Barriers and Enablers to Financing Decentralized Solar Energy Systems in Southeast Asia

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Abstract:

A global transition to renewable energy is required to address the sustainability challenge and mitigate the socio-ecological consequences of climate change. This thesis explores what factors contribute to slowing down the transition to renewable energy in Southeast Asia. The region was chosen due to its rising energy demand, high energy poverty rates and unsustainable energy generation. The objective is to identify what barriers and enablers inhibit and encourage the financing of decentralized solar energy systems (DSES) in the region.

The study applied a qualitative approach where five exploratory and 12 semi-structured interviews were conducted to gain rich and diverse insights into the current state of DSES within Southeast Asia. The PESTLE analytical framework was used to code the results in a systematic way.

This study found several barriers inhibiting an increased deployment of DSES. These included ineffective regulatory frameworks, systemic corruption and market monopolization of DSES, financial issues related to the small size of projects as well as technical and financial capacity among local actors.

At the same time, the study identified multiple enablers to address these challenges, including policies encouraging transparency and standardization, capacity building for maintenance or financial literacy and falling project costs due to technological innovation.

Keywords: Decentralized Renewable Energy Systems, Solar Energy, Financing, Barriers, Enablers, Southeast Asia

Statement of Contribution

This thesis is a testimony to a fascinating journey of discovery co-shared by an amazing team of passionate human beings who continually try to make the world a better place. Our international team - Jian (Tina) Wang (China), Lorenzo Gubbini (Italy), Lukasz Abraszek (Poland) and Alexander Henn (Germany) - tried to address the sustainability challenge by investigating the barriers and enablers to financing the transition to renewable energy in Southeast Asia, in particular in Cambodia, Indonesia and the Philippines. It was a truly insightful and personally enriching process.

We gained a lot of understanding on the obstacles and opportunities within the renewable energy sector. They challenged a lot of our initial assumptions and helped us to stay open-minded and humble against the complexity of the field. We also learned a lot from the group process and its dynamics - how to work together and deliver the final result while balancing different opinions and approaches. Discussing a shared vision for the project and arriving at a mutual understanding early on were essential success factors which helped us to work smoothly and efficiently. Each of us played a significant role in the thesis project and contributed in their unique way to the final outcome.

Thanks to Tina's knowledge and experience in the energy sector, as well as her extensive network in Southeast Asia we were able to reach all the key stakeholders for our interviews. Her drive and structured approach were crucial for creating momentum and advancing our thesis project at a stable and secure pace. Her smile and lightness of being invited us to stay cheerful and keep up our work in a joyous team spirit.

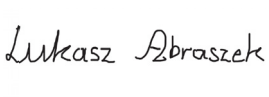
Lorenzo contributed with his excellent questions and by making sure that we all had a shared understanding of the key elements of our project and the way we wanted to proceed. He always tried to understand and emphasize the social, community impact of our work and how it could help address the human aspect of the sustainability challenge. He also showed great skill in conducting our interviews and in putting our thoughts onto paper during the write-up. He cared a lot about our team, our face-to-face interaction and the group dynamics.

Lukas supported our project with his hunger for knowledge, his scientific approach and his emphasis on ensuring the structure and practical relevance of our thesis. He helped us by reaching out to stakeholders and making sure communications with them and within our team ran smoothly. Lukas also took care of all technical aspects, such as providing a platform for our interviews as well as recording and transcribing them with due diligence. His positivity and enthusiasm were crucial for energizing our team and keeping us on track.

Alex contributed with his structured and rigorous approach which helped us scope our work and navigate through the complexity of the sustainability challenge. His critical thinking was incredibly useful when discussing the key elements of our thesis and deciding on shaping the narrative. His positive and calm approach helped us to put some of the challenges we faced into perspective by providing a systemic, big picture understanding.

We are grateful to each other for the time we spent together and for the collective learning. It contributed to both our professional and personal growth. Our hope is that thanks to our project and the powerful insights gained from it we will be able to implement some of the identified

potential solutions in order to accelerate the pace and the scale of the energy transition in Southeast Asia.

Lukasz Abraszek	Lorenzo Gubbini	Alexander Henn	Jian Wang
			

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Executive Summary

Introduction

Due to systemic errors in societal design, modern society is systematically degrading the socio-ecological system that provides the resources and conditions necessary for it to thrive (Robèrt et al. 2019). Not only that, but social issues such as poverty and growing inequalities also hinder society's ability to solve its systemic errors or react to complex issues such as climate change. By applying a strategic sustainable development approach, modern society can stabilize this downhill course and stop depleting the resources it relies on. This process involves transitioning from the current unsustainable society to one informed by a shared understanding of sustainability through principles that define the basic requirements for a society to be sustainable.

Energy is an essential element that allows global society to operate, and the demand for it is predicted to keep increasing parallel to the economic and population growth in developing countries. Since the current dominant form of producing energy globally is fossil fuel reliant (80% is generated from fossil fuels), energy generation and consumption compose 75% of the total greenhouse gas emissions that are causing climate change. Thus, energy plays a crucial role in the sustainability challenge, and a transition to renewable energy systems would be an aspect of crucial importance in society's transition to sustainability. In particular, solar energy holds significant potential for speeding up this transition, due to the fact that solar photovoltaics are highly modular, easy to install and maintain, and are currently the cheapest form of energy production.

Not only is the dominant form of global energy generation fossil fuel reliant, but energy is also produced and distributed through centralized energy systems. These generate power on a large scale from centralized facilities and transmit it over long distances, and their common failure to reach remote communities is one of the main causes of energy poverty: 1.1 billion people do not have access to energy worldwide. Decentralized energy systems can help address this issue by providing more local energy production and distribution which can be more environmentally friendly, faster to implement, more affordable and reliable, as well as empower local communities with decision making and a coping mechanism for system failures.

One region where an increasing energy demand is accompanied by unsustainable energy production is Southeast Asia. Fossil fuels dominate the region's energy mix (80%), and the energy demand from Southeast Asian countries (5% share of global energy demand) is expected to double by 2040. Another major challenge the region faces is reaching its roughly 45 million residents who are currently living without access to electricity. Hence, this study contends that a transition to renewable energy (with solar having the highest potential for the region) and an increased deployment of decentralized systems in Southeast Asia could address these issues and be a major contribution to society's transition towards sustainability.

While Southeast Asian countries have pledged to address the issue of climate change by setting targets for a more sustainable pathway for the energy sector, the energy transition and consequent phasing out of fossil fuels is not happening fast enough and at a big enough scale. Since only 1% of the total global energy finance is spent on decentralized solar energy systems,

this study asserts that a significant reason why the transition is not happening fast enough relates to financing. Hence, this thesis project is designed for exploring what factors are at play in diverting financial capital away from decentralized solar energy systems (DSES) and thus slowing down the transition to renewable energy in the region. This objective is mirrored in the thesis research question.

Research Question of the study: What are the barriers and enablers to financing decentralized solar energy systems in Southeast Asia?

Methodology

In order to answer the research question, a qualitative approach was chosen. While a quantitative approach would require more time to collect the required amounts of numerical data, qualitative research is advantageous due to the three-month time limit on the project. Five exploratory and 12 semi-structured interviews were conducted (17 in total), which supplied the research with deep and rich insights into the field.

The research process was divided into four main phases:

Phase 1: Literature Review
- Literature review to identify the research question

Phase 2: Data Collection 1- Initial/ Exploratory Interviews
- 5 exploratory interviews
- 12 further organizations were identified for interviews in phase 3

Phase 3: Data Collection 2 - Secondary/In-depth Semi-structured Interviews
- 12 semi-structured interviews

Phase 4: Data Analysis
- Thematic content analysis with PESTLE coding structure

Phase 1: Literature Review: Existing literature relevant to the scope of the project was reviewed to gain a shared understanding of key terminology, of the sector at hand, and to identify gaps in the research. This helped the study identify the research question.

Phase 2: Data Collection 1 - Initial Exploratory Interviews: The first five exploratory interviews built on the research and insights we gained in phase 1. They were conducted to inform the question formulation and scoping decisions. For example, they informed the decision to focus the research on three countries (namely Cambodia, Indonesia and the Philippines) due to the fact that they have the highest energy poverty rates and need for decentralized solutions in the region. The interviews also provided the study with a more in-depth and holistic understanding of the energy transition landscape in Southeast Asia. As a result, 12 further organizations were identified for interviews in phase 3 in order to gain more detailed information to answer the research question.

Phase 3: Data Collection 2 - In-Depth Semi-Structured Interviews: With the feedback and insights gained from phase 2, questions were tailored for the 12 follow-up semi-structured interviews to obtain more nuanced answers. 12 interviews were conducted with selected interviewees from a diverse range of fields relating to the renewable energy sector in Southeast Asia (see Table 2.2). They provided us with a significant database from which to draw conclusions.

Phase 4: Data Analysis: All the data generated from 17 interviews was recorded and transcribed, and analyzed through thematic content analysis. The PESTLE tool was used as an analytical framework in order to code and evaluate the results in a systematic way. Each factor was prescribed and coded with a unique color in order to make them identifiable. Subcodes for each factor emerged through analysis and clustering of data (See Figure 2.2). Finally, all the transcriptions were analyzed using this coding structure, and the results were reviewed and agreed by all authors.

Results and Discussion

The main findings of this study correspond to the PESTLE framework categories. The most important political barriers included systemic corruption which might ultimately lead to the monopolization of the energy sector and a lack of efficient regulatory frameworks hindering the transition to DSES within the region. They were followed by economic challenges which are often tightly interrelated with the country's political landscape, and can be exemplified by insufficient regulation translating into considerably higher business associated risks for DSES-interested investors. Another major challenge related to the financial sector appeared to be the lack of knowledge of the benefits of DSES among stakeholders in local financial institutions. What is more, lack of financial literacy and inadequate maintenance capabilities among local actors were also found to be significant factors affecting the pace and scale of DSES implementation in Southeast Asia. Finally, obstacles related to energy storage systems such as their relatively high cost, the availability of natural resources required for their manufacture and their direct dependence on global supply chains appeared to be of high importance for a wide-scale DSES implementation in the region.

All of the above-mentioned barriers appear to be complex and closely interconnected across all the levels of the socio-ecological system. They significantly contribute to hindering the DSES sector development and consequently slow down the energy transition in the region and on a global scale. They often benefit from the fragmentation of the current organizational reality and from siloed approaches to sustainable development, lacking strategic perspective and long-term, systemic thinking. What is more, current approaches to the energy transition seem to be missing a shared vision and understanding of sustainability by which to organize and structure numerous decentralized projects towards a single common outcome. It seems evident that, even with the most advanced technological solutions available, DSES projects will be deemed a failure without the implementations of collaborative national as well as international efforts guided by the definition of a common goal.

This study also identified several enablers that could help address the barriers impeding a swift transition to renewable energy discussed above. Transparent and robust regulatory frameworks fostering the strategic implementation of DSES projects and attempts to address systemic

corruption at all social levels appeared to be among the most powerful ways to tackle the energy challenge. When it comes to economic factors (which are intrinsically connected to political ones), blended finance (reducing the upfront risks for private investments into DSES), guarantees for microfinance institutions and the promotion of innovative business models were identified as key enablers for a swift transition. Some social enablers surfaced as promising ways to help expand the DSES sector in the region, including capacity building in the form of educating local actors and fostering engagement within local communities. Lastly, technology was also highlighted as an important opportunity on the transformative pathway. Some of the suggested solutions within this category included implementing hybrid systems (combining solar and diesel) on a wider scale as a promising intermediate and realistically achievable step. Another important solution that emerged is fostering technological innovation in energy storage and implementing alternative types of grid on a smaller scale.

