energy transition initiatives. The national government perceives Bali not only as a cultural and tourist hub but also as a symbolic leader in the country's commitment to environmental sustainability. Given its international visibility and influence, Bali is expected to pioneer Indonesia's efforts to achieve Net Zero Emissions (NZE) by 2045, a full 15 years ahead of the national target of 2060 (Dewi, 2022). This ambitious expectation is supported by various policy frameworks, including the Bali Clean Energy Policy and other regulations aimed at promoting RE adoption and reducing carbon emissions. The government has also highlighted Bali as a key player in demonstrating Indonesia's dedication to global environmental goals, using the island as a model that can be replicated across other regions in the country (Sabandar, 2015).

However, the reality on the ground shows a mix of progress and ongoing challenges in meeting these expectations. While Bali has made significant strides, particularly with initiatives like the goal of achieving 100% RE in Nusa Penida by 2030, there are still obstacles to overcome (Simanjuntak, 2023). The transition from fossil fuels to RE sources has been slower than anticipated in some areas, and there remains a significant dependence on conventional energy sources. The national government is closely monitoring these developments, with a clear expectation that Bali will accelerate its efforts to align with the ambitious timelines and goals set forth. The province's success in doing so is critical not only for its own sustainability but also for reinforcing Indonesia's position as a leader in the global energy transition.

From the international community's perspective, Bali has long been a focal point for global environmental discussions and initiatives. The island's reputation as a host for major international conferences, such as the G20 Summit, the World Water Forum, and other high-profile environmental meetings, underscores its role as a critical player in the global sustainability narrative. These events have elevated Bali's profile, positioning it as a key location where global leaders, policymakers, and environmental advocates come together to discuss and promote climate action and sustainability. The international community expects Bali to capitalize on this unique position by implementing and showcasing innovative RE solutions that can serve as a model for other regions worldwide. The focus is not only on Bali's capacity to transform its energy landscape but also on its ability to influence global policy and inspire similar actions in other parts of the world.

These expectations are accompanied by substantial international support, both in terms of funding and expertise. International Organizations and NGOs are heavily invested in Bali's energy transition, providing resources and technical assistance to help the island achieve its energy transition target. The international community's involvement reflects a broader belief that Bali can lead by example, demonstrating how sub-national regions can effectively contribute to global sustainability targets. By fulfilling these expectations, Bali

not only enhances its own environmental resilience but also strengthens its role as a global leader in the fight against climate change.

5.2.3. Exogenous Factor

Exogenous factors are external elements that influence the expectations and development of a niche. These factors are beyond the immediate control of the niche actors but significantly impact the niche's evolution. The policy and regulatory landscape plays a crucial role in shaping the expectations surrounding CE in Bali. One significant challenge is the limitations imposed by PLN (Perusahaan Listrik Negara), Indonesia's state-owned electricity company. Installing RE technologies such as solar panels is often complicated by PLN's control over the grid and regulatory restrictions that can delay or impede the integration of decentralized energy sources. However, there have been positive strides by the Bali government to mitigate these challenges. Policies aimed at supporting CE initiatives have been enacted which promotes and catalyses the use of clean energy (Keputusan Gubernur Bali Nomor 879/03-M/HK/2022 Pedoman Teknis Penyelenggaraan Bangunan Gedung Hijau Dalam Rangka Penyelenggaraan Bali Energi Bersih Di Provinsi Bali, 2022; Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021). Additionally, the government shows strong support for customary village-based initiatives, recognizing the unique role of customary village in fostering sustainable development. These regulatory supports create a more favorable environment for CE projects, boosting stakeholder confidence in the viability and future growth of RE in Bali.

Traditional financing for RE projects can be challenging, especially without sustainable practices such as a circular economy. However, emerging alternative financing options provide new avenues for funding CE projects. Credit cooperatives and customary village funds are increasingly being utilized to finance local RE initiatives, allowing communities to invest in and benefit from sustainable energy solutions. Despite these advancements, the challenge of securing adequate and sustainable financing persists. Without proper financial support, CE projects may struggle to maintain operations and expand, limiting their potential impact.

Technological advancements have also significantly influence the expectations surrounding CE in Bali. The cost of RE technologies, particularly solar panels, has decreased substantially in recent years, making it more accessible for communities to adopt these solutions. This reduction in cost, coupled with improvements in technology, enhances the feasibility of implementing RE systems in remote and rural areas. As a result, there is a growing optimism among stakeholders about the potential for widespread adoption of CE initiatives across Bali.

Bali's international exposure as a hub for sustainability, bolstered by hosting climate-related international meetings and the rise of sustainable eco-tourism, contributes to a positive outlook for CE initiatives. Events such as the G20 Summit and other international forums held in Bali highlight the island's commitment to sustainable development and position it as a model for integrating RE solutions within local communities. This global attention helps build momentum for CE projects, fostering a supportive environment for their development and implementation. At the same time, it gives Bali a constant pressure to be an exemplary region in energy transition, which often fell short in temporary and celebratory projects that ended up abandoned (Suriyani, 2021b; Interviewee 8).

While self-managed RE projects offer the potential for community autonomy and sustainability, they often struggle to compete with subsidized electricity provided by PLN. The lower cost of grid electricity can make it difficult for decentralized RE projects to attract investment and achieve financial viability. This competitive disadvantage necessitates additional support mechanisms, such as subsidies or incentives for RE, to level the playing field and ensure the success of CE projects. More often than not, mobilisation of communities to support CE has been cut short by the lack of direct financial incentive or benefit (Interviewee 5).

5.2.4. Endogenous Factor

Endogenous factors are internal elements that influence the development and expectations of a niche. These factors arise from within the niche itself and are largely controlled or directly influenced by the niche actors. Bali's unique cultural and spiritual heritage primarily shapes the vision and goals of its CE initiatives. Sustainable living is deeply embedded in Balinese indigenous knowledge and the values of Bali Hinduism, which emphasize harmony with nature and the importance of maintaining a balanced ecosystem. This cultural backdrop fosters a collective vision of sustainability that aligns with the goals of CE projects. The strong sense of community within Bali is reinforced through the customary village system, where local leaders wield significant influence. The collective nature of Bali's society means that people are more likely to adhere to the directives of village figures than those from government officials, ensuring cohesive and community-driven action towards sustainable energy goals.

The robust network of actors involved in Bali's CE initiatives is another critical endogenous factor. Monthly meetings held by local CE champions and activists provide a platform for exchanging knowledge, exploring collaboration opportunities, and identifying common values. These gatherings foster a strong sense of community and shared purpose among stakeholders, enhancing their collective capacity to drive CE initiatives forward. The active participation and engagement in these networks ensure continuous learning and adaptation, allowing for the refinement of technologies and strategies to better suit local needs and conditions.

Effective resource mobilization is essential for the sustainability and growth of CE initiatives. However, there are significant challenges in this area due to the need for both technical and economic knowledge. Local communities often lack the expertise required to navigate the complexities of RE systems and the associated economic models. This gap creates high expectations for NGOs and research entities to proactively facilitate knowledge exchange and provide the necessary technical support. By doing so, these organizations can empower local communities with the skills and information needed to effectively manage and sustain their CE projects.

Internal management and coordination within CE initiatives often face challenges due to heavy reliance on specific individuals, such as local champions, and the difficulty of organizing communities systematically. The success of many CE projects depends on the leadership and dedication of a few key figures, which can lead to sustainability issues if these individuals are no longer able to participate. Additionally, there can be a lack of systematic organization within communities, and a general reluctance or inability to maintain RE systems over the long term. Addressing these challenges requires building more robust and resilient organizational structures that can support continuous and sustainable efforts in CE initiatives.

5.3. Learning Processes

5.3.1. Technical Development and Infrastructure

Bali is one of the first provinces in Indonesia to make a statement towards regional-scale energy transition. The region is assigned as the centre for the development of clean energy in Indonesia since 2015 by the Ministry of Energy and Mineral Resources (Greenpeace Indonesia, 2018). Later in 2016, the government developed a Clean Energy Centre of Excellence (CoE) in the region as a home for the country's integrated research and learning hub (Hasan, 2016). During this period, the government planned a three-tier framework from 2015-2018 to achieve 100% clean energy within Bali. There are at least four energy sources that were the main focus of the technological development: solar, micro-hydro, waste-to-energy, and biogas. In relation to knowledge dissemination, forms of support consisting of technical information, landscape analysis, project facilitation, and basic knowledge support were promised (Sabandar, 2015). This showed the promise of a learning process between national and regional governments in terms of RE potential and

technology. However, up until 2018, Bali only has one active RE power plant, that is a solar power plant in Bangli Regency (Muhajir, 2018).

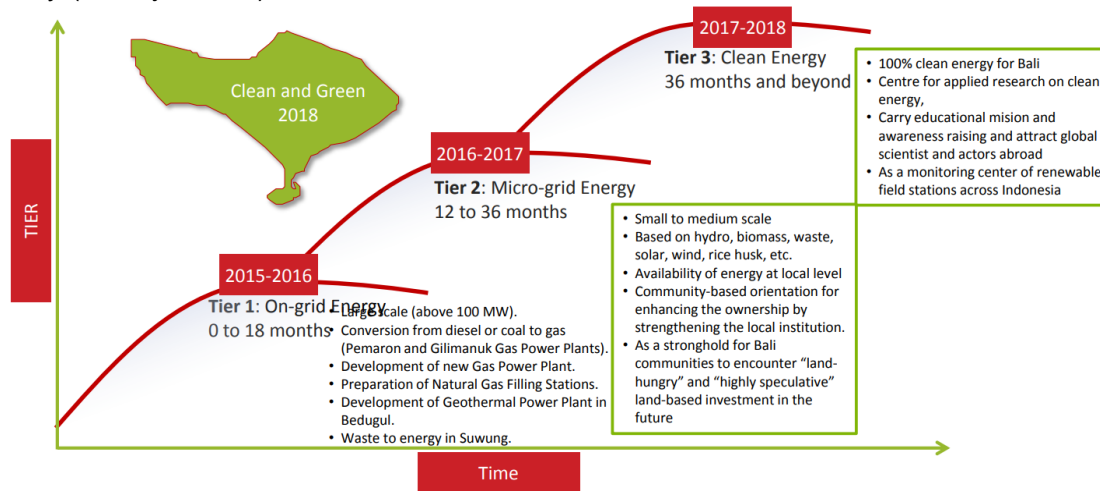


Figure 32. Three-tier plan of Bali Clean Energy CoE 2015-2018 (Sabandar, 2015)

The learning between CE practitioners, whether it is from local initiatives, NGOs, cooperatives, or other activism platforms can be tracked even further. In principle, Balinese people have always been conscious with integrating nature to their daily needs. The water distribution and management system called *subak* has existed since 882 AD. The practice is still preserved today and inherited for generations as a backbone of Bali people’s irrigation method and is now a part of the UNESCO World Heritage list (UNESCO World Heritage Centre, 2012). In the context of RE, the existence of *subak* is pivotal to the implementation of hydropower in Bali, as it is mandatory to involve local cooperatives that manage the *subak* during the execution and operation of the project. Coordination between CE initiatives and *subak* cooperatives allows for not only the participation of different groups of communities impacted by the project but also the exchange of knowledge on micro-hydro technology.