Similar to the barriers, all of the identified enablers also seem to be interconnected. The only viable approach to expanding the deployment of DSES and speeding up the transition to renewable energy in the region appears to be through collaborative, inclusive and participatory processes for DSES implementation. It implies bringing together all the stakeholder groups, such as policy and decision makers, investors, project developers and local communities. Among all the factors trust, community engagement and shared leadership proved to be of particular importance as they can successfully synergize the widespread DSES implementation. It appears highly advisable for Association of Southeast Asian Nations (ASEAN) member states to discuss a shared vision of sustainability and embed it in their national and regional regulatory frameworks. Finally, inter-ASEAN partnerships seem to be a key leverage point for the Southeast Asian energy transition by providing orchestrated, multifaceted and tailored solutions beneficial at the country and regional level.

Conclusion

In order to answer its research question, this study uncovered several key barriers and enablers that could assist decision makers when thinking about financing DSES in Southeast Asia.

This work also presents several ideas on how to work with the identified barriers and enablers at hand. For one, it appears crucial that more transparent, standardized and efficient policies regarding financing DSES in the region be implemented. In order to achieve this a participatory approach should be chosen that recognizes the needs of all parties involved. Transparency and dialogue appear to be crucial. Shifting from subsidizing fossil fuels towards renewable energy (with a focus on solar) is another proposed action, as the financial capital is already in place and would only need to be re-allocated strategically. Here a slow and calculated approach should be taken to avoid a harsh disruption of the current system that would carry a lot of unforeseen consequences. Action is still needed so that climate goals are achieved.

Lastly, an emphasis on education could also be important for the transition to renewable energy in the region: improved financial literacy and technical skills for the maintenance of DSES would allow for more durable projects and empower local communities to run their systems more efficiently. Community engagement aimed at fostering trust between all parties involved in energy generation, distribution and consumption (political institutions, businesses, investors,

and locals) would also make the push towards a decentralized renewable energy paradigm stronger and strengthen trust.

As a result, it should be noted that the main barriers and enablers to financing DSES are to be found in the legal, economic and social spheres. However, other factors should be considered as well, to adapt a holistic view of the situation. With this in mind the future of DSES in Southeast Asia seems to be promising and can definitely be expanded upon in the future to help with the pace and scale of the transition towards renewable energy. This will in turn contribute to a society that is sustainable and benefits all.

Glossary

Association of Southeast Asian Nations (ASEAN): An intergovernmental organization established on August 8, 1967 with ten member states: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam.

Blended Finance: Using mixed public and/or philanthropic funds to raise additional private capital.

Centralized Energy: Traditional electricity provision that relies on a hierarchical, unidirectional flow of electricity from centralized generation plants through transmission and then distribution lines.

Climate Change: A change in the state of the climate that can be identified by changes in the mean temperature and/or the variability of its properties, in which change persists for an extended period, typically decades or longer.

Consulting Firms/Platform: An organization connecting international investors with entrepreneurs for financing;

Crowdfunding: Using social media and/or online platforms in order to pool relatively small amounts of capital from single investors to finance projects.

Debt: Selling debt instruments (e.g. loans, bonds) to potential investors.

Decentralized Energy: Electricity production at or near the point of use, irrespective of size, technology or fuel used - both off-grid and on-grid.

Development Finance Institution: Also known as a development bank or development finance company, is a financial institution that provides risk capital for economic development projects on a non-commercial basis.

Energy System: An energy system comprises all components related to the production, conversion, delivery and use of energy.

Equity: Issuing stocks to raise funds, lenders receive shares of the company.

Financial Instruments: Contracts which give rise to a financial asset for one entity and a financial liability or equity instrument for another entity, e.g. debt, equity, and grant.

Grant: Usually lent by international development agencies such as the World Bank Group, the International Finance Corporation or the Asian Development Bank.

Green Bonds: Fixed-income instruments issued to support environmental or climate-change mitigation projects; the World Bank is a major issuer of green bonds.

Impact Investment Company: An investment fund that specifically seeks to support beneficial social or environmental outcomes, in addition to generating financial returns;

Intergovernmental Organization: An entity created by treaty, involving two or more nations, to work in good faith, on issues of common interest

Microfinance: Providing individuals from low-income groups with often simple, informal financial solutions who otherwise have no access to official, institutional financial services.

Pay-As-You-Go (PAYG): An innovative credit system that removes the initial financial barrier to solar energy access by allowing consumers to make a series of modest payments to purchase time units for using solar electricity instead of paying upfront for the entire solar system.

Prosumer: An individual who is simultaneously consumer and producer of a given product.

PESTLE Analytical Framework: A tool used to gain a systemic understanding of an industry environment. PESTLE stands for Political, Economic, Social, Technological, Legal and Environmental factors.

Private Company: A privately owned company working on decentralized renewable energy.

Public Private Partnership (PPP): Agreement between the public and private sector of a long-term nature, primarily used for infrastructure projects; expected to be the preferred way of financing renewable energy projects for larger Asian economies, such as Indonesia, the Philippines, Malaysia, Vietnam and Thailand in the near future.

Renewable Energy: Energy sources that, apart from geothermal, are drawn directly or indirectly from current or recent flows of the constantly available solar or gravitational energy.

Small and Medium-sized Enterprises (SMEs): Businesses have revenues, assets, or a number of employees below a certain threshold.

Social Enterprise: An organization that applies commercial strategies to maximize improvements in financial, social and environmental well-being. This may include maximizing social impact alongside profits for co-owners.

Southeast Asia: The region is composed of eleven countries of impressive diversity in religion, culture and history: Brunei, Cambodia, Laos, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste and Vietnam.

Sustainability Challenge: A combination of systematic errors within societal design that are driving humans´ unsustainable effects on the socio-ecological system, the serious obstacles to fixing those errors, and the opportunities for society if those obstacles are overcome.

Sustainable Development: Transition from the current, unsustainable society towards a sustainable society, and continued development within sustainability constraints thereafter.

Venture Philanthropy: Applying the rules of venture capital (type of private equity financing) to achieve philanthropic or social impact goals.

List of Abbreviations

ACE	ASEAN Centre for Energy
ADB	Asian Development Bank
APAEC	ASEAN Plan of Action for Energy Cooperation
ASEAN	Association of Southeast Asian Nations
CO2	Carbon Dioxide
CPI	Corruption Perceptions Index
DC	Direct Current
DES	Decentralized Energy Systems
DFI	Development Finance Institution
DSES	Decentralized Solar Energy Systems
EPC	Engineering, Procurement and Construction
GHG	Greenhouse Gas
IEA	International Energy Association
IPCC	Intergovernmental Panel Climate Change
IRENA	International Renewable Energy Agency
MFI	Microfinance Institutions
NGO	Non-Governmental Organization
OECD	Organisation for Economic Cooperation and Development
OPEX	Operational Expenditure
PAYG	Pay-As-You-Go
PE	Private Equity
PESTLE	Political, Economic, Social, Technological, Legal and Environmental
PPP	Public Private Partnership
PV	Solar Photovoltaics

ROI	Return of Investment
SMEs	Small and Medium Enterprises
USAID	United States Agency for International Development
WHO	World Health Organization

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1 Introduction

1.1 Sustainability Challenge

Human society relies on the ecological system it is nested within to provide the resources and conditions necessary for it to thrive. Due to systemic errors in societal design (which manifest into overpopulation, overexploitation of natural resources, climate change, land degradation and loss of biodiversity), modern society is systematically degrading the ability of the biosphere to provide for it (Robèrt et al. 2019). Not only that, but social issues such as poverty, growing inequalities and discrimination also hinder society's own ability to solve its systemic errors or react to complex issues such as climate change. The visual metaphor below (Figure 1.1) illustrates the sustainability challenge modern society is facing: the closing walls of the funnel represent how we are systematically degrading the socio-ecological system we rely on, and how the room (and time) for action is decreasing. Modern society can stabilize this "downhill course" and stop depleting the resources it relies on by applying a strategic sustainable development approach. This process involves transitioning from the current unsustainable society to one informed by a shared understanding of sustainability through principles that define the basic requirements for a society to be sustainable. The walls of the funnel level out when society's systemic and unsustainable "errors" are eliminated, and humans can start thinking about "restorative" actions aimed at widening the wall of the funnel again (Robèrt et al. 2019).

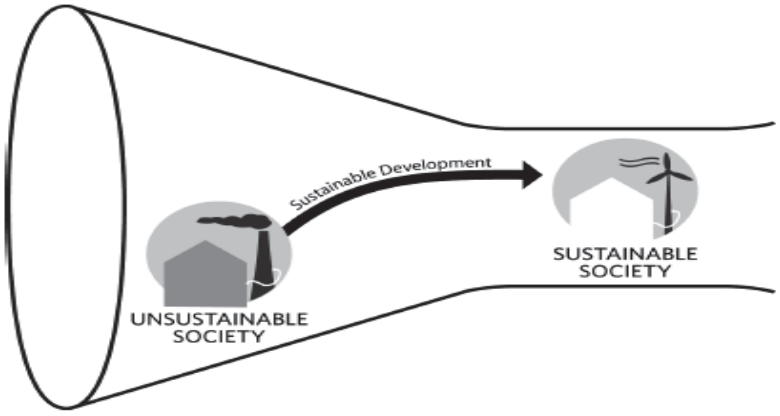

Figure 1.1. The Funnel Metaphor (Robèrt et al. 2019, 14)

1.2 Global Energy: A Systemic Perspective

Energy is an essential element for today's global society to operate. It serves humanity by providing heat and electricity for households, factories, and buildings; and it is necessary for powering the transport, manufacturing, and agricultural sectors to name only a few. The global demand for energy has grown around 10 times from 1999 to 2019 (IEA 2019). This demand is predicted to only keep increasing parallel to the economic and population growth in developing countries (Delina 2021).

The current dominant form of producing energy is fossil fuels reliant, and is thus one of the main drivers of the global sustainability challenge: 80% of the world's energy is sourced from fossil fuels, and the emissions resulting from its consumption cause 75% of the greenhouse gas emissions causing climate change (IEA 2021a). Moreover, the way in which most energy is currently produced and consumed contributes to exacerbating inequalities and negatively affecting people's health: 1.1 billion people still do not have access to electricity, and 2.6 billion still rely on dangerous and unhealthy fossil fuels (gas tanks and wood/coal-based cooking stoves) for heating and cooking (Khanna et al. 2019). The World Health Organization (WHO) estimates that around 3.8 million people a year die from illnesses caused by regular exposure to kerosene and coal powered cooking stoves (WHO 2021). Overall the need to change to sustainable energy sources appears to be beneficial to both the environment as well as society. The International Energy Association (IEA) already predicts that the pledges made all over the world to address the emissions caused by the current energy demand will not be enough to fulfil the Net Zero Emissions (NZE) by 2050 Scenario (IEA 2021a). This indicates just how much the world still depends on carbon-based energy production.

1.3 Renewable Energy Systems

A worldwide energy shift is required to meet the targets of preventing an average surface temperature increase above 2° Celsius. To achieve this, a transition from fossil fuels to low-carbon renewable energy sources is necessary, as energy-related carbon dioxide (CO2) emissions represent 66% of every ozone depleting substance (Core, P.K. and Meyer 2014).

The energy transition will likely be empowered by technological innovation, predominantly in the field of renewable energy. The latter is defined as "energy flows which are replenished at the same rate as they are used" and are "obtained from the continuous and repetitive currents of energy recurring in the natural world" (Peake 2018, 13). Renewable energy sources can be partitioned into the following six classifications: wind, hydro, tidal, geothermal, biomass and solar (Peake 2018). These all have their benefits and weaknesses. Hydropower has a capacity of 117 gigawatt and covers 17% of global electricity generation, but it requires huge surface areas and carries some environmental issues with it (IEA 2021b). Harnessing tidal energy requires building big and expensive tidal barrages. Geothermal energy systems can only be built in specific suitable locations and are also difficult to implement on a small scale (Peake 2018). Wind farms require a lot of space, and researchers have found that the turbines have noise and visual impact on surrounding residences and wildlife. Wind farms also have issues related to maintenance, making them not the best solution to supply small remote regions with energy (Delicado, Figueiredo, and Silva 2016). Biomass is another possible environmentally friendly option. However, the problem here is community acceptance, as the resulting air pollution coming from the combustion of wood and agricultural/animal waste can be problematic (Shafie et al. 2011). This leaves us with solar energy. While having some negative impacts on the environment due to their manufacturing process, solar photovoltaics (PV) still appear to be the best option for bringing renewable energy to remote regions, as they are highly modular, and require less maintenance than the other options and are getting cheaper (Pratiwi and Juerges 2020).

The unprecedented increase in renewable energy projects around the world shows that the energy transition is already taking place. This can be ascribed to quickly falling prices of

renewables especially for solar PV and wind power (IEA 2021a). In 2020, the European Union (EU) already managed to have a 22% share of energy when it comes to renewable sources (Eurostat 2022). However, change seems to not be happening quickly enough to achieve the goals of the NZE (IEA 2021a). While progress is occurring, the large-scale uptake of renewable energy has lacked a unified global strategy and remains inhibited by a number of different barriers at both local and global levels.

1.4 Centralized Energy Systems and an Emerging Decentralized Understanding

Energy systems are broadly classified into two categories: centralized energy systems and decentralized ones. Centralized energy systems are currently the dominant form of producing, distributing and consuming energy worldwide. They generate power on a large scale from centralized facilities which are usually located far away from end-users. This means that a significant amount of energy is lost during transmission (Liu et. al. 2017). Centralized grids can also be unstable where there is unreliable or non-regularly-maintained transmission infrastructure. Not only that, but centralized systems' common failure to reach remote communities is one of the causes of energy poverty (Phoumin 2018). In fact, the costs of creating the infrastructure to extend the central grid to remote areas is often too high and time consuming, resulting in people either living without access to electricity or using costly, inefficient, polluting and unstable diesel-fuel generators to power their households for a few hours a day (Phoumin 2018).

Instead of relying on one power plant generating and then distributing energy over a long distance, decentralized energy systems (DES) rely on a more local energy production and distribution, which can also empower local communities with more autonomy in their decision making (Ha and Kumar 2021). One model that exemplifies this aspect is the "prosumer". A prosumer is an individual who is simultaneously consumer and producer of a given product. In the case of decentralized solar systems, this would mean that not only does the end-user consume the energy from the PVs but also produce it. The prosumer can then sell excess energy to neighbours by implementing a peer-to-peer energy sale system, thus contributing to furthering the electrification of his own community (Filho et al. 2020). DES can also be faster to implement; be more environmentally friendly; be cheaper in terms of upfront cost; be more affordable and reliable; have lower risk; and enhance the ability of local communities to cope with system failures (Ha and Kumar 2021).

DES have been disseminated worldwide for improving access to energy for rural households (Yaqoot, Diwan, and Kandpal 2016). However, decentralized solutions are not without limitations: a decentralized power system may face a power outage if the supply cannot keep with the demand. Adding to that is the issue of having to maintain multiple smaller systems rather than a single big one. This makes organizing and monitoring energy supply and distribution rather difficult as well. There is also the question of what to do with an energy surplus, i.e. energy storage. While a centralized system can just reroute the surplus with ease, decentralized ones require investments in storage facilities which raise the project costs significantly (McKenna 2018).

1.5 Energy Outlook in Southeast Asia

Southeast Asia is home to over 655 million people which is equal to around 10% of the global population (IEA 2019). Countries in the region are developing very rapidly, with high economic and population growth, urbanization and corresponding increase in energy demand (Fuentes, Urmee, and Chapman 2020). The share has been rising steadily, with the region today accounting for nearly 5% of global energy demand. The latest Association of Southeast Asian Nations (ASEAN) Energy Outlook projected that energy demand in the region may more than double by 2040 compared with 2017 (ACE 2020). The current energy mix of the region comprises 80% oil, coal and natural gas (Phoumin, Kimura, and Arima 2021), and renewable energy accounts for a small fraction, only 15% of the region's energy supply (excluding the traditional use of solid biomass, with progress in renewable energy deployment being diverse across each country) (IEA 2019). A significant fraction of projected global coal capacity growth in the next ten to 15 years could occur in this region, particularly Indonesia, Vietnam, and the Philippines (Fuentes, Urmee, and Chapman 2020). Southeast Asia is one of the regions where increasing energy demand is accompanied by unsustainable energy production, so it is easy to see why renewable energy could have a significant impact in the region (Andrews-Speed 2021).

1.6 Transition to (Decentralized) Renewable Energy Systems in Southeast Asia

A transition to renewable energy and an increased deployment of decentralized systems in Southeast Asia will likely lead to addressing issues related to the current energy system in the region. The main reasons for transitioning as well as an assessment of the current state of the transition are outlined below.

A) Reasons: Aside from making its energy mix more sustainable, a major challenge the region faces is reaching its roughly 45 million residents who are currently living without access to electricity (IEA 2019, ACE 2021). This challenge stems from the inefficacy of centralized energy systems in reaching remote communities (Phoumin 2018). Due to their small-scale nature, flexibility, low cost and efficiency, decentralized renewable energy systems could help eradicate energy poverty in the region (Phoumin 2018).

The current and potential impact of climate change on countries in Southeast Asia also calls for an urgent acceleration of the transition towards renewable energy (EU-ASEAN Business Council 2021). Compared with an estimated 450,000 in 2018, the number of annual premature deaths caused by outdoor and household air pollution in the region is predicted to rise to more than 650,000 by 2040 (IEA 2019). The entire region will also be affected by the increased frequency and intensity of natural disasters (typhoons, floods, droughts, and increased spread of tropical diseases due to warmer weather), with lower-income and vulnerable families that will be affected the most (EU-ASEAN Business Council 2021).

B) Current state of the transition: Southeast Asia is a very diverse and dynamic region experiencing wide economic development gaps in terms of gross domestic product, population growth, energy use, and technologies. Each country is committed to addressing the common climate change issue by ensuring a secure, affordable and more sustainable pathway for the energy sector (Phoumin, Kimura, and Arima 2021, IEA 2019). ASEAN member states agreed

to achieve two major targets: to increase the share of renewable energy to 23% of the total primary energy mix by increasing its share in power capacity to 35%; to reduce the energy intensity by 32% by 2015 through the ASEAN Plan of Action of Energy Cooperation Phase II (ACE 2020). Nevertheless, emerging countries face energy access and affordability issues, while promoting renewable energy and other clean energy technologies remains costly. While solar and wind module costs may have fallen drastically, the system cost remains high for low- and middle-income countries. Policy attention, including regulations and financing mechanisms, with support from high-income countries, will be required to make these clean and green technologies available to less affluent countries in the region (Phoumin, Kimura, and Arima 2021).

1.7 Renewable Energy Finance

Global and Regional Overview

Globally, the private sector is the main provider of the financial capital for renewable energy projects; it contributed to 86% of all the investments between 2013 and 2018 (IRENA and CPI 2020). Public finance, representing the remaining 14%, was mainly secured by development finance institutions. The public funding often helps to reduce the upfront risk pertinent to the projects, attract potential private investors and stabilize the emerging markets.

On the contrary, within the ASEAN region, more than 60% of the clean energy finance was coming from the public sector and was concentrated on large-scale renewable energy projects (Susantono et al. 2021). There is a significant and increasing need within the region for private funding which could help increase the competitiveness of the market, diversify it and attract potential foreign investments.

Private equity (PE) funds, which represent one form of the private capital, are foreseen to be more active within the ASEAN region (Draper et al. 2021). In June 2021 Asia focused PE funds recorded a 65% increase in raised financial capital compared to the same period the year before (Zhou 2021). BlackRock, a US-based investment giant, suggests that the Asian region creates unique investment opportunities for global investors interested in climate change mitigation due to predicted regional increases in electricity demand, urbanization and fast-paced economic development (Teneo 2022).

In the ASEAN region large-scale renewable energy projects, including solar, are mainly financed by the public sector, whereas the decentralized, off-grid installations are primarily funded by private actors (Susantono et al. 2021). It often results from the fact that providing each household with grid access, so-called last mile delivery, is quite costly and might not be profitable from the respective national energy utility's perspective. It is one of the reasons for the active presence of multiple private players at the regional market who try to solve the challenge by applying disruptive technologies and providing innovative business models. However, the need to develop the decentralized, off-grid projects still remains high with surprisingly only 1% of the total renewable energy finance spent on these types of installations (IRENA and CPI 2020). The financial instruments that are commonly used for renewable energy in Southeast Asia are presented below (See Table 1.1).

Table 1.1. Most Commonly Used Financial Instruments for Renewable Energy in Southeast Asia (ADB 2018, IRENA and CPI 2020, Susantono et al. 2021)

All renewable energy systems	**Decentralized renewable energy systems**
1. Debt	1. Equity
2. Equity	2. Debt
3. Grant	3. Grant
4. Public private partnerships (PPPs)	4. Blended finance
5. Other, including green bonds	5. Other, including venture philanthropy, crowdfunding, microfinance

Table 1.2. Definition of the Terms

Debt	Selling debt instruments (e.g. loans, bonds) to potential investors
Equity	Issuing stocks to raise funds, lenders receive shares of the company
Grant	Usually lent by international development agencies such as the World Bank, the International Finance Corporation or the Asian Development Bank (ADB)
Public private partnership (PPP)	Agreement between the public and private sector of a long-term nature, primarily used for infrastructure projects
Green bonds	Fixed-income instruments issued to support environmental or climate-change mitigation projects; the World Bank is a major issuer of green bonds
Blended finance	Using mixed public and/or philanthropic funds to raise additional private capital
Venture philanthropy	Applying the rules of venture capital (type of private equity financing) to achieve philanthropic or social impact goals
Crowdfunding	Using social media and/or online platforms in order to pool relatively small amounts of capital from single investors to finance projects
Microfinance	Providing individuals from low-income groups with often simple, informal financial solutions who otherwise have no access to official, institutional financial services

Barriers to Renewable Energy Finance

While the number and diversity of financial instruments used for implementing renewable energy projects is increasing, a few obstacles to a wide-rage adoption still remain.