“We need to consult and ask permission to the subak cooperatives before starting the micro-hydro project. The power plant would only reroute the water flow and not disturb the volume distributed, but we still need to make sure that the irrigation purpose is undisturbed.” (Interviewee 7)

Solar PV is a more popular RE technology in Bali, particularly due to the local government’s encouragement of the adoption of rooftop PV (Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021). I Gusti Ngurah Agung Putradhyana (Gung Kayon), an RE activist with a background in architecture is generally known as a figure who has been leading the advocacy of solar PV use in Bali. He got the *Energi Prakarsa Perorangan* (Individual Energy Initiator) award from the Ministry of Energy and Mineral Resource in 2016 for his effort in popularizing the use of solar PV for mass use in Bali. Gung Kayon is well known by most of the interviewees in the research, with several of them having the experience of learning directly from him—proving the pivotal role of a local champion figure within technical knowledge dissemination in the CE realm.

Table 12. Interviewees with direct connections to a certain local champion (Gung Kayon)

No	Interviewee	Quote
1	Interviewee 1	<i>“Gung Kayon helped us to learn about solar PV and apply it in our office.”</i>
2	Interviewee 2	<i>“Before it becomes a trend, he (Gung Kayon) has already advocated the use of solar PV using a solar-powered motorcycle that he built himself.”</i>
3	Interviewee 3	<i>“Gung Kayon is our (a CE initiative) mentor in solar PV.”</i>
4	Interviewee 6	<i>“We often collaborated with Gung Kayon in solar-related projects.”</i>

5.3.2. Industrial Development

In recent years, the learning aspect emphasizes more on understanding a more practical way to adopt the latest RE technologies (Interviewee 2). The decreasing cost and increasing accessibility of technologies such as solar panels and biogas systems have made it more feasible for communities to implement RE projects (Interviewee 1; Interviewee 4). This is further strengthened by the willingness of private distributors to provide aftermarket services such as installation and maintenance (Udayana & Kumara, 2020; Interviewee 8). In this case, the learning process happened between actors within the niche which are closer to the grassroots: NGOs, local initiatives, project funders, and private enterprises (Interviewee 1; Interviewee 8).

Local NGOs, supported by research institutions and private companies, play a vital role in providing technical training and support to ensure that community members can effectively use and maintain these systems. Workshops and hands-on training sessions are essential components of technological learning, where community members learn about installation, maintenance, and troubleshooting of RE systems (Interviewee 3; Interviewee 5). Additionally, there is a focus on integrating traditional knowledge with modern technologies to create solutions that are both innovative and culturally appropriate (Harsamto, 2022; Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali Energi Bersih, 2019). This technological learning process ensures that RE systems are tailored to the specific needs and conditions of Balinese communities, enhancing their effectiveness and sustainability (Interviewee 4; Interviewee 8).

5.3.3. Social and Environmental Context

The social learning process in Bali’s CE landscape is deeply embedded in the island’s cultural and communal practices (Interviewee 4). The high level of trust and collective action within Balinese customary villages provides a unique social fabric that supports the implementation of CE projects. Local NGOs facilitate social learning by organizing workshops, community meetings, and training sessions that educate residents about the benefits and operation of RE systems. Monthly meetings held by CE local champions and activists are crucial for social learning. These gatherings serve as platforms for exchanging knowledge, exploring collaboration opportunities, and finding common values among diverse stakeholders (interviewee 1; Interviewee 6). Social learning in this context also involves adapting RE projects to fit within the cultural and social norms of Balinese communities, ensuring that these projects are not only technically viable but also socially acceptable and supported by the local population. This collective approach fosters a strong sense of

ownership and responsibility towards CE initiatives, enhancing their sustainability and success (Interviewee 7; Interviewee 8).

The environmental learning process within Bali's CE initiatives is significantly enriched by the international exposure the island receives through global meetings and the influx of international tourists and diasporas concerned about sustainability issues. This dynamic interaction fosters a deeper understanding of environmental sustainability and drives the implementation of eco-friendly practices within the local community. Bali has hosted numerous international conferences and summits focused on climate change and sustainability, such as the United Nations Climate Change Conference and the G20 Summit. These events bring together global leaders, environmental experts, and activists who share insights and best practices in sustainable development and RE. The knowledge exchanged during these meetings provides Balinese stakeholders with access to cutting-edge research, innovative technologies, and effective strategies for combating climate change.

For instance, during the G20 Meeting in Bali, there was a discussion on global trends in energy transition, which Bali's CE projects can adapt and implement locally. These discussions highlight the importance of reducing carbon footprints and transitioning to RE sources, reinforcing the environmental benefits of CE initiatives. Moreover, the exposure to international policies and frameworks helps local policymakers align Bali's environmental strategies with global standards, fostering a more integrated approach to sustainability (G20 Indonesia, 2022).

Bali's vibrant tourism industry attracts millions of international visitors annually, many of whom are increasingly conscious of environmental issues. This influx of environmentally aware tourists promotes the exchange of sustainable practices and ideas. Tourists often seek eco-friendly accommodations and activities, which encourages local businesses to adopt RE solutions and other sustainable practices to meet this demand. The feedback and expectations of these visitors drive continuous improvement and innovation in Bali's CE projects. Additionally, the Balinese diaspora and expatriates living on the island play a crucial role in knowledge transfer. Many of these individuals bring expertise and experiences from countries with advanced RE infrastructures.

5.3.4. Development of the User Context

The major cities and regencies in Bali are enjoying the abundance of electricity supply from the Java-Bali grid (Tambunan et al., 2020). However, the case is not the same for other regencies further away from the island's hotspots, particularly the ones in separate, nearby islands such as Nusa Penida and Nusa Lembongan. These other parts of Bali are suffering from constant electrical outages because some of them are not directly connected to the main grid (Interviewee 3). In the mainland, RE is perceived as an interesting alternative source of energy to explore – whether for lifestyle or commercial purpose. On the other hand, the more rural areas of Bali require RE to fulfil their basic needs of electricity supply (Simanjuntak, 2023). The trickier access to those areas also led to the people within it suffer from lack of information exchange and access to all the necessities required to develop their own CE (Interviewee 3; Interviewee 10).

“For us (people living in rural Bali), RE is not an option. It is a necessity to fulfil our energy demand.” (Interviewee 3)

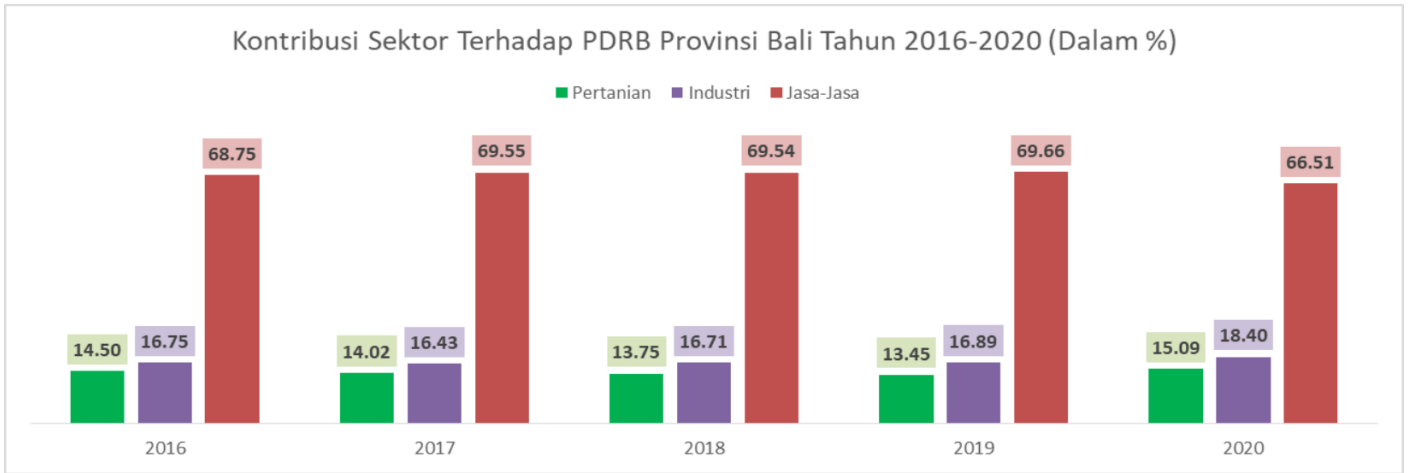


Figure 33. Bali regional income share (Green: Agriculture; Purple: Industry; Red: (Hospitality) Service) (Kharisma, 2024)

Similar to residential sector, tourism sector also heavily reliant on steady supply of electricity. It shares the same grid as residential areas, causing occasional conflict of interest. The Bali people sometimes blame the frequent outages to the excessive use of energy from the hotels, villas, and other tourist lodges (Interviewee 3). Considering that the sector accounts for more than 65% of regional income as shown in Figure 33, there are expectations to enforce a certain grid energy consumption limit towards the tourism enterprises (Kharisma, 2024, Interviewee 3). On the brighter side, the tourism industry practitioners are starting to get aware of the matter and catching up with the trend of eco-tourism – thus implementing RE practices in their energy management system (Chevalier & Budarma, 2016; Interviewee 6)

5.3.5. Government Policy and Regulatory Framework

Political support is crucial for the adoption and scaling of RE technologies. Local NGOs and community leaders engage in active dialogue with policymakers to advocate for favorable policies and regulations that support CE projects. This engagement involves continuous learning about the intricacies of policy-making processes, understanding the political landscape, and leveraging political support to facilitate the implementation of RE projects. Most of the time, CE practitioners are showing lack of interest to follow the progress in policy side due to scepticisms. However, they are also hopeful for the matter considering the constant policy support improvement made by the local government (Interviewee 3; Interviewee 4; Interviewee 7). For instance, the Bali government has enacted supportive policies, that promotes the use of solar rooftop and implementation of green building (Keputusan Gubernur Bali Nomor 879/03-M/HK/2022 Pedoman Teknis Penyelenggaraan Bangunan Gedung Hijau Dalam Rangka Penyelenggaraan Bali Energi Bersih Di Provinsi Bali, 2022; Surat Edaran Nomor 17254 Tahun 2021 Tentang Pemanfaatan Pembangkit Listrik Tenaga Surya (PLTS) Atap Di Provinsi Bali, 2021). This policy framework is a result of extensive lobbying and advocacy efforts by local NGOs and community groups (Interviewee 1). These actors learn to navigate the regulatory environment, build relationships with policymakers, and advocate for changes that can make it easier to install RE technologies despite existing limitations posed by PLN's control over the grid. The support for customary village-based initiatives, recognizing the role of customary villages in fostering sustainable development, is another example of how political learning and advocacy shape the expectations and success of CE projects in Bali (Interviewee 7; Interviewee 11).