First, the role of the private sector in the energy transition is still limited in the region - the ADB estimates that more than 60% of renewable energy projects are financed by the public sector, mainly due to the bankability issues (Susantono et al. 2021).

Second, the lack or immaturity of regulatory frameworks in the Southeast Asia region directly translates into higher market volatility and increased risks for investors which deter potential foreign investments (ADB Economics Working Paper Series 2018).

Third, there is a significant heterogeneity of market and economic development across the ASEAN member states which together with the lack of common standards might lead to challenges with financing and implementing of the renewable energy projects.

Another obstacle could be related to the limited use of innovative financing models within the region, e.g. it is estimated that only 1% of all green bonds in the region has been issued for renewable energy compared to 4% on a global scale (Susantono et al. 2021).

Last but not least, the relatively high cost of capital, due to the nature of renewable energy investments - often perceived as highly technical and risky, might also be a significant challenge while trying to finance the energy transition within the region. The requirement to move towards renewable energy systems globally has become clear. In places like Southeast Asia this transition has become increasingly needed as development increases, despite this need for funding that supports the systemic introduction of renewable projects is inhibited by a number of challenges, this study aims to identify significant barriers and enablers to the implementation of decentralized solar energy systems (DSES) within Southeast Asia.

1.8 Research Question

- What are the barriers and enablers to financing decentralized solar energy systems in Southeast Asia?

2 Methodology

2.1 Research Design

This study explored the barriers and enablers to financing decentralized renewable energy systems in Southeast Asia. A qualitative approach was chosen to answer the research question. This design is advantageous due to the three-month time limit on the project. Qualitative research allows practitioners to use a smaller sample to collect analytically generalizable data, while a quantitative approach would require more time to collect the vast amount of numerical data needed (Savin-Baden and Howell Major 2013). The data collected was thus characterized by words and meaning, which allowed the researchers to explore the subjective perspectives of the participants and identify key themes from their answers.

2.2 Research Scope

This research focuses on decentralized energy systems (DES) (A) solar (B) energy systems in three countries - Cambodia, Indonesia and the Philippines, (C). The scoping decisions were informed by both the results of the five exploratory interviews and the literature review the study carried out. The rationale for how the research defined the scope is presented below:

A) DES: The choice of focusing this research on DES reflected the current trend in global energy generation, whereby "countries are transitioning from traditional, one-directional and centralized generation towards decentralized systems" (USAID 2021, 72) due to the increased availability of small scale, intelligent grid and digitalized technologies. These decentralized energy solutions can contribute to overcoming the issues resulting from the shortcomings of centralized energy grids, which include the following:

- High energy costs and greenhouse gas (GHG) emissions
- Low energy efficiency due to losses during energy transmission
- High risks relating to grid instability
- Energy poverty resulting from the failure to reach off-grid communities and provide last-mile delivery (Phoumin 2018).

DES are small-scale, flexible, and have a lower cost of capital, making it a proven solution for last-mile delivery and providing off-grid communities with efficient, cheap, and stable access to energy (Phoumin 2018). Supplying underserved communities with energy through DES deployment can catalyze local economic development and improve livelihoods, health conditions and access to education (Phoumin 2018). At a system's level, addressing energy poverty can thus contribute to reducing inequalities, and consequently strengthen social systems and their adaptive capacity in the face of climate related risks. DES can also contribute to sustainable development by providing the possibility to introduce renewable energy to remote regions that would otherwise end up relying on fossil fuels to fulfil energy needs. Thus, DES can play an important part in contributing to speeding up the transition towards a sustainable society.

B) Solar: The choice to focus on solar also reflected current trends in global energy production, and was based on the current price, flexibility, and potential of the energy source in Southeast Asia. According to the International Energy Agency report of 2020, "solar [photovoltaic] is now the cheapest source of electricity in history" (IEA 2020, 214). Thanks to subsidies and incentives in the West and a consequent sharp increase in manufacturing, the decade between 2010-2019 saw a decline in the cost of solar photovoltaics (PV) of 82%, and a 13% yearly cost decrease of electricity generated from solar PV (IRENA 2020a). While the price of other renewables has also fallen, solar is still the cheapest and most accessible energy source available, and an exponential increase in its generation is projected to occur (Mathis and Murtaugh 2022). Solar systems are also the most flexible: solar panels can be installed anywhere, be easily removed or maintained, and do not take up much space. Other renewables such as wind power require more space and logistics planning, higher technical capacity for maintenance, involve energy losses during transmission, and have higher infrastructure costs (Mathis and Murtaugh 2022). In Southeast Asia, solar energy is the most attractive also due to the immense amount of yearly solar radiation that nations within the region receive: in Indonesia it is estimated that by installing solar PVs on the country's disused land could result in generating 18% more power than the entire globe consumes in a year (Mathis and Murtaugh 2022).

C) Cambodia, Indonesia and the Philippines. The research chose to focus on these 3 countries for the following reasons:

1- *Energy poverty and market for decentralized solutions*. All three countries have the highest energy poverty rates in the region (second only to Myanmar, which this study does not focus on due to its socio-political unrest since February 2021 and resulting unreliable data) (Delina 2021). This is partly due to the countries' topography, characterized by rural areas and islands which are costly and difficult for the national grid to reach. For example, the Philippines are composed of 7,107 islands, making the electrification of its various provinces highly challenging: 649 islands remain completely unelectrified, while many of the country's supposedly electrified provinces still have limited and unstable access due to issues in providing last mile delivery (Berthau 2020). Hence, the energy needs and demand for decentralized solutions is the highest in the countries selected.

2-Political stability: the research defines political stability as the regularity of government exchange / rule, and the presence / absence of political conflict and upheaval. All the countries selected currently possess the political stability necessary for their economies to grow, to attract investment and for their renewable energy markets to flourish.

2.3 Research Development Process

The research process was divided into four main phases which overlap and build on each other (see Figure 2.1).

Phase 1: Literature Review
- Literature review to identify the research question

Phase 2: Data Collection 1- Initial/ Exploratory Interviews
- 5 exploratory interviews
- 12 further organizations were identified for interviews in phase 3

Phase 3: Data Collection 2 - Secondary/In-depth Semi-structured Interviews
- 12 semi-structured interviews

Phase 4: Data Analysis
- Thematic content analysis with PESTLE coding structure

Figure 2.1. Research Process

The following sections expanded on these phases and explained the rationale behind the methods selected.

Phase 1: Literature Review

The study reviewed existing literature relevant to the scope of our project, so as to gain a shared understanding of key terminology, of the sector at hand, and to identify gaps in the research. The literature we examined included research on the following topics:

- renewable energy solutions;
- energy transition; energy systems (centralized, decentralized, and microgrids);
- global energy mix;
- energy poverty;
- current financing solutions for energy projects;
- financing solutions with potential for development; and
- energy trends worldwide as well as in Southeast Asia.

Reviewing the relevant literature helped us identify our initial research question: "What are the barriers and enablers to financing decentralized renewable energy systems in Southeast Asia?" In particular, this project set out to better understand the barriers and enablers influencing the pace and scale of the transition towards renewable energy in the region.

Phase 2: Data Collection 1 - Initial/Exploratory Interviews

This phase built on the research and insights gained in phase 1. Here the study started with designing explorative interviews. The reason to choose interviews as the tool was that interviews gathered deeper, richer data than questionnaires. They also yielded information to answer the research question directly and can also be used to probe and follow up. They allowed research participants to construct their answers in their own words with fewer restrictions, and allowed the research process to enter unknown and unplanned areas of theory – going off at tangents (Savin-Baden and Howell Major 2013).

Five exploratory interviews with five different experts (see Table 2.1) were conducted to scope the project while remaining flexible with the questions that could be asked. Four organizational types where engaged with, they included:

- Private company: the privately owned company working on decentralized renewable energy;
- Impact investment company: the investment fund that specifically seeks to support beneficial social or environmental outcomes, in addition to generating financial returns;
- Social enterprise: an organization that applies commercial strategies to maximize improvements in financial, social and environmental well-being. This may include maximizing social impact alongside profits for co-owners;
- Consulting firms/platform: the organization is connecting international investors with entrepreneurs for financing.

The criteria for selecting relevant interviewees were:

- The organization provides or is related to energy financing in Southeast Asia. The study could have also looked at companies that are currently not active in Southeast Asia to understand why they are not operating in the region. However, for the first five interviews we decided it would be better to see what patterns emerge related to financing in the region as this could give us an idea of which types of financing we would like to explore further.
- The organization should have more than one financing option that they are related to. This is an important criterion as the study would like to see as many opinions on as many funding models as possible to see if anything stands out.

Table 2.1. List of Organizations of Five Initial Interviews

Working Geographic Locations	Cambodia	Indonesia	The Philippines	Other Southeast Asian Countries
Private company				
1. Yoma Micro Power			√	√
Impact investment company				
2. Nexus for Development	√	√		√
3. Impact Investment Exchange (IIX)	√		√	√
Social enterprise				
4. ATEC International	√	√		√
Consulting firm/platform				
5. Sevea Consulting	√			√

At least three interviewers were present to conduct the interviews, while one researcher took notes. The following are some of the questions asked during these interviews:

- What do you see as barriers and enablers to financing in Southeast Asia?
- What do you think are the most promising financing schemes for the region?
- Is there anything you know that will help the transition to renewable energy?

A number of themes emerged from the initial five exploratory interviews. These themes were then incorporated into the following 12 semi-structured interviews: they informed the question formulation and scoping decisions. Following the exploratory interviews, the project focus shifted to solar power since the energy source is seen as the most promising and common form of renewable energy generation in the region (see section 2.2). Nonetheless, having a full overview of all renewable energy models and their respective barriers and enablers could be a topic for future research. The research also chose to focus on the countries of Cambodia, Indonesia and the Philippines (see section 2.2.). Consequently, exploratory interviews also led to the modification of our research question to the following: "What are the barriers and enablers to financing decentralized solar energy systems in Southeast Asia?".

As a result of these interviews, further organizations were identified as relevant to the study, and these were utilized in phase 3 (data collection 2) in order to gain more detailed information to answer the new research question.

Phase 3: Data Collection 2 - Secondary/In-Depth Semi-Structured Interviews

The five exploratory interviews from phase 2 provided the study with a more in-depth and holistic understanding of the energy transition landscape in Southeast Asia. The feedback and insights gained from them led to tailoring the questions for the 12 follow-up semi-structured interviews to obtain more nuanced answers. They provided a useful structure to lead the conversation while allowing space for additional comments and tailoring the interview accordingly (Savin-Baden and Howell Major 2013). This was helpful when time for each interview was limited. Thanks to the predefined design we were able to approach each of the sessions in a systematic, strategic manner. On the other hand, this type of interview also provided the study with some space for exploration which might have not been possible with a fully structured interview format. The twelve interviews provided the study with a significant database from which to draw data and conclusions.

The semi-structured interviews were conducted in the months of March and April. The selected interviewees came from a diverse range of fields relating to the renewable energy sector in Southeast Asia (see Table 2.2). Five organizational types where engaged with, they included:

- Intergovernmental organization: an entity created by treaty, involving two or more nations, to work in good faith, on issues of common interest;
- Consulting firms/platform (see data collection 1);
- Private company (see data collection 1)
- Development finance institution: also known as a development bank or development finance company, is a financial institution that provides risk capital for economic development projects on a non-commercial basis.