Legal learning processes involve understanding the regulatory frameworks and compliance requirements associated with RE projects. This includes navigating the legalities of grid connection, obtaining necessary permits, and ensuring that CE projects comply with local and national laws. Local government and research entities often provide legal guidance and support to community initiatives, helping them understand and meet the regulatory requirements (Interviewee 9; Interviewee 11). Engaging with legal experts and policymakers is a critical aspect of this learning process, as it helps community members and CE project

leaders stay informed about changes in the legal landscape that could impact their projects. Continuous legal learning ensures that CE initiatives are not only compliant but also positioned to take advantage of new regulatory opportunities that may arise, further supporting the growth and sustainability of RE projects in Bali

5.3.6. Resource Potential and Analysis

Bali has substantial solar energy potential, particularly due to its geographic location, which offers high solar irradiance (Greenpeace Indonesia, 2018). For instance, Nusa Penida, an island southeast of Bali, exemplifies this potential with an annual solar energy generation capacity of approximately 4.67 terawatt-hours (TWh). This amount is significantly higher than the island's current electricity demand, suggesting that solar energy alone could potentially cover much of Bali's energy needs if properly harnessed (Sutopo et al., 2019). The expansion of rooftop solar installations, especially in hotels, government buildings, and local businesses, is seen as a crucial step towards Bali's goal of becoming a 100% RE region by 2045 (Sisdwinugraha & Citraningrum, 2024).

Hydropower is another critical component of Bali's RE landscape. The island has a modest but important capacity for hydropower, which is expected to play a foundational role in achieving its low-carbon objectives. The Bali Statement on Powering Sustainable Growth, released during the World Hydropower Congress 2023, emphasized the role of sustainable hydropower in supporting Indonesia's energy transition. The statement advocates for increasing investment in hydropower to double global investment to \$100 billion annually, underscoring hydropower's importance in Bali's energy strategy (International Hydropower Association, 2023).

5.3.7. Economical and Organizational Analysis

Economic learning processes in the context of CE initiatives in Bali revolve around understanding and securing financing mechanisms for RE projects. Traditional financing models often fall short, prompting the exploration of alternative options such as credit cooperatives and customary village funds (Interviewee 1; Interviewee 8). These financial tools are tailored to the local context, allowing communities to invest in RE systems and ensuring that the economic benefits are retained within the community. Learning about these financial mechanisms involves collaborating with financial experts, NGOs, and research institutions to design and implement sustainable financing practices. There is a significant focus on developing economic models that incorporate principles of the circular economy to ensure long-term sustainability. This includes learning how to create revenue streams from RE projects, such as selling excess energy back to the grid or integrating RE into local businesses, such as tourism and agriculture (Interviewee 2). Despite these advancements, challenges remain in ensuring the financial viability of CE projects without consistent and sustainable funding, highlighting the need for continuous economic learning and adaptation

5.4. Niche Shielding

5.4.1. Active Shielding

Active shielding refers to the actions taken to protect and nurture niche innovations from the competitive pressures and established norms of the mainstream market. This concept is essential in SNM as it allows new, sustainable technologies or practices to develop and mature in a supportive environment before they are exposed to broader market forces. In the context of CE in Bali, regulatory supports by the local government has kickstarted a legal form to protect and sustain CE projects from some of the competitive pressures faced by traditional energy sources (Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali

Energi Bersih, 2019). Additionally, financial support from international NGOs and local cooperatives helps to address the initial funding challenges faced by these projects. Research institutions and NGOs offers technical expertise, facilitates research collaborations, provides media exposure, and channels towards funding opportunities that enhance the technological robustness of CE initiatives (Interviewee 2; Interviewee 6; Interviewee 8). Moreover, network-building activities, such as monthly meetings held by CE local champions and activists, create a supportive community that fosters continuous learning and collaboration (Interviewee 1; Interviewee 8).

5.4.2. Passive Shielding

Passive shielding is the inherent protective conditions that naturally arise within a niche environment, providing a buffer against external pressures without deliberate intervention. This type of shielding is crucial in the early stages of niche development as it allows new technologies or practices to grow and evolve with some degree of insulation from the competitive mainstream market. The geographical isolation of many Balinese villages, particularly the ones in Nusa Penida Island, means that CE projects can develop in relative isolation from the competitive pressures of the larger energy market (Interviewee 3). These projects often serve remote areas where the extension of the centralized grid is not economically viable, creating a natural niche for localized RE solutions.

The strong cultural and social norms in Bali provide an additional layer of passive shielding. Bali's unique cultural and social norms play a pivotal role in the development and sustainability of CE initiatives. The island's society is deeply rooted in the principles of harmony between humans, nature, and the spiritual realm. This cultural backdrop naturally aligns with the goals of RE and sustainability, fostering a strong communal support for CE projects. Balinese Hinduism, with its rituals and ceremonies that honor the environment, further reinforces the importance of sustainable living. This cultural framework provides a solid foundation for CE initiatives, as community members are more likely to embrace and support projects that align with their cultural values and environmental ethos. Quoting from one of the CE practitioners:

“Most of Bali RE initiatives were born not because of financial motives, but environmental consciousness and spiritual believes. Sustainable lifestyle has been embedded in the society of Bali since a long time ago.” (Interviewee 4)

The thriving customary village system is integral to the social structure of Bali and play a crucial role in the implementation and success of CE projects. These villages operate under traditional governance systems, which are highly respected and influential among the Balinese people. The leaders of customary villages hold significant authority and can mobilize community members effectively. This communal governance structure ensures that decisions are made collectively, and projects are managed in a way that benefits the entire community. The strong sense of collective identity and responsibility within customary villages means that community members are more willing to participate in and support CE initiatives, viewing them as a means to enhance communal welfare and environmental sustainability. The social fabric of Bali, characterized by high levels of trust and cooperation, significantly enhances the learning processes associated with CE projects. Regular community meetings and the active participation of local champions in these initiatives foster a continuous exchange of knowledge and experiences.

5.5. Niche Empowerment

Given the current monopolistic nature of Indonesia's electricity sector, dominated by PLN, CE actors face significant challenges in attempting to implement strategies that aim to stretch and transform the existing regime. Changing key regime dimensions such as formal institutions and electricity distribution mechanisms remains difficult, as any move towards liberalizing the electricity sector is seen as contravening the

constitution. The government heavily regulates and subsidizes electricity tariffs and controls privatization in the power generation sector through feed-in tariff regulations.

Consequently, niche actors in the CE sector employ fit and conform strategies, particularly with small-scale projects, to carve out a competitive position within Indonesia's electricity landscape. CE initiatives in Bali are more successful in rural areas or regions with high electricity demand but limited supply. Additionally, several CE projects focus on direct use for residential or business purposes, offering marginal benefits. However, these benefits are often insufficient to create a sustainable circular economy for the initiatives themselves.

5.6. Barriers and Opportunities

5.6.1. Political Barriers

Policy and political barriers of CE implementation stem from the broader regulatory and institutional landscape of Indonesia's energy sector, which is tightly controlled by the central government and dominated by PLN (Perusahaan Listrik Negara), the state-owned electricity company. The pervasive distrust towards RE projects within the Bali people is rooted in the history of abandoned government-backed initiatives. Numerous RE projects initiated by the government in the past were either poorly managed or left incomplete, leading to scepticism among local communities and stakeholders. This history of failure undermines the credibility of new CE projects and makes it difficult to gain the trust and support of local communities and potential investors.

5.6.2. Economic Barriers and Opportunities

The lack of sufficient incentives for local champions and CE initiatives themselves is another critical barrier. Local champions, who play a crucial role in advocating for and leading CE projects, often do not receive the necessary financial support or recognition from the government. Without adequate incentives, it is challenging to sustain their motivation and efforts over the long term (Interviewee 4; Interviewee 7). Moreover, CE initiatives frequently struggle to secure funding and subsidies, which are vital for their development and sustainability (Interviewee 2). This lack of financial support makes it difficult for these projects to scale up and become economically viable. It faces more challenges knowing that there is a lack of understanding and willingness among local communities to financially sustain and manage CE projects. Many community members are not fully aware of the long-term benefits and potential cost savings of RE systems, leading to hesitation in investing their resources. This financial illiteracy and lack of managerial skills create substantial obstacles for the ongoing maintenance and operation of CE initiatives, making them vulnerable to failure once initial funding or external support diminishes (Interviewee 2; Interviewee 5).

CE initiatives in Bali struggle to compete with the low price of grid electricity provided by PLN. The heavily subsidized rates offered by PLN make it challenging for decentralized RE projects to offer a competitive alternative. This price disparity discourages investment in CE projects, as the economic incentives appear less attractive compared to the readily available and cheaper grid electricity. Overcoming this barrier requires not only financial support and incentives from the government but also a concerted effort to educate and engage communities about the broader environmental and socio-economic benefits of RE, beyond immediate cost savings (Interviewee 2; Interviewee 6).

Despite the economic barriers faced by CE initiatives in Bali, there are emerging opportunities that can significantly enhance their viability and sustainability. One of the most promising economic opportunities is the rise of alternative funding schemes, such as credit cooperatives, which are increasingly being leveraged to support CE projects. Credit cooperatives, which operate on principles of mutual aid and collective financial

support, offer a viable funding mechanism for CE initiatives. These cooperatives pool resources from their members, providing loans and financial assistance to support community projects (Interviewee 1). In the context of Bali, credit cooperatives can play a crucial role in bridging the financial gap for CE initiatives. They enable communities to access the necessary capital to invest in RE systems, which might otherwise be unattainable through traditional banking or government funding channels. These form of RE credits can be acquired through private cooperatives and customary village cooperatives (Interviewee 8).

5.6.3. Social Barriers and Opportunities

CE social barriers in Bali revolve around the lack of understanding and knowledge among the local population. Many community members have limited awareness of the benefits and operational requirements of RE systems. This lack of knowledge can lead to hesitation and resistance when it comes to adopting new technologies, as people may not fully comprehend how these systems work or the long-term advantages they offer—particularly in financial context.

However, despite these barriers, Bali's unique social fabric presents numerous opportunities that can significantly enhance the success of CE initiatives. One of the most significant social opportunities is the strong sense of collectiveness and community cohesion inherent in Balinese society. This communal spirit is deeply embedded in the island's culture and social structures, which emphasize mutual support and collective action. The existence of customary villages exemplifies this collective ethos. They operate under traditional governance systems that hold considerable influence over local communities. These villages can mobilize residents effectively to participate in and support CE projects, ensuring a high level of community engagement and commitment. The strong bonds between Bali's communities and both local and international NGOs provide a robust support network for CE initiatives. These collaborations enhance the capacity of local communities to manage and sustain CE projects effectively, creating a supportive environment for innovation and sustainable development.