Table 2.2. List of Organizations of 12 Secondary Interviews

Working Geographic Locations	Cambodia	Indonesia	The Philippines	Other Southeast Asia Countries
Intergovernmental organization				
1. and 2. ASEAN Centre for Energy	√	√	√	√
Consulting firm/platform				
3. Private Financing Advisory Network - Malaysia				√
4. Private Financing Advisory Network - Thailand				√
5. Private Financing Advisory Network - Indonesia		√		
6. Climate Bonds Initiative	√	√	√	
7. Smart Power Myanmar				√
8. Valores Global	√	√	√	√
9. CSi Energy Solutions International			√	
Private company				
10. Okra Solar	√			√
Impact investment company				
11. Uberis Capital	√	√		√
Development finance institution				
12. Asian Development Bank	√	√	√	√

Each interview was conducted according to the structure prepared beforehand (see Appendix A). The whole team (consisting of four researchers) was present during the majority of the interviews. For each of the sessions one researcher took the leading interviewer role and was supported by the others when needed. One researcher was also taking notes. Each of the interviews lasted between 45 and 60 minutes and was recorded with audio recording software.

Phase 4: Data Analysis

All the data generated from the five exploratory and 12 semi-structured interviews was recorded and transcribed using transcription software - Otter.ai.

The data was analyzed through qualitative content analysis, which "is an approach of analyzing documents and texts that aims to quantify content in terms of predetermined categories in a way that is systematic and replicable" (Bryman 2021, 272). Specifically, the study applied thematic content analysis: this method involves familiarizing the researchers with the data, creating initial codes, identifying and evaluating themes, choosing final themes and writing the report (Braun and Clarke 2006).

The transcriptions were reviewed and discussed with the other researchers to ensure transcript quality before being coded. The PESTLE (Political, Economic, Social, Technological, Legal and Environmental) analytical framework was applied for code structure, because it is a tool used to map the external trends which can allow one to gain a systemic understanding of the environment happening around the organization, both in the present and for the foreseeable future. It allows for a strategic and systematic evaluation of prospects, risks and opportunities in a new environment (Robèrt et al. 2019). Each factor was prescribed and coded with a unique color in order to make them identifiable. Subcodes for each factor emerged through analysis and clustering of data (See Figure 2.2).

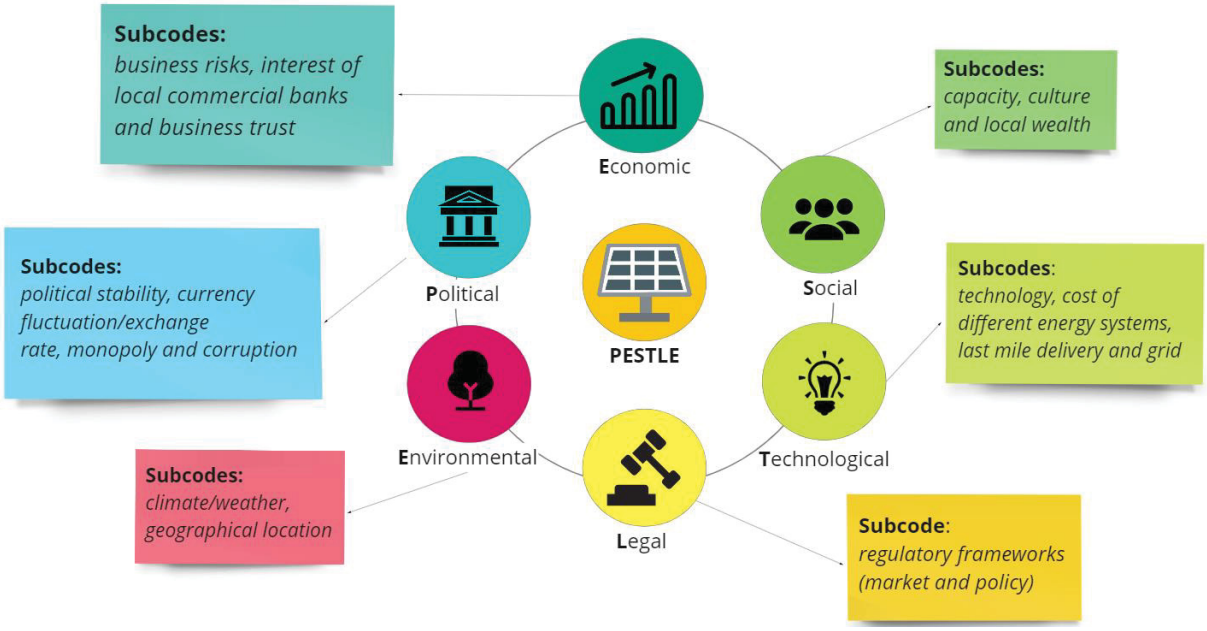

Figure 2.2. PESTLE Coding Structure

Political factors relate to government control and influence over the economy and industry. The data was clustered under four subcodes that fit this category, namely political stability, currency fluctuation/exchange rate, government related market monopoly and corruption.

Table 2.3. Subcodes for Political Factors

Subcodes	Example Quote
Political stability *(Status of regularity of government exchange/ rule, and the presence/ absence of political conflict and upheaval)*	*"The most important thing is the stability of the country"* (Interviewee 5, 2022)
Currency fluctuation/ exchange rate *(Exchange rate fluctuations stemming from the political stability of the country involved)*	*"While there is relative currency instability in Cambodia, I do not think it is a problem"* (Interviewee 12, 2022)
Monopoly *(A national energy company, "a single buyer", holds a dominant position of influence on the market, to the point of excluding other viable competitors)*	*"[...] just wants to build one big grid to control it and they don't want anything. They don't want anyone else owning energy assets"* (Interviewee 14, 2022)
Corruption *("Certain influential groups"* or *"certain vested interests")*	*"[Corruption] is an issue, it varies country by country. Some are worse than others"* (Interviewee 4, 2022)

Economic factors have a direct impact on a company's long-term prospects in a market. The economic environment may affect how a company prices their products or influence the supply and demand model. The data was clustered into four subcodes under this category, including business associated risks, interest of local commercial banks and business trust.

Table 2.4. Subcodes for Economic Factors

Subcodes	Example Quote
Business risks *(High upfront cost, small project scale, low rate of return, losing the market due to the grid expansion)*	*"Business risk of the company, [...] is ultimately the biggest risk and those we just have to evaluate ourselves"* (Interviewee 1, 2022)
Interest of local commercial banks *(Interest of local commercial banks regarding solar energy projects)*	*"We are not seeing support from local [commercial] banks for those sorts of things [small scale distributed solar]"* (Interviewee 15, 2022)
Business trust *(Relationship or rapport building with the investors)*	*"The more information you have in terms of rich relationship building with the investor, the easier it is to break the barrier"* (Interviewee 7, 2022)

Social factors refer to how demographics and culture can impact the industry by influencing peak buying periods and purchasing habits, for example. Society is important as people's culture and lifestyle can influence when, where and how they

are likely to engage with products and services. The data was clustered into three subcodes under this category, namely capacity, culture and local wealth.

Table 2.5. Subcodes for Social Factors

Subcodes	Example Quote
Capacity *(Understanding and maintaining technology related to solar energy as well as financial literacy)*	*"[The lack of proper documentation] has been a big challenge for investors"* (Interviewee 2, 2022)
Culture *("Shared mental model" of the region that mainly expresses itself in the level of local acceptance of solar, the trust between each other and foreign entities as well as the general mindset of the population)*	*"[...] community engagement is a challenge for those projects. [...] you'd have to be pretty confident that the community is actually part of the project*" (Interviewee 8, 2022)
Local wealth *(Local capacity to pay for solar projects)*	*"You need to be sure that they can afford what they can pay"* (Interviewee 5, 2022)

Technological factors may have a direct or an indirect influence on an industry. While some industries will be more affected by technology than others, innovations in technology may affect the market and consumer choices and buying power. The data was clustered into four subcodes (such as last mile delivery and energy system costs) to fit under this category.

Table 2.6. Subcodes for Technological Factors

Subcodes	Example Quote
Technology *(Technology related to solar PV manufacture, implementation and maintenance, energy storage/battery systems as well as innovative business models)*	*"So, I can foresee that tomorrow's solar home systems will be using lithium batteries that can contain a lot more energy or can be more efficiently controlled"* (Interviewee 12, 2022)
Grid *(Stability/flexibility of grid, national grid, alternative types of grid and scale of the grid)*	*"Building out the national grid much faster than we had anticipated. So that actually hurts our business"* (Interviewee 4, 2022)
Last mile delivery *(Providing secure, affordable and equal energy access at the final step of reaching each household)*	*"The last mile is always really challenging [...] Cambodia is really getting behind the others"* (Interviewee 12, 2022)
Cost of different energy systems	*"In terms of financial investment,*

(Cost comparison between fossil fuel and renewable energy)	*sometimes dirty energy is actually more affordable than renewable energy systems... renewable energy systems might be more expensive than a diesel engine, at least in the short-term"* (Interviewee 2, 2022)

Legal factors may affect both the internal and external environment of a company. The legal and regulatory environment can affect the policies and procedures of an industry. Its "regulatory frameworks (market and policy)" subcode was placed under this category.

Table 2.7. Subcodes for Legal Factors

Subcodes	Example Quote
Regulatory frameworks (market and policy) *(Data collected on a government's political will to transition to renewables and its energy and investment policies/regulations (including any subsidies, tariffs and incentives in the energy sector)*	"*The barrier is actually regulatory* (Interviewee 8, 2022)

Environmental factors include all those relating to the physical environment. Data clustered in subcodes relating to climate and geographical location were placed under this category.

Table 2.8. Subcodes for Environmental Factors

Subcodes	Example Quote
Climate/ weather *(Extreme climate/weather in Southeast Asia, such as typhoons, floods, droughts, etc.)*	*"The humidity in the region really is not helping with the electronics"* (Interviewee 6, 2022)
Geographical location *(Geographical location of the energy projects)*	*"Doing the maintenance especially in these remote areas [they] might operate systems"* (Interviewee 15, 2022)

All the transcriptions were analyzed using this coding structure, and the results were reviewed and agreed upon by all authors.

3 Results

This section shares results of the findings related to the barriers and enablers to financing the decentralized solar energy systems (DSES) in Southeast Asia. These results reflect the data collected from the 17 interviews. The most representative and relevant excerpts are presented in the tables below.

3.1 Political Factors

All 17 interviewees spoke of political factors influencing the financing of DSES in Southeast Asia. Results relating to political factors suggested a number of significant outcomes regarding political stability, the impact of currency exchange rate fluctuations, political corruption and the monopolization of the energy market by the national utility company. The data collected on these political barriers and enablers is presented below:

Table 3.1. Political Factors

Factors	**Times mentioned**
Political stability	6 interviewees mentioned political stability
Quotes	
"Political stability is a prerequisite [...] We are now exploring new markets because everything in Myanmar is currently in stand-by" (Interviewee 1)	
"One barrier is the political risk: we've seen it over the past 2 years as well as the COVID crisis, they have been affecting small and medium-sized enterprises (SMEs) a lot, in their work and in their ability sometimes to pay back their loans" (Interviewee 2, 2022)	
"One issue is country risk. So, if a country isn't politically stable [...] we almost ended up in Myanmar, that would obviously have not worked out very well" (Interviewee 3, 2022)	
"In emerging markets there is political risk, which we can often lose sight of. And then you have conflicts come up" (Interviewee 4, 2022)	
"The most important thing is the stability of the country" (Interviewee 5, 2022)	
"And that's because in Cambodia the situation is more stable. In fact, it is a lot more stable compared to Myanmar" (Interviewee 7, 2022)	
Currency fluctuation/ exchange rate	6 interviewees mentioned currency fluctuation/ exchange rates
Quotes	
From an investment perspective, the second risk is currency exposure. So, depending on the country you're working in [...] there is the whole risk of currency fluctuations" (Interviewee	

3, 2022)	
"The currency is going up and down all the time…and when your currency is unstable, no one wants it [...] no one wants to invest" (Interviewee 5, 2022)	
"As long as the project rates are economically feasible [...] I think that the exchange rate is not a major issue for the private sector" (Interviewee 9, 2022)	
"While there is relative currency instability in Cambodia, I do not think it is a problem" (Interviewee 12, 2022)	
"For decentralized projects, the exchange rate is still challenging in some areas" (Interviewee 13, 2022)	
"Foreign currency exchange risk is also a big one. We typically try to deal with that by just getting local debt. But that kind of risk we haven't dealt with yet" (Interviewee 14, 2022)	
Monopoly	5 interviewees mentioned market monopolization
Quotes	
"if you want to do a generation project, you need to have permission from PLN, they need to the national grid operator, and they need to effectively prove that you can provide them electricity at lower cost than they could elsewhere" (Interviewee 4, 2022)	
"Indonesia is being monopolized and controlled by one state owned company called PLN. They have also begun to complete a power development plan which is still heavily rely on coal" (Interviewee 9, 2022)	
"The Philippines have applied the liberalized market which has more competitive market prices for electricity generation and supply. [...] it's become more flexible for them compared to the one that has 1 off taker" (Interviewee 9, 2022)	
"A sort of reluctant and defensive attitude by the [Cambodian] national grid was a deterrent to the development of that sector that was nonetheless promising in the beginning" (Interviewee 12, 2022)	
"The bureaucracy and the defensive slash, the protectionist attitude from the national grid, or national electricity companies, in many parts" (Interviewee 12, 2022)	
"[...] there is one single national electricity company in Indonesia PLN that is pretty much the big influence over whatever happens there. And so PLN doesn't always play a positive role towards helping out small independent power producers who are producing independent energy" (Interviewee 12, 2022)	
"The regulation never passed; we understand that PLN was very strong in resisting the change even though they have a monopoly on electricity transmission. So it didn't actually hamper PLN, because they would have then been the single buyer and the purchase agreement. But the fact of the matter is that this actually never developed any further" (Interviewee 12, 2022)	

"(The Cambodian utility company) *just wants to build one big grid to control it and they don't want anything. They don't want anyone else owning energy assets"* (Interviewee 14, 2022)	
Corruption	7 interviewees mentioned corruption
Quotes	
"[Corruption] is an issue, it varies country by country. Some are worse than others" (Interviewee 4, 2022)	
"Because political will plus some interests make things a bit more difficult" (Interviewee 7, 2022)	
"The project was taken by a certain influential group. And because it was taken by a certain influential group most of this group have no idea how to build a solar farm" (Interviewee 7, 2022)	
"I think corruption is significant" (Interviewee 8, 2022)	
"Effective regulation is missing because of mindset or corruption, I think it's a bit of both" (Interviewee 12, 2022)	
"Most of these companies do not have an anti-corruption system in place. In other words, there's nothing in place to create early warning signals or anything to make corruption recognizable and visible. So from that point on you think of course corruption exists, it's rather prevalent" (Interviewee 12, 2022)	
[on fossil fuels] *"it's almost an excuse for not further developing what could be substituting it, because you have very strong interests behind it"* (Interviewee 12, 2022)	
"*EDC* (Cambodia national utility company) *is completely corrupt. There's huge political corruption, and in order to do a project, you need to make sure that the government has a role and they're being paid for their assistance"* (Interviewee 14, 2022)	
"Things are very different in these countries. Local interests and people that are powerful and have connections, that is a non-regulatory barrier, and it's a very important one [...] it's a lesson everybody learns once when they come to Asia" (Interviewee 15, 2022)	
"And governments will never say that that's the case. But in fact, it is, and these are part of non-regulatory, non-financial issues, which are very important and normally can be solved by navigation with a local partner, just as long as you've got someone with integrity" (Interviewee 15, 2022)	
"Then you go to somewhere like the Philippines where the mayor is elected for three or four years to make the money back that he paid everybody to elect him" (Interviewee 15, 2022)	
"There are some countries where if you don't get along with local governments, specifically in Indonesia, the party doesn't like you, you don't have a project" (Interviewee 15, 2022)	
"You've got significant vested interests in the fossil fuel business, you've got vested interests in government, even government employees and senior level government representatives,	

who themselves run businesses that are linked to diesel or coal businesses. And this, of course, makes it extremely difficult to extricate policy from these systems that have been embedded for many, many years. And that that is actually going to be one of the biggest challenges with regards to decommissioning coal plants" (Interviewee 16, 2022)

3.2 Legal Factors

All 17 interviewees noted legal factors and their influence on financing decentralized solar energy projects. The results suggested outcomes relating to the theme of regulatory frameworks, a category which refers to a government's political will to transition to renewables and its energy and investment policies / regulations (including any subsidies, tariffs and incentives in the energy sector). The data collected relating to this theme is presented below:

Table 3.2. Legal Factors

Factors	**Times mentioned**
Regulatory frameworks (market and policy)	10 interviewees mentioned regulatory frameworks / policy
Quotes	
"*The economy in Cambodia is actually quite open and easy to deal with [...] regulatory burdens and restrictions are much lower. Cambodia is one of the easier countries to invest in, it actually has a very easy regulatory system for investing*" (Interviewee 4, 2022)	
"*The implementation of policies may not be strong enough to facilitate or expedite this transition"* (Interviewee 7, 2022)	
"At the end of the day the rules are not strong enough to change the situation, but it takes some time and the transparency factor might not be so high in various countries" (Interviewee 7, 2022)	
"*Cambodia has a national solar mission"* (Interviewee 8, 2022)	
"The barrier is actually regulatory" (Interviewee 8, 2022)	
"From the regional perspective, I think one of the things that would help to make all the grids more stable is that if they had an ASEAN grid. And that has been under discussion for a long time. And they keep saying, you know, next year, in four years, we're gonna have this interconnection" (Interviewee 8, 2022)	
"The Philippines want to add more solar energy and replace the diesel power plants with more small-scale renewables to clean their power supply portfolio" (Interviewee 9, 2022)	
(Cambodia) *"The regulation is weak in the sense that the government doesn't really chase people or check"* (Interviewee 10, 2022)	

(Indonesia) "*There's no regulation that can connect the dots in helping solar for decentralized off-grid energy to play its role in the market"* (Interviewee 11, 2022)
"In Indonesia, Independent power producers are supported by the government in the sense that the government is committed to the two-degree scenario under the Paris Agreement" (Interviewee 12, 2022)
(Cambodia) "*a sort of reluctant and defensive attitude by the national grid was a deterrent to the development of that sector [...] so I think it's a mix between, you know, lack of boldness in the regulation, and then tax incentives"* (Interviewee 12, 2022)
(Cambodia) "*A failure to build independent power producers, the sector is weak in that regard*" (Interviewee 12, 2022)
(Cambodia) *"There will need to be a system to guarantee debt, there will need to be a system to provide subsidies, etc. There also needs to be a very strong supervision system with incentives and penalties if they fail to meet the objectives. I don't think the whole thing exists. It's not enforced. So, that is missing"* (Interviewee 12, 2022)
(Indonesia) *"There's no regulation. So are you allowed, or you're not allowed? For us, it was not an easy investment. What if you build a large network with a large investment and no regulatory framework to base yourself on? What if the government decides to go the other way in the future, then your you will be putting everything at risk"* (Interviewee 12, 2022)
(Indonesia) *"The regulatory framework is somewhat deficient here, there is no connection within government, between different silos in a bureaucracy, they are operating sort of distinctly. For example, between FDI, promotion and tax incentives, this cooperation level of public policy is sometimes lacking. So development isn't fast to follow"* (Interviewee 12, 2022)
(the Philippines) *"The barriers there are also regulatory, the regulation in relation to foreign investment is not super clear, it's like a nightmare*" (Interviewee 14, 2022)
(DES in the Philippines) "*haven't taken off because the enabling policies aren't in place*" (Interviewee 15, 2022)
"The policies aren't truly trickling down, and the financial entities [...] I think the local banks would be really important to trigger that. But it's that the enabling policies aren't there" (Interviewee 15, 2022)
"In Indonesia they're still obsessed with coal" (Interviewee 15, 2022)
"The enabling policies aren't there yet" (Interviewee 15, 2022)
*"In Indonesia there is a strong coal lobby [...] Everybody is desperate to change their (*energy*) systems because their operating costs have gone through the roof. Everybody wants to do the right thing for the wrong reasons"* (Interviewee 16, 2022)
"*Policy to support renewable energy in the energy mix is lacking"* (Interviewee 16, 2022)

"The policy level needs to support financing as well. But permitting and licensing around decentralized energy solutions and the policy frameworks for those are devilishly difficult and very time consuming. Every country in Southeast Asia is at a different stage in development with those, particularly with relationships to grid interconnection" (Interviewee 16, 2022)
"It is a big barrier. Homogenous technical standards: a lot of developments of decentralized energy solutions being looked at in Southeast Asia don't have homogenous technical standards. There's a lot of delays in permitting, because governments are still trying to figure out what those standards should be and how they should be applied" (Interviewee 16, 2022)

3.3 Economic Factors

All 17 interviewees noted that the economic aspect is one of the most important areas regarding financing DSES in Southeast Asia. Results for economic factors suggested a number of significant outcomes, these are the business risks (upfront cost, rate of return and project scale), the impact of the interest of local commercial banks, and the effect of business trust with the investors. The data collected on economic barriers and enablers is presented below:

Table 3.3. Economic Factors

Factors	**Time mentioned**
Business risks	12 interviewees mentioned business risks
Quotes	
"Business risk of the company, [...] is ultimately the biggest risk and those we just have to evaluate ourselves" (Interviewee 1, 2022)	
"[...] but from anything that's going out to a rural consumer that generally means a relatively poor consumer who has a limited amount of disposable income but no savings. So that's an upfront investment [...]. It still relies on your ability to go in and ultimately take back the product, if the customer stops paying." (Interviewee 3, 2022)	
"You always need to work with the Ministry of Energy and the national utility, because they are the one extending the grid. So, if you make a project and three years after they extend the grid [there], then your project is useless. So you need to coordinate with them." (Interviewee 5, 2022)	
"*They don't have a very good return for these kinds of [decentralized/small scale] solar projects*" (Interviewee 5, 2022)	
"Most investors are trying to invest in bigger scale projects to avoid the risk" (Interviewee 7, 2022)	
"Small capacity solar makes it much more difficult for funding." (Interviewee 10, 2022)	