Indigenous wisdom and Hinduism values also play a pivotal role in shaping positive attitudes towards RE in Bali. These cultural and religious values foster a deep respect for the environment and a strong commitment to preserving natural resources. By integrating these values into CE projects, stakeholders can enhance community buy-in and ensure that RE initiatives resonate with local beliefs and practices—albeit suboptimal economic benefit, for instance. The communal spirit, the influential role of customary villages, the supportive network of local and international NGOs, and the alignment of RE with indigenous wisdom and Hinduism values all contribute to a fertile ground for the successful implementation and sustainability of CE projects.

5.6.4. Technological Opportunities

The most significant technological opportunities for CE initiatives in Bali is the increasing affordability and accessibility of RE technologies. Over the past decade, there has been a substantial reduction in the cost of RE systems, particularly solar photovoltaic (PV) panels and battery storage solutions. This trend is driven by advances in manufacturing processes, economies of scale, and technological innovation, making these technologies more attainable for communities in Bali and around the world. The cost of solar PV panels has dropped dramatically, with prices decreasing by more than 80% since the past decade (IRENA, 2019; Interviewee 1; Interviewee 4). This reduction has made it feasible for even small communities and individual households to invest in solar energy systems. The lower upfront costs, combined with the decreasing cost of battery storage, enable communities to harness solar power more effectively, providing a reliable and sustainable energy source that can meet local needs. These advancements have made solar energy an attractive option for off-grid areas in Bali, where extending the conventional electricity grid may be prohibitively expensive.

Additionally, the efficiency and durability of RE technologies have improved significantly. Modern solar panels have higher conversion efficiencies, meaning they can generate more electricity from the same amount of sunlight. Similarly, advancements in battery technology have increased storage capacities and reduced degradation rates, ensuring longer lifespans and better performance. These improvements enhance the economic viability of RE systems, offering long-term savings and reduced maintenance costs.

5.6.5. Legal Barriers

Major legal barrier in the development of CE is the restrictive policies and bureaucratic hurdles imposed by the central government. For instance, the requirement for high local content (Tingkat Komponen Dalam Negeri or TKDN) in RE projects limits the choice of technology and equipment, often leading to higher costs and delays (Interviewee 9). Additionally, the complex and slow bureaucratic processes required to integrate CE systems into PLN's grid further hinder the implementation of these projects. There are cases when CE initiatives are in fear of being charged more due to not complying with PLN's grid regulation, which already difficult to access in the first place (Interviewee 3; Interviewee 4). The need to navigate through multiple layers of regulation and obtain various approvals can be time-consuming and discouraging for CE developers.

5.6.6. Environmental Opportunities

Bali is a globally recognized tourist destination, attracting millions of visitors annually. Many of these tourists are increasingly conscious of environmental issues and seek sustainable travel options. This growing demand for eco-friendly tourism provides a powerful incentive for local businesses to adopt RE solutions and sustainable practices. Local communities and businesses are becoming more aware of the environmental and economic benefits of RE. Educational campaigns and initiatives by local NGOs and international organizations have played a significant role in raising awareness about sustainability. This increased awareness is fostering a cultural shift towards greater environmental responsibility and support for RE projects. The traditional Balinese philosophy of Tri Hita Karana, which emphasizes harmony between humans, nature, and the spiritual realm, aligns well with these sustainability goals. By integrating RE into their operations, businesses and communities can enhance their environmental credentials, attract environmentally conscious tourists, and contribute to the island's overall sustainability.

Bali has abundant natural resources that are ideal for RE production. The island receives ample sunlight throughout the year, making it an excellent location for solar energy projects. The high levels of solar insolation mean that solar photovoltaic (PV) systems can generate substantial amounts of electricity, contributing significantly to the island's energy mix. Additionally, Bali's geographical features offer potential for other forms of RE. The island's mountainous regions and river systems provide opportunities for small hydroelectric power projects, which can generate clean energy while supporting local water management needs. Furthermore, Bali's agricultural economy is a hotbed for biomass-based power generation, ensuring a diversified and resilient energy supply.

6 Discussions

6.1. Bali as an International Hub

One of the most notable events hosted by Bali was the United Nations Climate Change Conference in 2007, also known as COP13. This conference was a critical moment in international climate negotiations, resulting in the Bali Roadmap. The Bali Roadmap laid out a two-year process for finalizing a binding agreement to succeed the Kyoto Protocol, setting the stage for subsequent climate agreements. The conference brought together representatives from over 180 countries, highlighting Bali's capacity to facilitate large-scale international negotiations and its role in shaping global climate policy.

Bali has also hosted various international meetings focused on sustainable tourism. The island's natural beauty and cultural heritage make it an ideal location for discussions on balancing tourism development with environmental conservation. Events like the Global Sustainable Tourism Conference have been held in Bali, bringing together experts, policymakers, and stakeholders to discuss best practices in sustainable tourism. These conferences emphasize the importance of protecting Bali's ecosystems while supporting the local economy, demonstrating the island's commitment to sustainability in its tourism sector.

In addition to climate change and sustainable tourism, Bali has been a venue for international meetings on marine conservation. The island hosted the World Ocean Summit, which focused on strategies for preserving marine biodiversity and addressing the impacts of climate change on ocean ecosystems. By hosting such events, Bali underscores its role in global marine conservation efforts and highlights the importance of protecting the marine environment for future generations.

Recently, Bali hosted the World Water Forum, which gathered experts, policymakers, and stakeholders to discuss global water issues, including water scarcity, pollution, and sustainable management of water resources. The forum provided a platform for sharing knowledge and strategies to tackle water-related challenges, emphasizing the critical role of water in sustainable development and climate resilience. Hosting this forum reinforced Bali's position as a hub for environmental discourse and highlighted the island's proactive approach to addressing complex global issues.

The high-profile international meetings hosted in Bali create significant opportunities for the development of CE projects on the island. These events draw global attention and resources, fostering an environment conducive to innovation and investment in sustainable energy solutions. The discussions and collaborations that take place at these conferences can directly support CE initiatives by attracting international funding, expertise, and partnerships. For example, the emphasis on sustainable tourism and marine conservation aligns with CE projects that aim to provide RE solutions tailored to local needs and environmental conditions.

Moreover, the local and international networks established through these forums can enhance community engagement and support for CE projects. By integrating the insights and best practices shared during these international meetings, Bali can develop robust CE projects that leverage both traditional wisdom and modern technology. This approach not only aligns with Bali's cultural values of harmony with nature but also contributes to the island's broader sustainability and climate goals. In conclusion, Bali's role in hosting international meetings on sustainability and climate change positions the island as a leader in environmental innovation and provides a strong foundation for the successful development of CE projects.

6.2. Government “Versus” Local Champions

The development of CE projects in Bali reveals a significant tension between government authorities and local champions. This tension is rooted in differing priorities and approaches to energy development and sustainability. The Balinese government, through its policies and regulations, aims to promote RE to meet national and international sustainability goals. Initiatives such as the Peraturan Gubernur Bali No. 45/2019 on Clean Energy reflect a top-down approach to achieving a cleaner energy mix. However, these policies often encounter resistance from local communities who feel that their unique needs and perspectives are not adequately considered in government-led projects.

Table 13. Interviewee quotes on scepticism towards the government

No	Interviewee	Quote
1	Interviewee 1	<i>“We hope that the government start focusing more on what actually matters and less about personal interests.”</i>
2	Interviewee 3	<i>“Government-led projects are often done hastily without community participation and mentorship.”</i>
3	Interviewee 4	<i>“It is hard to put too much trust in the government nowadays.”</i>
4	Interviewee 8	<i>“Government tend to build monumental RE projects without a clear purpose that ended up abandoned, therefore building distrust within the community.”</i>

Local champions of CE projects in Bali, including community leaders, NGOs, and grassroots organizations, advocate for energy solutions that are tailored to the specific socio-cultural and environmental contexts of their communities. They emphasize the importance of integrating traditional wisdom and local knowledge into RE initiatives. For instance, many local groups favor small-scale, community-managed RE projects that align with Balinese cultural values of sustainability and harmony with nature. These local champions often express frustration with what they perceive as the government's one-size-fits-all approach, which can overlook the nuanced requirements of different communities and lead to projects that are less effective or culturally insensitive.

The conflict is further exacerbated by the bureaucratic hurdles and complex regulatory requirements imposed by the government. Local champions often struggle to navigate these processes, which can delay or even halt the implementation of CE projects. This bureaucratic complexity can be particularly challenging for smaller community groups that lack the resources and expertise to comply with intricate regulatory demands. As a result, there is a growing sense of disenfranchisement among local champions, who feel that the government's regulatory framework is more of an obstacle than a facilitator of sustainable energy development.

Financial disparities also contribute to the tension. While the government may have access to international funds and national budgets, local communities often rely on smaller grants and local fundraising efforts to support their projects. This financial imbalance can lead to situations where government-supported projects overshadow community-led initiatives, despite the latter potentially offering more culturally appropriate and locally accepted solutions. The disparity in funding and support further fuels the perception that government policies prioritize large-scale, commercially viable projects over community-based, inclusive energy solutions.

Efforts to reconcile these tensions include increasing dialogue and collaboration between the government and local champions. Some initiatives aim to create platforms for local voices to be heard in policy-making processes, ensuring that CE projects are co-designed with community input. For example, stakeholder meetings and participatory planning sessions can help bridge the gap, fostering mutual understanding and more equitable energy solutions. By recognizing and addressing the unique contributions of local champions, the government can enhance the effectiveness and acceptance of CE projects, paving the way for a more inclusive and sustainable energy future in Bali.

In summary, the tension between the Balinese government and local champions in CE development is evident in their differing priorities, bureaucratic challenges, financial disparities, and the need for better collaboration. Addressing these issues through inclusive and participatory approaches can help harmonize efforts and ensure that CE projects are both effective and culturally appropriate, benefiting all stakeholders involved.

6.3. Roles of Customary Villages

Customary villages play a crucial role in the development of CE projects in Bali. These villages are integral to Balinese society, governed by traditional laws and customs that emphasize communal decision-making and sustainable living. They are often seen as custodians of the island's cultural and environmental heritage, making them vital stakeholders in any initiative aimed at promoting sustainability and RE.

The unique governance structure of customary villages allows for a high degree of community involvement and consensus-based decision-making. This participatory approach is particularly beneficial for CE projects, which require local buy-in and active participation for successful implementation and maintenance. By leveraging their traditional leadership and organizational frameworks, customary villages can facilitate the acceptance and integration of RE technologies within their communities. For example, community meetings and traditional councils (*banjar*) provide platforms for discussing and planning CE projects, ensuring that they align with local needs and values.