"I think there is a role for government money working as a catalyst for promoting private investment in blended finance" (Interviewee 11, 2022)	
"So the bigger size you grow, the more opportunity for you to even find investors" (Interviewee 11, 2022)	
"Where the grid was progressively extended, the provision of electricity would then be very cheap. So it becomes very difficult for renewable energy producers like village grids, for example, to produce electricity cheaper than the national tariff, because you would have an expenditure, capital expenditure plus operational expenditure (OPEX) to recoup" (Interviewee 12, 2022)	
"The solution is possibly blended finance using a mix of public investment/philanthropy, venture philanthropy plus private investment. That is not just a feature of electricity, we see that everywhere across the impact investing so far for numerous business models, not just last mile energy" (Interviewee 12, 2022)	
"Things that are challenging for an investor and distributed resources off grid is that one day the grid might arrive there, and it will be much cheaper. Then what happened in Cambodia is that the grid came everywhere and all those businesses are out of business now" (Interviewee 15, 2022)	
"It is extremely difficult to attract private financing to small scale solar development, and it's extremely difficult to get commercial banks interested in this space" (Interviewee 16, 2022)	
"*The problem there is that many of the private equity firms or the other kinds of financing institutions are not really interested in any project which is less than $50 million. So it is extremely difficult to attract financing to rural areas"* (Interviewee 16, 2022)	
"There's still a significant upfront investment required to set up these assets, even if they're decentralized" (Interviewee 17, 2022)	
"And the other thing is that [...] because they're mostly financed by deposits, the timeframe for those deposits is between one and five years. So you don't want to commit your money to something that can only pay itself back and say 10 or15 years depending on the scale of the solar installation" (Interviewee 17, 2022)	
Interest of local commercial banks	9 interviewees mentioned interest of local commercial banks
Quotes	
"They (banks) are much more used to working with fossil fuel assets. And those are generally with big companies who already have a track record of working within the banking system, so it's much easier for them to tap into that financing" (Interviewee 2, 2022)	
"*Banks are still very conservative"* (Interviewee 7, 2022)	
"In the less developed countries, one of the biggest problems you face is commercial banks" (Interviewee 11, 2022)	

"We are not seeing support from local [commercial] banks for those sorts of things [small scale distributed solar]" (Interviewee 15, 2022)	
"But the real problem is not their skepticism about the project [decentralized solar energy project], and it is really that they just don't know" (Interviewee 16, 2022)	
"The bankers also don't seem to want to spend extra time looking for stuff to invest in or companies to lend to that are operating in the space of, for example, solar, whereas they already know the candidates for the other stuff" (Interviewee 17, 2022)	
Business trust	6 interviewees mentioned business trust
Quotes	
"You need the backup documentation, you need a solid sort of pitch deck, and you need a data room sitting behind that. [...] And that's usually the best way of building that relationship, building that trust" (Interviewee 3, 2022)	
"It's the relationship between the project owner and the investor that's discrete enough for the owner to convince the investor to come in" (Interviewee 7, 2022)	
"The more information you have in terms of rich relationship building with the investor, the easier it is to break the barrier" (Interviewee 7, 2022)	
"Trust and relationship building are absolutely key and it's even more so. I mean, we talk about due diligence and you know, a lot of this is done on Excel or somewhere on a computer [...] but the banking transactions come down to who you know, and how friendly you are with them [...] and who gets the best deal" (Interviewee 17, 2022)	

3.4 Social Factors

12 interviewees noted social factors and their influence on financing decentralized solar energy projects. The answers categorized under social factors present several significant outcomes, including capacity for maintenance and financial literacy, local culture, population mindset and local wealth. The data collected relating to this theme is presented below:

Table 3.4. Social Factors

Factors	**Times mentioned**
Capacity	9 interviewees mentioned capacity
Quotes	
"[The lack of proper documentation] has been a big challenge for investors" (Interviewee 2, 2022)	
"Financial literacy is key. How do people understand what it means to take a loan? So	

already taking out a loan for two-three years is quite a long period for them [...] People will be thinking more in the short term, and will also have immediate needs, such as putting their children in school, to produce more etc." (Interviewee 2, 2022)
"[This is] not sustainable, the project will not last long. For example, for the solar home system, if you donate this, then you don't have any technical assistance to maintain the system." (Interviewee 5, 2022)
"The main risk is how to make it last: you need to train people in the village technically to maintain it [the system]. Yeah, it's about making the project long term (sustainability) by making sure that they can maintain it or replace equipment so they can find it locally. Access to technicians." (Interviewee 5, 2022)
"[...] community engagement is a challenge for those projects. So financially, even if the government gives you a good purchase rate, as an entrepreneur or a developer, you'd have to be pretty confident that the community is actually part of the project" (Interviewee 8, 2022)
"[western] institutional buildings and capacity enhancement they have in the last say, you know, five years plus they have been progressively compelled back and the relationship with the government is now not a positive. So, I would say Are they really allowed to keep doing their job and push it further? Are they still doing it? Are they really audible? Are they, you know, really being listened to? Still influential in one word, I really doubt it. So, you can see the impact on the ground" (Interviewee 12, 2022)
"Like what I heard, European investors need projects but projects in Indonesia could not provide documents. That's the issue" (Interviewee 13, 2022)
"So one big capacity building is just like they don't know what to use energy for, because they've never really had experience using energy" (Interviewee 14, 2022)
"So that's, that's another one [risk] who's going to be in the areas doing the maintenance especially in these remote areas we might operate systems. People don't have the capacity or training to do it" (Interviewee 15, 2022)
"*What we found is that simple things like training credit committees in commercial banks has had a remarkable impact on the willingness of the banks to get involved in this asset class. This is particularly for rooftop solar, which is going to be a very, very significant piece of Southeast Asia's renewable energy landscape in the coming 2030"* (Interviewee 16, 2022)

Culture	8 interviewees mentioned culture
Quotes	
"You have to understand the cultural dimension; you need to find a model that matches the way they are living. So this cultural dimension of investment is a barrier sometimes that we need to overtake" (Interviewee 2, 2022)	
"The first risk is to make something adapted to the people [...] the mentalities are totally different. And we need to understand what they need and what they want [...]. So you need to understand their needs. So this is maybe the first risk, to think that we know what they	

want, or what they need" (Interviewee 5, 2022)	
"Solidarity at grassroot level is problematic in most of these countries, because they have been through 50 years of Communism so It is rather difficult. [...] especially Cambodia, of course, were very wary of the traditional solidarity links and society links between people before so it's kind of a you know, starting from scratch, with the extreme case of Cambodia where the Khmer Rouge regime, radically destroyed, prevent or the traditional society before it hasn't really been restored, since what you see is a phenomenon where people are already suspicious, jealous, the Community Links have something difficult to build" (Interviewee 12, 2022)	
"I mean local acceptance is interesting. You can't really like the household that is next to each other that doesn't want to be connected because they're like having a fight. So like, we don't put a connection line between those houses, but that's all can be kind of handled on the ground" (Interviewee 14, 2022)	
"you'll find villages will actually rip [solar PVs] out. There's been instances where villages have said. This is against our national doctrine, and they've ripped out the solar because the sun is a God given resource. So as a consequence, it shouldn't be monetized for gain" (Interviewee 15, 2022)	
"Bring electricity access to rural communities and businesses, you can stimulate the local economy, that you are probably saving the development institutions or the government a lot of money in filling in for all of the poverty related problems" (Interviewee 16, 2022).	
"Southeast Asia is a region where people and businesses do copy each other very quickly, when there are successes and they can get replicated very swiftly. That type of model and so on could be extremely helpful to encourage other places to be emboldened. This also helps to unlock financing in new ways, especially where financing institutions have not been typically involved in this asset class before" (Interviewee 16, 2022)	
Local wealth	3 interviewees mentioned local wealth
Quotes	
"You need to be sure that they can afford what they can pay" (Interviewee 5, 2022)	
"What people don't realize is that the living costs are really, really lower in these communities […] even a biogas system of like $200-$300 would be super expensive[…] if you have to pay about two months' salary for the device, this is an expensive product" (Interviewee 2, 2022)	
"And I think the main problem is the upfront cost: Where you have the grid (also in Cambodia) you need to pay to access it. And then when you are off grid the main problem is how to buy the system, or how to make a project in your village" (Interviewee 5, 2022)	
"[...] if you can do it, they will pay for it. They have income, they have money to use, they just need services" (Interviewee 5, 2022)	

3.5 Technological Barriers

Alongside the political, economic and social aspects, the technological one emerged as an important factor to enhance the pace and scale of transition towards renewable energy. All 17 interviewees mentioned it while discussing the conditions for energy transition in Southeast Asia. Multiple themes related to the technological side of the decentralized energy systems surfaced, including:

- technology related to photovoltaic (PV) panels and energy storage (batteries), their manufacture and costs
- types of grid within each country, including the national, centralized one and some innovative approaches (micro, mini, mesh grids)
- last mile delivery - providing each household with access to clean energy, particularly in remote areas (mountains, islands);
- cost of different energy systems - fossil fuel-based versus renewable energy systems.

The most significant points that were covered by our participants are presented in Table 3.5.

Table 3.5. Technological Factors

Factors	**Times mentioned**
Technology	17 interviewees mentioned technology
Quotes	
"You walk into a store and buy (PV) and put it up yourself in some of these markets. And that's good and bad, reflects the cost has come so far down that it can be a kind of a cash consumer product" (Interviewee 4, 2022)	
"One problem with the solar home system is that you need a battery. This is the bottleneck, the weakness of the system because it doesn't last long" (Interviewee 5, 2022)	
"Solar is quite easy to understand: you buy a solar panel connected to a battery, and then you have the DC that you can use. Solar is passive, you don't need to do anything except clean the solar panel" (Interviewee 6, 2022)	
"But I think one of the challenges is actually waste disposal, that end of life cycle" (Interviewee 8, 2022)	
"In the Philippines, there are a lot of small islands in Indonesia as well. And they start to replace diesel power plants with off grid solar and with hybrid technology" (Interviewee 9, 2022)	
"So I can foresee that tomorrow's solar home systems will be using lithium batteries that can contain a lot more energy or can be more efficiently controlled" (Interviewee 12, 2022)	

"Lithium batteries typically [...] every house will have a battery. Lithium prices within battery prices [...] we're pretty worried about that. The chip shortage affected us. A lot of kinds of supply chain dynamics have definitely gotten worse in the pandemic" (Interviewee 14, 2022)	
"The battery cost ends up being as much as your solar installation. So it doesn't make financial sense" (Interviewee 14, 2022)	
"They're a little bit more expensive, but batteries in the tropics tend not to go very well. So some of the really early entry systems suffered after about two years. They just stopped operating" (Interviewee 15, 2022)	
"We're seeing a little bit more interest in sort of different types of battery systems and different types of storage. Storage is one but the other one is actually looking at hydrogen" (Interviewee 16, 2022)	
"We're also going to have a geopolitical problem around it [availability of resources] because we're looking at the behavior again, in Russia and in parts of China. You can see that these moves are also strategic in terms of where some of these mines are and how these resources move across continents" (Interviewee 17, 2022)	
Grid	12 interviewees mentioned grid
Quotes	
"Building out the national grid much faster than we had anticipated. So that actually hurts our business" (Interviewee 4, 2022)	
"Cambodia, where there's effectively no, essentially no national grid that covers the entire country" (Interviewee 5, 2022)	
"Microgrid is something that we will see more and more, like the DC microgrid where also you can connect different solar home systems [...] it seems like a very good (type of) project for the future" (Interviewee 6, 2022)	
"So the government is also spending money on increasing the resilience of the grid" (Interviewee 9, 2022)	
"From the regional perspective, I think one of the things that would help to make all the grids more stable is that if they had a Southeast Asian grid" (Interviewee 10, 2022)	
"Utility scale batteries together with these decentralized solar installations would be quite powerful because you can then build localized grids that can have that kind of demand side response within like a village or a set of households as opposed to trying to force through a massive grid that isn't possible to be built, for example, in a place like Cambodia" (Interviewee 17, 2022)	
Last mile delivery	9 interviewees mentioned last mile delivery
Quotes	