Furthermore, the deep-rooted cultural emphasis on harmony with nature (*Tri Hita Karana*) among villages aligns seamlessly with the principles of RE and sustainability. This cultural philosophy, which promotes balance between human, environmental, and spiritual well-being, naturally supports the adoption of clean energy solutions. Projects such as community-managed micro-hydro systems or solar panels are often more readily accepted and maintained because they resonate with these long-standing values.

Additionally, they have the potential to serve as influential examples for other communities. Successful CE projects in these villages can demonstrate the viability and benefits of RE, inspiring neighboring communities and garnering broader support across the island. The communal nature also means that knowledge and best practices can be shared more easily within and between villages, fostering a collaborative approach to CE development. However, the involvement of customary villages in CE development is not without challenges. Traditional governance structures must navigate modern regulatory frameworks and technological complexities, which can sometimes lead to friction or delays. Ensuring that traditional leaders are adequately informed and supported in these processes is crucial for bridging any gaps between customary practices and modern energy solutions.

In conclusion, customary villages are pivotal to the successful development of CE projects in Bali. Their deep-rooted cultural values, participatory governance structures, and influential role within Balinese society make them essential partners in promoting sustainable energy solutions. By integrating traditional wisdom with modern RE technologies, customary villages can help drive a more sustainable and resilient energy future for Bali.

6.4. Post-pandemic Rebound

Before the COVID-19 pandemic, Bali was steadily progressing in its efforts to develop CE projects as part of its broader sustainability goals. The island had been leveraging its international profile from hosting significant climate and sustainability conferences to attract attention and support for RE initiatives. Various projects, such as community-managed solar power systems and micro-hydro installations, were being piloted in rural areas, driven by a combination of governmental support, international partnerships, and the active involvement of local communities. The economic benefits of these projects were beginning to be realized, as they not only provided clean energy but also created jobs and fostered local enterprise.

The COVID-19 pandemic brought unprecedented challenges to Bali, significantly disrupting its economy, which heavily relies on tourism. With the drastic decline in tourist arrivals due to global travel restrictions, Bali faced an economic crisis that exposed the vulnerabilities of its tourism-dependent economy. The financial strain affected all sectors, including the development and maintenance of CE projects. Funding became more challenging to secure as both public and private resources were redirected towards immediate pandemic response and economic relief efforts. Moreover, logistical issues and movement restrictions hampered the implementation and scaling of ongoing CE projects.

The pandemic also highlighted the critical need for resilient and sustainable energy solutions. With reduced tourism activity, many local communities faced economic hardships, emphasizing the importance of diversifying income sources and enhancing energy security. This period underscored the potential of CE projects to provide stable energy and economic benefits, even in times of crisis. Despite the setbacks, some communities continued to push forward with their RE initiatives, recognizing their long-term importance for sustainability and resilience.

As Bali moves towards post-pandemic recovery, there is a renewed focus on building a more sustainable and resilient economy. The economic crisis triggered by the pandemic has spurred a re-evaluation of Bali's economic dependencies, with a growing recognition of the need to diversify beyond tourism. CE projects are seen as a critical component of this new economic strategy. The government, along with international partners and local communities, is working to revitalize and expand RE initiatives. There is an increased emphasis on securing funding and investments to support CE development, including grants, low-interest loans, and international aid.

The pandemic has also accelerated the adoption of digital tools and remote collaboration, facilitating the exchange of knowledge and best practices for CE projects. Efforts are being made to strengthen local capacities through training and education, ensuring that communities are better equipped to manage and maintain RE systems. Additionally, the crisis has fostered a stronger sense of community and cooperation, essential for the collective success of CE projects.

In conclusion, the COVID-19 pandemic has been a catalyst for both challenges and opportunities in the development of CE in Bali. The pre-pandemic momentum faced significant disruptions, but the economic crisis underscored the importance of sustainable energy solutions. As Bali rebuilds, CE projects are poised to play a crucial role in creating a more resilient and diversified economy, supported by enhanced local capacities and stronger international and community partnerships.

6.5. Replicability of Best Practices

Bali presents a unique landscape for CE development, characterized by its rich cultural heritage, strong community structures, and a vibrant tourism industry. The island's distinct cultural and social fabric plays a crucial role in the successful implementation of CE projects. The presence of *customary villages* and the principle of harmony among people, nature, and the spiritual realm align with the goals of RE and sustainability. This cultural alignment has facilitated community acceptance and active participation in CE projects, making Bali an exemplary model for integrating traditional wisdom with modern RE technologies.

The supportive policy environment in Bali also contributes to its unique position. As a special province, Bali is allowed to develop their own policies that often bypass the complicated bureaucracies often suffered by other provinces in Indonesia. Furthermore, Bali's international profile, enhanced by hosting significant climate and sustainability conferences, attracts global attention and resources, fostering a conducive environment for CE initiatives. These factors collectively create a robust ecosystem for CE development, positioning Bali as a leader in community-driven RE projects.

However, replicating Bali's success in other parts of Indonesia poses several challenges. One significant challenge is the diverse cultural and social landscapes across the Indonesian archipelago. Unlike Bali, where the customary village system is well-established, other regions may not have similarly strong community structures or cultural values that align with sustainability principles. This variability can impact community engagement and the effectiveness of CE projects. Additionally, the regulatory and policy environment in other regions may not be as supportive or well-developed, posing further challenges for the implementation of CE initiatives.

Financial and technical barriers are also more pronounced in less developed regions. While Bali benefits from substantial international attention and funding, other parts of Indonesia may struggle to secure the necessary financial resources and technical expertise to develop and maintain CE projects. The logistical challenges of working in remote or underdeveloped areas, including limited infrastructure and access to technology, further complicate the replicability of Bali's model.

Moreover, the economic dynamics differ significantly across Indonesia. Bali's economy, driven largely by tourism, creates a unique context where CE projects can also support economic diversification and resilience. In contrast, other regions may rely on different economic drivers, such as agriculture or mining, which could influence the priorities and feasibility of CE projects. Addressing these regional differences requires tailored approaches that consider local contexts and needs.

In conclusion, while Bali's unique cultural, social, and economic landscape has made it a successful model for CE development, replicating this success in other parts of Indonesia involves navigating a range of challenges. These include diverse cultural and social dynamics, varying levels of regulatory support, financial and technical barriers, and differing economic contexts. To effectively replicate Bali's CE initiatives, it is essential to adopt flexible and context-specific strategies that engage local communities, align with regional priorities, and leverage appropriate resources and technologies.

7 Conclusions and Recommendations

7.1. Conclusion

7.1.1. What is the current stage of CE initiatives in Bali?

CE initiatives in Bali are currently at an intermediate stage of development, characterized by a blend of pilot projects, growing community involvement, and supportive policy frameworks, but still facing significant challenges to full-scale implementation and sustainability. Numerous pilot projects have been established across the island, particularly in rural areas where traditional values and the principles of Tri Hita Karana—the Balinese concept of harmony among people, nature, and the spiritual realm—are strong. These projects include community-managed solar power systems, micro-hydro installations, and biogas units. These initiatives have not only provided RE solutions but also fostered local economic development and job creation. Community involvement is high, with local champions and customary villages playing crucial roles in the planning and implementation of these projects. This high level of community engagement is vital for the acceptance and sustainability of CE initiatives in Bali.

The policy environment in Bali is increasingly supportive of CE initiatives. Regulations such as Peraturan Gubernur Bali Nomor 45 Tahun 2019 Tentang Bali Energi Bersih (2019) provide a framework for promoting RE development. These policies aim to reduce the island's reliance on fossil fuels and transition to a more sustainable energy system. Additionally, Bali's role as a host for international sustainability and climate change conferences has helped attract international attention and resources, further bolstering the development of CE projects.

Despite these positive developments, several challenges remain. Financial and technical barriers continue to hinder the scaling up of CE projects. While international funding and grants are available, accessing these resources can be complex and competitive. Local communities often lack the technical expertise required for the development and maintenance of advanced RE systems, leading to reliance on external experts. Moreover, the economic impact of the COVID-19 pandemic has strained financial resources, redirecting focus and funds towards immediate economic recovery efforts. The tension between government authorities and local champions also presents a significant challenge. Differing priorities and approaches can lead to conflicts and delays in project implementation. Government-led projects may not always align with the specific needs and cultural contexts of local communities, emphasizing the need for better communication and collaboration between stakeholders.

7.1.2. What are the roles of the stakeholders in the development of CE initiatives in Bali?

The development of CE initiatives in Bali involves a diverse array of stakeholders, each playing a crucial role in promoting and supporting these projects. These stakeholders include the Balinese government, local communities, non-governmental organizations (NGOs), international organizations, academic institutions, and the private sector. The Balinese government, through various regulatory and policy frameworks, plays a central role in facilitating the development of CE initiatives. Key policies provide a supportive regulatory environment aimed at promoting RE projects. The government is responsible for setting RE targets, providing subsidies and incentives, and simplifying the permitting process for CE projects. Additionally, government

agencies such as the Bali Department of Energy are involved in overseeing and coordinating these initiatives, ensuring they align with regional and national sustainability goals.

Local communities and customary villages are pivotal in the grassroots implementation and acceptance of CE projects. These customary villages operate based on traditional governance structures and communal decision-making processes, which are essential for the planning and execution of CE initiatives. Customary village leaders and community members actively participate in project development, ensuring that RE solutions are culturally appropriate and aligned with local values of sustainability and harmony with nature. Their involvement is critical for gaining community buy-in and ensuring the long-term success and maintenance of CE projects.

NGOs play a vital role in advocating for CE projects, providing technical expertise, and facilitating community engagement. Organizations such as the World Resources Institute (WRI) and local environmental groups work closely with both government bodies and local communities to promote RE solutions. They often bridge the gap between policy and practice by helping to design and implement CE projects, conducting educational workshops, and providing resources and support to local champions. NGOs also play a crucial role in securing funding and fostering international collaborations that bring additional expertise and resources to Bali. International organizations and donors are significant stakeholders in the development of CE initiatives in Bali, providing essential financial and technical support. Programs like the Bali Clean Energy Program, supported by the United States Agency for International Development (USAID), offer grants, low-interest loans, and technical assistance for RE projects. These organizations help to introduce best practices and innovative technologies, enabling Bali to advance its CE initiatives more effectively. Their involvement also helps to raise Bali's profile as a leader in sustainable energy, attracting further international investment and support.

Research institutions in Bali, such as Universitas Udayana, contribute to the development of CE projects through research, innovation, and education. These institutions conduct studies on RE potential, develop new technologies, and provide training programs to build local capacity. They also serve as a knowledge hub, facilitating the exchange of information and best practices between researchers, practitioners, and policymakers. By engaging students and researchers in CE projects, academic institutions help to cultivate the next generation of RE experts and advocates.

The private sector is increasingly becoming involved in CE development in Bali, providing investment, technological solutions, and project management expertise. Companies specializing in RE technologies, such as solar and wind power, collaborate with local communities and government bodies to implement CE projects. The involvement of the private sector is crucial for scaling up CE initiatives, bringing efficiency, innovation, and financial resources to the table. Private companies also play a role in creating market mechanisms and business models that make RE projects economically viable and sustainable.

7.1.3. What are the factors that influence the development of CE initiatives in Bali?

The development of CE initiatives in Bali is influenced by a complex interplay of regulatory, cultural, financial, technical, and economic factors. A key factor is the regulatory framework and government policies. Bali has implemented supportive policies that helps the province to adopt RE technology faster than other parts of Indonesia. These policies create a conducive environment for RE development, but their inconsistent implementation and bureaucratic hurdles can impede progress. Effective regulatory support is crucial for overcoming these challenges and ensuring the successful deployment of CE initiatives.

Cultural and social dynamics also play a significant role in the acceptance and success of CE projects in Bali. The island's strong communal values and the principles of harmony among people, nature, and the spiritual realm align well with the goals of RE and sustainability. The involvement of customary villages and their traditional governance structures facilitates community participation and consensus-based decision-making, which are essential for the planning and execution of CE projects. This cultural alignment fosters

community buy-in and active participation, ensuring that CE projects are both accepted and sustained over the long term.

Access to financial resources is another critical factor influencing the development of CE initiatives. Funding for these projects often comes from a mix of government subsidies, international grants, and private investments. Programs like the Bali Clean Energy Program, supported by organizations such as USAID, provide essential financial assistance. However, securing these funds can be competitive and complex, particularly for smaller communities that may lack the capacity to navigate intricate application processes. Financial constraints can thus limit the scale and scope of CE projects, highlighting the need for more accessible and streamlined funding mechanisms.

Technical expertise and capacity within local communities are also significant factors. Many CE projects require specialized knowledge and skills for their design, implementation, and maintenance. In Bali, partnerships with academic institutions like Universitas Udayana and international organizations help provide the necessary technical support and capacity-building. Training programs and workshops are crucial for equipping local communities with the skills needed to manage these projects independently. However, reliance on external experts can be costly and unsustainable, underscoring the importance of ongoing local capacity development.

The economic impact of external events, such as the COVID-19 pandemic, has also profoundly affected the development of CE initiatives. The pandemic severely disrupted Bali's economy, which is heavily reliant on tourism, leading to an economic crisis that diverted attention and resources away from RE projects. Financial strain affected all sectors, including the development and maintenance of CE projects. However, the pandemic also highlighted the importance of energy resilience and the potential of CE projects to provide stable energy sources and economic benefits in times of crisis. This has spurred a renewed focus on sustainable energy solutions as part of Bali's economic recovery strategy.

7.1.4. How can Bali address the barriers and utilize the drivers of CE development to foster its growth?

To effectively address the barriers hindering the development of CE initiatives in Bali, several strategic actions need to be taken. One significant barrier is the complex regulatory environment and bureaucratic hurdles. Streamlining the regulatory process and simplifying the permitting procedures can facilitate quicker and more efficient implementation of CE projects. The Balinese government can enhance transparency and reduce bureaucracy by adopting digital platforms for permit applications and approvals. Additionally, regular updates and clear guidelines on policy implementation can help local communities and developers navigate the regulatory landscape more effectively.

Financial constraints are another major barrier. Securing funding for CE projects can be challenging, especially for smaller communities. To address this, the government and international partners can establish dedicated funding mechanisms that provide grants and low-interest loans specifically for CE initiatives. Simplifying the application process for these funds and providing technical assistance to help communities prepare strong proposals can increase access to financial resources. Additionally, creating public-private partnerships can attract private investment and share the financial burden of developing and maintaining CE projects.

The lack of technical expertise within local communities also poses a challenge. Investing in education and capacity-building programs is crucial to equip community members with the necessary skills to manage and maintain CE projects. Partnerships with academic institutions like Universitas Udayana and international organizations can provide training workshops, certification programs, and ongoing technical support. Developing a local workforce skilled in RE technologies ensures the sustainability and scalability of CE initiatives.

Several factors can drive the growth of CE initiatives in Bali, and leveraging these drivers is essential for fostering development. One of the key drivers is Bali's cultural and social alignment with sustainability

principles. Balinese philosophy, which promotes harmony among people, nature, and the spiritual realm, aligns perfectly with the goals of CE projects. By highlighting the cultural relevance and environmental benefits of RE, CE initiatives can gain stronger community support and participation. Engaging village leaders and involving them in project planning and decision-making can further enhance community buy-in and ensure that projects are culturally appropriate.

Bali's international profile and its role in hosting significant climate and sustainability conferences provide a unique opportunity to attract global attention and resources. Leveraging this international exposure can help Bali secure funding, technical expertise, and partnerships to support CE projects. By positioning itself as a leader in sustainable energy, Bali can attract investment from international donors, NGOs, and private sector companies interested in RE development. These collaborations can bring in the necessary resources and innovative solutions to overcome existing barriers.

Another driver is the potential for economic diversification through CE projects. The COVID-19 pandemic has exposed the vulnerabilities of Bali's tourism-dependent economy, highlighting the need for alternative sources of income. CE initiatives can create jobs, stimulate local economies, and provide stable energy sources, contributing to economic resilience. Promoting the economic benefits of CE projects, such as job creation and energy cost savings, can garner broader support from both the government and local communities.

7.2. Academic Contribution

This research extends the application of the SNM framework to the context of a developing region with unique socio-cultural dynamics. Most SNM studies have focused on industrialized nations with advanced technological and regulatory infrastructures. By applying SNM to Bali, the research enriches the theoretical framework by incorporating elements such as cultural heritage, traditional governance systems, and community-led initiatives. This broadened application demonstrates the versatility of SNM and provides a more comprehensive understanding of how niche innovations can be nurtured and empowered in diverse settings.

The study offers valuable insights into the role of cultural and social factors in the adoption and success of CE initiatives. Bali's emphasis on harmonisation of anthropological and natural value as well as the involvement of villages illustrate how deeply embedded cultural values can align with and support sustainable energy transitions. This finding is crucial for policymakers and practitioners aiming to implement RE projects in culturally rich and diverse regions. The research highlights the importance of culturally sensitive approaches that respect and leverage local traditions and values to foster community acceptance and participation.

The research provides practical policy implications by identifying specific barriers and drivers of CE development in Bali. It underscores the need for streamlined regulatory processes, accessible funding mechanisms, and robust capacity-building programs. These insights can inform the design of more effective policies and interventions that address the unique challenges faced by CE initiatives in similar contexts. Furthermore, by showcasing successful case studies and pilot projects, the research offers replicable models that can guide CE development in other regions of Indonesia and beyond.

7.3. Recommendations

7.3.1. Recommendations for Policymakers

Based on the result of the research, policymakers should work towards simplifying and streamlining regulatory processes for CE projects. This can be achieved by reducing bureaucratic hurdles and ensuring that permitting procedures are clear, transparent, and efficient. Implementing digital platforms for permit applications and approvals can facilitate quicker and more efficient processes. Regular updates and clear

guidelines on policy implementation will help local communities and developers navigate the regulatory landscape more effectively, thereby accelerating the deployment of CE initiatives.

To address financial barriers, the establishment of dedicated funding mechanisms that provide grants and low-interest loans specifically for CE initiatives is proven to be crucial. These funding mechanisms should be accessible, with simplified application processes to encourage participation from smaller communities. Additionally, creating public-private partnerships can attract private investment and share the financial burden of developing and maintaining CE projects. Policymakers should also consider leveraging international aid and grants, ensuring that these resources are effectively channelled to support CE development in Bali.

Building local capacity is crucial for the long-term sustainability of CE projects. Policymakers should invest in education and training programs to equip community members with the necessary skills to manage and maintain CE systems. Partnerships with academic institutions like Universitas Udayana and international organizations can provide valuable technical support and capacity-building initiatives. Developing a local workforce skilled in RE technologies ensures that communities can independently sustain and scale CE projects over time. Recognizing and leveraging Bali's cultural values can significantly enhance the acceptance and success of CE projects. Policymakers should engage with village communities and local leaders in the planning and decision-making processes of CE initiatives.

The economic impact of the COVID-19 pandemic has highlighted the need for economic diversification in Bali, which heavily relies on tourism. Policymakers should promote CE initiatives as a means to create jobs, stimulate local economies, and provide stable energy sources. Highlighting the economic benefits of CE projects, such as job creation and energy cost savings, can garner broader support from both the government and local communities. This approach not only supports economic resilience but also enhances the overall sustainability of the energy system in Bali.

7.3.2. Recommendation for Researchers

Researchers should embrace interdisciplinary approaches to studying CE development in Bali. Understanding the complexities of CE projects requires integrating knowledge from various fields, including engineering, economics, sociology, and environmental science. Given Bali's unique cultural and social dynamics, researchers should also prioritize studies that are sensitive to local contexts. Engaging with local communities and leaders through participatory research methods can yield valuable data that respects and incorporates local knowledge and perspectives, enhancing the relevance and impact of research outcomes.

Exploring innovative economic and financial models is essential for scaling CE projects. Researchers should study different funding mechanisms, including grants, low-interest loans, public-private partnerships, and community crowdfunding, to determine the most effective ways to finance CE initiatives—considering the non-profit nature of CE in Indonesia. Additionally, examining the economic impacts of CE projects, such as job creation and energy cost savings, can provide compelling evidence to support the expansion of these initiatives.

Longitudinal studies that track the development and outcomes of CE projects over time are crucial for understanding their long-term viability and impact. Researchers should design studies that monitor various aspects of CE projects, including technical performance, economic benefits, social acceptance, and environmental impacts. Long-term data can reveal trends, successes, and areas for improvement, providing a solid foundation for future CE development strategies.

7.4. Limitations

One significant limitation of this research is its limited geographic scope, focusing primarily on Bali. While Bali provides a unique and culturally rich context for studying CE initiatives, the findings and recommendations may not be directly applicable to other regions in Indonesia or globally. Bali's specific cultural, social, and regulatory environment plays a significant role in shaping the success of CE projects, and

these factors can differ widely in other areas. Therefore, while the insights gained are valuable, they need to be adapted and tested in different contexts to evaluate their broader applicability.

The research may also be constrained by the availability and quality of data. Reliable and comprehensive data on CE initiatives, including technical performance, economic impacts, and social acceptance, can be challenging to obtain. In many cases, data may be fragmented, outdated, or inconsistent, which can affect the accuracy and robustness of the analysis. This limitation underscores the need for improved data collection and management practices to support ongoing and future research in this field. Another limitation is the temporal scope of the research. The dynamic nature of RE policies, technological advancements, and socio-economic conditions means that the findings may become outdated relatively quickly. For instance, changes in government policies, technological breakthroughs, or significant economic shifts (such as those caused by the COVID-19 pandemic) can alter the landscape of CE development rapidly. Longitudinal studies are needed to capture these changes over time and provide more enduring insights.

The research might not fully capture the diverse perspectives of all stakeholders involved in CE initiatives. While efforts are made to include views from government agencies, local communities, NGOs, and the private sector, there is always a risk of some voices being underrepresented. Ensuring comprehensive stakeholder engagement is crucial for obtaining a holistic understanding of the challenges and opportunities in CE development. Future research should strive to include a wider range of stakeholder perspectives, particularly those of marginalized or less vocal groups.

7.5. Extensions and Future Works

Indonesia and other developing countries. By comparing the development and implementation of CE initiatives in various cultural, economic, and regulatory environments, researchers can identify universal best practices and context-specific strategies. This approach would provide a broader understanding of how different factors influence CE projects and could lead to more adaptable and scalable solutions. Comparative studies could also highlight unique challenges and opportunities that are specific to particular regions, contributing to a more nuanced understanding of CE development.

Given the dynamic nature of RE technologies and policies, longitudinal studies are essential to capture changes and trends over time. Future research should focus on monitoring and evaluating CE projects over extended periods to assess their long-term sustainability, economic impacts, and social acceptance. Longitudinal studies can provide valuable insights into how projects evolve, the factors that contribute to their success or failure, and the long-term benefits and challenges associated with CE initiatives. This type of research can inform continuous improvement and adaptation of CE strategies to ensure their relevance and effectiveness over time.

Future research should focus on analyzing the impact of specific policies on the development and success of CE initiatives. This can involve evaluating the effectiveness of existing regulatory frameworks, financial incentives, and support programs in promoting CE projects. By understanding which policies are most effective and why, researchers can provide evidence-based recommendations for policy improvements. This type of research can also explore the unintended consequences of policies and identify ways to mitigate any negative impacts.

Engaging local communities in the research process through participatory action research (PAR) can ensure that CE initiatives are aligned with local needs and priorities. PAR involves collaborative research where community members actively participate in the design, implementation, and evaluation of projects. This approach can enhance the relevance and impact of research findings, foster community ownership of CE projects, and ensure that the solutions developed are culturally appropriate and sustainable. PAR can also help build local capacity and empower communities to take an active role in their energy transitions.

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Appendices

Appendix A. Interview Questions List

No.	English	Bahasa Indonesia
Introduction		
1	Can you tell me about your organization and your organization's experience with community energy initiatives?	<i>Tolong jelaskan tentang organisasi anda dan pengalaman organisasi Anda dengan komunitas energi.</i>
2	Why and what role did your organization participate in the development of community energy initiatives in Bali?	<i>Apa peran organisasi anda dalam pengembangan inisiatif energi komunitas di Bali? Apa alasan mengambil peran tersebut?</i>
Development of Community Energy as a niche and the overall landscape and regime in Bali		
3	What and how are the current developments of community energy initiatives in Bali?	<i>Bagaimana perkembangan terkini komunitas energi di Bali?</i>
4	What are the main factors that influence the development of community energy initiatives in Bali (internally and externally, in various scopes)? Will there be possible/expected changes in the said factors?	<i>Apa faktor utama yang mempengaruhi perkembangan komunitas energi di Bali (internal dan eksternal, dalam beragam konteks)? Apakah ada perubahan yang diharapkan terkait faktor-faktor tersebut?</i>
5	What do you think about the trends of other issues such as climate change, sustainable living, or even economic and political shifts in the development of community energy? Would it be considered a challenge or an opportunity?	<i>Apa pendapat Anda tentang tren isu lain seperti perubahan iklim, sustainability, atau bahkan pergeseran ekonomi dan politik dalam konteks komunitas energi? Apakah itu menjadi tantangan atau peluang?</i>
Shaping of expectation		
6	What are your expectations for community energy initiatives in Indonesia (both within the initiative and other factors surrounding it)?	<i>Apa ekspektasi anda terhadap komunitas energi di Bali (baik secara umum maupun spesifik dalam konteks institusi/pribadi)?</i>
7	Have the expectations changed over time and why?	<i>Apakah harapan tersebut berubah seiring waktu dan mengapa?</i>
Social network formation		
8	Who are the important actors in the development of community energy initiatives in Indonesia and what are their roles?	<i>Siapa aktor penting dalam pengembangan komunitas energi di Indonesia dan apa perannya? Apakah peta aktor atau pandangan mereka berubah seiring waktu?</i>
9	Is your organization involved in cooperation with other actors in the field? What are their roles in the development of community energy initiatives?	<i>Apakah organisasi anda bekerjasama dengan aktor lain di bidang ini? Apa peran mereka dalam pengembangan komunitas energi?</i>
10	Have you encountered any challenges in cooperating? Or have you found any opportunities from cooperating? How did you manage to overcome the challenges and/or capitalize the opportunities?	<i>Apakah ada tantangan dalam bekerjasama atau apakah ada peluang dari kerjasama tersebut? Bagaimana cara mengatasi tantangan dan/atau memanfaatkan peluang tersebut?</i>
Learning process		

11	What activities have you participated in/initiated to enhance your knowledge about community energy?	<i>Kegiatan apa yang telah anda/organisasi anda ikuti/selenggarakan untuk meningkatkan wawasan anda tentang komunitas energi?</i>
12	What have you learned from your organization's engagement on the matter?	<i>Apa yang dapat dipelajari dari keterlibatan dalam kegiatan tersebut?</i>
13	What can you learn about community in Bali?	<i>Apa yang dapat dipelajari tentang komunitas energi di Bali?</i>
14	What activities have you participated in/initiated to enhance public knowledge about community energy?	<i>Kegiatan apa yang telah anda/organisasi anda ikuti untuk meningkatkan wawasan public tentang komunitas energi?</i>

Barriers and opportunities

15	What are the main barriers to the development of community energy?	<i>Apa hambatan dalam pengembangan komunitas energi di Bali?</i>
16	What are the main opportunities that can catalyze the development of community energy?	<i>Apa peluang dalam pengembangan komunitas energi di Bali?</i>
17	What have you done to address those barriers and opportunities?	<i>Apa yang telah anda/organisasi anda lakukan untuk menghadapi hambatan dan peluang itu?</i>

Economic feasibility

18	Could you explain to me how your organization/initiative work in the field of community energy?	<i>Bisakah anda menjelaskan bagaimana organisasi anda bekerja/berperan di komunitas energi?</i>
19	What do you think are the main factors that make community energy operation feasible for its purpose?	<i>Apa faktor utama yang membuat inisiasi komunitas energi dapat berjalan?</i>
20	Is the current model able to accelerate the development of community energy?	<i>Apakah model yang ada saat ini dapat mempercepat perkembangan komunitas energi?</i>
21	What are the alternative models that might work?	<i>Apa model alternatif yang mungkin bisa diterapkan?</i>
22	How might current regulations and policies enhance or limit the development of community energy? What can be improved?	<i>Apakah peraturan dan kebijakan saat ini meningkatkan atau membatasi pengembangan komunitas energi? Apa yang bisa diperbaiki/dikembangkan?</i>
23	What measures and actions would be further needed to enhance the development of community energy, particularly within your role in the field?	<i>Tindakan dan langkah apa yang lebih diperlukan untuk meningkatkan pengembangan komunitas energi, terutama terkait peran organisasi anda?</i>

Conclusion

24	Do you think community energy in Bali can set an example to the other regions in Indonesia?	<i>Dapatkah komunitas energi di Bali menjadi percontohan komunitas energi bagi daerah lain di Indonesia?</i>
25	Is there additional information you might want to share regarding community energy that has not been covered?	<i>Apakah ada informasi tambahan yang ingin dibagi terkait komunitas energi?</i>
26	Do you have any recommended interviewees for the matter?	<i>Apakah Anda memiliki rekomendasi narasumber lain terkait ini?</i>

Appendix B. Informed Consent

		YES	NO
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION A: Persetujuan Umum – Tujuan Penelitian, Peran Peserta dan Kebersediaan berpartisipasi			
1	<p>I have read the information regarding this study above, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.</p> <p><i>Saya telah membaca informasi diatas mengenai studi ini, atau yang telah dibacakan kepada saya. Saya dapat mengajukan pertanyaan mengenai penelitian ini dan pertanyaan saya telah dijawab secara jelas.</i></p>		
2	<p>I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time.</p> <p><i>Saya bersedia menjadi narasumber pada penelitian ini dan mengerti bahwa saya memiliki hak untuk menolak menjawab pertanyaan dan dapat mengundurkan diri dari penelitian kapan saja.</i></p>		
3	<p>I understand that taking part in the study involves a video-recorded interview and the interview will be transcribed as text.</p> <p><i>Saya mengetahui jika penelitian ini meliputi rekaman video wawancara dan transkrip teks wawancara.</i></p>		
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION) B: Potensi Resiko Dalam Berpartisipasi (Termasuk Hal Proteksi Data)			
4	<p>I understand that taking part in the study also involves collecting specific personally identifiable information (PII) such as name, organisation name and job title with the potential risk of my identity being revealed. The research will mitigate the potential risk of a data breach using the TU Delft system.</p> <p><i>Saya mengetahui jika dalam berpartisipasi dalam studi akan meliputi pengumpulan informasi identitas pribadi seperti nama, nama organisasi dan posisi pekerjaan, di mana data ini akan berpotensi untuk mengungkap informasi pribadi. Penelitian ini akan memitigasi resiko dari pelanggaran data melalui sistem TU Delft.</i></p>		
5	<p>I understand that personal information collected about me that can identify me, such as name, organisation name, and job title will not be shared beyond the study team.</p> <p><i>Saya mengetahui jika informasi pribadi yang dikumpulkan dan yang bisa digunakan untuk mengidentifikasi saya, seperti nama, nama organisasi dan posisi pekerjaan tidak akan dibagikan diluar tim riset.</i></p>		
6	<p>I understand that the identifiable personal data I provide will be destroyed after the completion of the research.</p> <p><i>Saya mengetahui data pribadi yang dikumpulkan akan dihapus setelah penelitian selesai.</i></p>		
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION			
7	<p>I understand that after the research study, the de-identified information I provide will be used for the report.</p> <p><i>Saya mengetahui bahwa setelah penelitian selesai, informasi yang dikumpulkan akan digunakan untuk pembuatan laporan.</i></p>		
8	<p>I agree that my responses, views or other input can be quoted anonymously in research outputs.</p> <p><i>Saya setuju jika jawaban atau informasi dapat dikutip secara anonim dalam laporan penelitian.</i></p>		
9	<p>I understand that access to the output (report) repository is publicly available.</p> <p><i>Saya mengetahui jika repositori laporan akhir penelitian dapat diakses oleh umum.</i></p>		

Appendix C. News Data Acquisition Source Code

```
import json
from eventregistry import *

er = EventRegistry(apiKey='9ac6d6bf-b9c9-4615-ab57-87789da27b06')

query = {
    "$query": {
        "$and": [
            {
                "$or": [
                    {"keyword": "komunitas", "keywordLoc": "body"},
                    {"keyword": "masyarakat", "keywordLoc": "body"},
                    {"keyword": "desa", "keywordLoc": "body"},
                    {"keyword": "kampung", "keywordLoc": "body"}
                ]
            },
            {"keyword": "energi", "keywordLoc": "body"},
            {"keyword": "bali", "keywordLoc": "body"},
            {"lang": "ind"}
        ]
    },
    "$filter": {
        "dateStart": "2016-01-01",
        "dateEnd": "2024-05-31"
    }
}

# Initialize the query
q = QueryArticlesIter.initWithComplexQuery(query)

articles = []

# Execute the query and collect the results
for article in q.execQuery(er,
    returnInfo = ReturnInfo(
        articleInfo=ArticleInfoFlags(concepts=True, categories=True, duplicatelist=True,
location=True, bodyLen=300),
        sourceInfo=SourceInfoFlags(location=True, image=True)
    )):
    articles.append(article)

# Save the results to a JSON file
with open('articles.json', 'w', encoding='utf-8') as f:
    json.dump(articles, f, ensure_ascii=False, indent=4)
```

Appendix D. News Data Cleaning Source Code

```
import pandas as pd
from Sastrawi.Stemmer.StemmerFactory import StemmerFactory
from Sastrawi.StopWordRemover.StopWordRemoverFactory import StopWordRemoverFactory

df = pd.read_json('articles.json')

stemmer_factory = StemmerFactory()
stemmer = stemmer_factory.create_stemmer()

stopword_factory = StopWordRemoverFactory()
stopword_remover = stopword_factory.create_stop_word_remover()

additional_stopwords = ['list of stopwords']
stopword_factory.get_stop_words().extend(additional_stopwords)
stopword_remover = stopword_factory.create_stop_word_remover()

def clean_text(text):
    text_without_stopwords = stopword_remover.remove(text)
    stemmed_text = stemmer.stem(text_without_stopwords)
    return stemmed_text

df['body_clean'] = df['body'].apply(clean_text)
```

Appendix E. News Data Visualization Source Code

Wordcloud

```
from wordcloud import WordCloud

all_cleaned_text = ' '.join(df['body_clean'].tolist())
word_counts = Counter(all_cleaned_text.split())

top_20_words = dict(word_counts.most_common(50))

wordcloud = WordCloud(width=800, height=400,
background_color='white').generate_from_frequencies(top_20_words)

plt.figure(figsize=(10, 5))
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis('off')
plt.show()
```

Concepts

```
import pandas as pd
import matplotlib.pyplot as plt

file_path = 'articles.json'
dataset = pd.read_json(file_path)
wiki_concepts_exploded = dataset['wiki_concepts'].str.split(',').explode().str.strip()

top_10_wiki_concepts_corrected = wiki_concepts_exploded.value_counts().head(10)

print(top_10_wiki_concepts_corrected)

plt.figure(figsize=(10, 6))
top_10_wiki_concepts_corrected.plot(kind='bar', color='skyblue')
plt.title('Most Mentioned Topics')
plt.xlabel('Topic')
plt.ylabel('Frequency')
plt.xticks(rotation=45, ha='right')
plt.tight_layout()

plt.savefig('concepts.png')
plt.show()
```

Appendix F. Interview Data Source Code

Transcriber

```
import whisper

model = whisper.load_model("base")
result = model.transcribe("interview.m4a", language="id")

print(result["text"])

with open("transcript.txt", "w", encoding="utf-8") as f:
    f.write(result["text"])
```

Cleaner and Visualizer

```
import os
import re
from wordcloud import WordCloud
import matplotlib.pyplot as plt
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from Sastrawi.Stemmer.StemmerFactory import StemmerFactory
import nltk

nltk.download('stopwords')
nltk.download('punkt')

factory = StemmerFactory()
stemmer = factory.create_stemmer()

def load_transcripts(folder_path):
    transcripts = []
    for filename in os.listdir(folder_path):
        if filename.endswith(".txt"):
            file_path = os.path.join(folder_path, filename)
            with open(file_path, 'r', encoding='utf-8') as file:
                transcripts.append(file.read())
    return transcripts

def preprocess_text(text):
    # Convert to lowercase
    text = text.lower()

    # Remove punctuation and non-alphabetic characters
    text = re.sub(r'^a-z\s', '', text)

    # Tokenize the text
    words = word_tokenize(text)

    # Stem the words
    stemmed_words = [stemmer.stem(word) for word in words]
```

```

# Replace specific words after stemming
replaced_words = [
    "bali" if word == "bal" else
    "pemerintah" if word == "perintah" else
    "kebijakan" if word == "bijak" else
    "harapan" if word == "harap" else
    "energi" if word == "energy" else
    word
    for word in stemmed_words
]

stop_words = set(stopwords.words('indonesian'))
custom_stopwords = {"list of stopwords"}
stop_words.update(custom_stopwords)
filtered_words = [word for word in replaced_words if word not in stop_words]

return ' '.join(filtered_words)

def generate_wordcloud(text, output_file):
    wordcloud = WordCloud(
        width=800,
        height=400,
        background_color='white',
        max_words=50 # Limit to 50 words
    ).generate(text)

    plt.figure(figsize=(10, 5))
    plt.imshow(wordcloud, interpolation='bilinear')
    plt.axis('off')
    plt.savefig(output_file) # Save the figure to a file
    plt.show()

def main(folder_path, output_file):
    transcripts = load_transcripts(folder_path)
    combined_text = ' '.join(transcripts) # Combine all transcripts into a single string
    cleaned_text = preprocess_text(combined_text)
    generate_wordcloud(cleaned_text, output_file)
    print(f"Wordcloud saved as {output_file}")

folder_path = 'interviews/'
output_file = 'interviews/combined_wordcloud.png'

os.makedirs(os.path.dirname(output_file), exist_ok=True)

main(folder_path, output_file)

```

Appendix G. Actor Analysis Recap

Actor	Interest	Desired situation	Existing situation	Cause	Solution
Bali Department of Energy	Promote sustainable energy development, reduce dependency on fossil fuels, ensure energy security	Increased use of RE sources, improved energy infrastructure, and reduced greenhouse gas emissions	Current energy mix is heavily reliant on fossil fuels, limited RE infrastructure	High initial investment costs, lack of technical expertise, regulatory bottleneck with the central government	Implement supportive policies and incentives for RE projects, provide technical training and capacity building
State Electricity Company (PLN)	Maintain reliable and affordable electricity supply, integrate RE into the grid	Stable energy supply and stable profit, minimized operational disruptions, enhanced community and environmental benefits.	Dependence on conventional energy sources, challenges in integrating intermittent renewable sources, ongoing CSR initiatives.	Grid stability issues, high cost of RE integration, regulatory and technical challenges.	Develop regulations for grid integration of renewables, enhance CSR programs focusing on community RE projects, support educational initiatives in RE.
Pertamina	Diversify energy source, reduce carbon footprint, remain competitive in the market, meet CSR objectives.	Increased investment in RE projects, reduction in fossil fuel consumption, positive community and environmental impact through CSR activities.	Predominantly involved in fossil fuel extraction and distribution, limited RE projects, active CSR programs in various sectors.	Established fossil fuel infrastructure, economic reliance on fossil fuels.	Invest in research and development of RE technologies, form partnerships for RE projects, align CSR initiatives with community RE needs, support local education and health programs.
Private Company	Explore business opportunities	Successful implementation of profitable	Emerging market with high potential,	Regulatory uncertainty, high initial	Develop public-private partnerships,

	in RE, ensure profitability and market growth, achieve CSR targets.	RE business model, establishment of market presence in Bali, impactful CSR contributions to local communities.	regulatory and financial hurdles, ongoing CSR projects.	capital investment, long return of investment.	advocate for favorable policies, invest in innovative financing solutions, design CSR projects that support community RE initiatives, engage in local capacity building and environmental conservation efforts.
Local NGO	Promote environmental sustainability, advocate for community benefits from RE projects.	Empowered communities with access to clean and affordable energy, enhanced environmental conservation.	Limited community engagement in energy projects, high reliance on non-RE sources.	Lack of awareness and funding, limited technical knowledge.	Conduct awareness campaigns, provide training and support for community-led RE projects, seek funding from international donors.
International NGO	Support global RE transitions, enhance local capacities.	Successful implementation of RE projects in Bali, model for other regions.	High potential but underutilized RE resources, need for capacity building.	Insufficient local knowledge, financial and regulatory barriers.	Provide funding and technical assistance, facilitate knowledge exchange and best practices.
Research Entities	Advance scientific knowledge and technology in RE, contribute to sustainable development.	Development of innovative RE solutions, successful application in community projects.	Ongoing research projects, limited practical application in communities.	Gap between research and implementation, funding limitations.	Collaborate with local initiatives and government, secure research grants and funding.

Local Initiatives	Drive local RE projects, create sustainable community solutions.	Self-sufficient communities with RE systems, increased local resilience.	Fragmented efforts, limited resources and expertise.	Lack of coordination, financial constraints.	Establish cooperative models, seek technical and financial assistance from NGOs and government agencies.
Customary Village (<i>Desa Adat</i>)	Preserve cultural heritage, ensure sustainable development for the community.	Integration of RE in ways that respect and enhance local culture and traditions.	Traditional community engagement practices, limited access to modern RE technologies.	Cultural barriers, lack of resources and technical knowledge.	Engage in participatory planning, provide culturally appropriate RE solutions, involve local leaders in project development.
Project Funders (Cooperative/Grant)	Support sustainable and impactful projects, achieve social and environmental goals.	Successful and transparent use of funds in RE projects, measurable impact on community development and sustainability.	Limited visibility and accountability in project implementation , need for robust monitoring and evaluation mechanisms.	Inadequate project management skills, lack of transparent reporting systems.	Implement stringent monitoring and evaluation frameworks, provide capacity-building for project implementers , ensure regular reporting and stakeholder engagement.
Hospitality and Tourism Industry	Enhance sustainability credentials, reduce operational costs, attract eco-conscious tourists.	Integration of RE systems in hotels and resorts, promotion of Bali as a sustainable tourism destination.	High energy consumption from non-renewable sources, increasing operational costs, growing demand for sustainable tourism.	High upfront costs for RE installations, limited incentives for green investments.	Develop partnerships with RE providers, advocate for government incentives and subsidies, promote the benefits of sustainable

					practices to the tourism market.
Community/People of Bali	Access to affordable and reliable energy, improved quality of life, environmental sustainability.	Reliable and clean energy supply, reduced energy costs, improved health and environment.	High energy costs, reliance on non-RE sources, environmental degradation.	Economic constraints, lack of awareness and alternatives.	Promote community-based RE projects, provide subsidies or financial support, educate the community on benefits of RE.