"Like in Cambodia they had a very high electrification rate. But it doesn't mean people have access to electricity. Because they put a transformer in the village. So for them, the village is connected. Most of the time, especially at the beginning, people don't get connected to the grid. Because it's expensive" (Interviewee 5, 2022)
"The last mile is always really challenging [...] Cambodia is really getting behind the others" (Interviewee 12, 2022)
"*Places like Cambodia, the lowest hanging fruits are energized first with mini grids. And then kind of the problem gets smaller and smaller. But you actually have lots of households that are still not connected to power"* (Interviewee 14, 2022)
"They've got power in school, and then in that last area, they don't have power and the reason they don't have power is because they're not politically important" (Interviewee 15, 2022)
"So this could be a part of the last mile solution. [...] You're generating your power for, say, a set of ten households and then you can store and kind of sell electricity back to your neighbors when they need it when you don't need it" (Interviewee 17, 2022)

Cost of different energy systems	5 interviewees mentioned cost of energy systems
Quotes	
"In terms of financial investment, sometimes dirty energy is actually more affordable than renewable energy systems [...] renewable energy systems might be more expensive than a diesel engine, at least in the short-term" (Interviewee 2, 2022)	
"The accelerators are the collapsing price of solar because of China's amalgamation of the solar industry and a conscious decision to drive prices down" (Interviewee 15, 2022)	

3.6 Environmental Factors

Five interviewees noted environmental factors and their influence on financing decentralized solar energy projects. They mainly spoke to factors related to climate and weather as well as the geographical location as relevant factors. The data collected relating to this theme is presented below:

Table 3.6. Environmental Factors

Factors	**Times mentioned**
Climate/weather	2 interviewees mentioned climate/weather
Quotes	
"The humidity in the region really is not helping with the electronics" (Interviewee 6, 2022)	

"Batteries in the tropics tend not to go very well. So, some of the really early entry systems suffered after about two years; they just stopped operating" (Interviewee 15, 2022)	
Geographical location	3 interviewees mentioned geographical location
Quotes	
"Like the Philippines, there are a lot of small islands in Indonesia as well" (Interviewee 9, 2022)	
"Doing the maintenance especially in these remote areas [they] might operate systems"" (Interviewee 15, 2022)	
"The islands in Indonesia, for example, are entirely powered by diesel solutions" (Interviewee 16, 2022)	

4 Discussion

This section interprets and discusses the key findings of the current study. It also touches upon its strengths and limitations as well as ultimately providing some recommendations for potential further research.

In order to address the research question, this study has utilized a number of experts in the field to identify significant barriers and enablers to financing decentralized solar energy systems (DSES) within Southeast Asia. The most significant are discussed below in light of their influence on the strategic sustainable development of the region.

4.1 Barriers to Financing DSES in Southeast Asia

The data collected presents what the current reality of the transition to DSES in Southeast Asia is. Our data analysis has made clear that a number of significant barriers lie in the way of the large-scale implementation of DSES in Southeast Asia.

The data collected during this study was coded based on whether it related to political, legal, economic, social, technological or environmental factors. Nonetheless, the barriers identified impact each other and are intrinsically connected: the findings reflect the complex and interconnected nature of the transition towards renewable energy in Southeast Asia. Hence, this section will exhibit how adopting a holistic systems perspective is helpful and allows for more visibility on the barriers and enablers influencing the energy transition in the region.

4.1.1 Lack of Enabling Regulatory Frameworks

All respondents mentioned political and legal barriers to financing DSES, stating their influence was significant on the transition to renewable energy and the reduction of energy poverty in the region. Specifically, ten interviewees spoke of how regulatory frameworks are crucial for either challenging or enabling the development of the decentralized solar energy field in the countries selected for our research. The category "regulatory frameworks" includes data collected on a country's political will to transition to renewables; its energy policies (including subsidies, tariffs and incentives in the energy sector); its restrictions and regulations on foreign investment; and its policies on financial transparency for businesses and projects operating within its borders.

Interviewees stated that, due to the rising cost of fossil fuels, the political will to transition to renewable energy is actually there in most countries: *"everybody is desperate to change their (*energy*) systems because their operating costs have gone through the roof. Everybody wants to do the right thing for the wrong reasons"* (Interviewee 16, 2022). The Philippines want to "*add more solar energy […] to clean their power supply portfolio"* (Interviewee 9, 2022). Cambodia "*has a national solar mission"* in place (Interviewee 8, 2022) and while Indonesia still has *"a very strong coal lobby"* (Interviewee 16, 2022), *"the government is committed to the two-degree scenario under the Paris Agreement"* (Interviewee 12, 2022).

However, translating political will into regulation that can incentivize decentralized solar solutions and attract investment is challenging and not happening fast enough: respondents outlined how in the Philippines, Cambodia and Indonesia *"the barrier is actually regulatory"* (Interviewee 8, 2022), in that "*policy to support renewable energy in the energy mix is lacking" (*Interviewee 16, 2022). Respondents agree that none of the countries involved in this study have tangible policies in place that:

1. Encourage locals to adopt or implements DSES (such subsidies and tax incentives);
2. Attract foreign investment into renewables;
3. Ensure transparency from local companies and provides guarantees to investors;
4. Have standardized requirements establishing what prerequisites decentralized solar energy projects need to fulfil in order to be authorized.

Since politics and the economy are intrinsically connected, the lack of the aforementioned types of governmental policies inevitably influences outcomes in growth, infrastructure development and investments into the DSES sector of these countries. Thus, not only is the transition to renewable energy in these countries hindered, but the global challenge of lowering the dependence on fossil fuels is negatively affected.

The regulatory challenge to the expansion of DSES is also a direct obstacle to tackling inequalities stemming from energy poverty in the region. Indeed, insufficient regulatory frameworks can result in a failure to ensure last mile delivery, i.e. providing secure and affordable energy access to each household: nine interviewees identified how governments' focus on electrifying a village on paper, without actually building the necessary infrastructure to reach individual households due to high costs that this would entail. Since enabling regulatory frameworks are not currently in place, the DSES sector is not adequately supported to fulfil its role in addressing the issue of last mile delivery and hence the reduction of energy poverty.

4.1.2 Corruption and Energy Market Monopolization Deprioritize DSES

Interviewees identified that the reason why there is a leadership failure to implement appropriate regulatory frameworks to incentivize the expansion of the DSES sector in the region is corruption. More specifically, they stressed the importance of political corruption and the consequent single-company monopolization of the national energy market.

Transparency International (the leading international non-governmental organization combating corruption around the globe) defines corruption as "the abuse of entrusted power for private gain" (Transparency International n.d.). By applying euphemisms such as "*certain influential groups"* (Interviewee 7, 2022) or "*certain vested interests"* (Interviewee 16, 2022), seven interviewees spoke of corruption as a major challenge that DSES project developers face in Cambodia, the Philippines and Indonesia: *"local interests and people that are powerful and have connections, that is a non-regulatory barrier, and it's a very important one […] it is a lesson everybody learns when they come to Asia"* (Interviewee 15, 2022).

This finding is reflected by data from Transparency International's "Corruption Perceptions Index (CPI)", which is the most common and reputable corruption index in the world. It tracks

and measures the level of corruption in a given country's public sector. In 2021, Cambodia was assigned the worst score (23/100, with 100 meaning there is a perceived absence of corruption) and rank (157th out of 180 countries, with 180 being the most corrupt in the world) of all ASEAN member states (Transparency International 2021). The Philippines was also assigned a high corruption score (33/100) and rank (117/180) by the CPI in 2021. Not only that, but surveys run from Transparency International found that 86% of Filipino respondents believe governmental corruption is an issue in the country (Transparency International 2021). In Indonesia, a different survey on corruption found that 92% of respondents perceive the Indonesian public sector to be corrupt (Transparency International 2021).

One major reason why corruption can challenge the financing and development of DSES is because there may be conflict of interest with either local officials giving the project the go-ahead or with politicians deciding on energy policy: "*You've got significant vested interests in the fossil fuel business, you've got vested interests in government, even government employees and senior level government representatives, who themselves run businesses that are linked to diesel or coal businesses"* (Interviewee 16, 2022). This statement is reflected in the latest IPCC report (2022), which identifies the vested interests of politicians, big business and media conglomerates as a direct barrier to the acceleration of the transition to renewable energy (IPCC 2022).

Tied to corruption is the issue of monopolization of energy markets. Five interviewees referred to single companies having a monopoly over their country's (specifically Indonesia and Cambodia) energy generation and transmission as a barrier to the development of decentralized solar energy systems. This is due to the fact that monopolizers can have a "*defensive, protectionist attitude"* (Interviewee 12, 2022): they can apply their influence to steer government policy, exclude competition (and hence decentralized solar energy projects) and protect their interests in fossil-fuel-based energy generation, for example.

Corruption and energy market monopoly influence the deployment of DSES at the local, national and international level. Locally, the presence of people in power who have economic interests in the very same energy sources (fossil fuels) that solar power is trying to substitute will translate into obstacles for DSES developers to get authorization and permits for project roll-out. At the national level, corruption will also translate into a hindrance to governmental policy-making that incentivizes the development of the renewable sector: corruption "*makes it extremely difficult to extricate policy from these systems that have been embedded for many, many years. And that is actually going to be one of the biggest challenges'* (Interviewee 16, 2022). On the contrary, if corrupt policy makers have vested interests in the fossil fuel industry, this will result in regulation that will help the same industry they have a stake in.

A corrupt political system will also have consequences at the international level: inter-governmental collaborations have the potential of unlocking funds, formulating shared visions for development and mapping out strategic action plans. In the energy sector, this can translate to the formulation of common goals for transitioning to renewable energy since the impending consequences of not doing so are a universal problem. Corrupt political systems composed of powerful individuals with vested interests in fossil fuels will hinder the possibility of enacting such international political efforts. Hence, corruption is not bounded by the borders within which it takes place: the presence of a corrupt political system in Cambodia, Indonesia or the Philippines can impact the energy transition for the whole region of Southeast Asia, and consequently affect the sustainable development of modern global society as a whole.

4.1.3 Business Risks Impede the Investment to DSES

Another result of corruption, monopolization of the energy market and insufficient regulatory frameworks is the lack of transparency from the government in disclosing plans for the expansion of the national grid. This manifests as a business risk for DSES developers and investors, since a sudden change of government policy/plan could result in an expansion of the centralized grid to reach communities where decentralized projects were about to be deployed, essentially putting developers out of business.

This is not the only business risk related to DSES. 12 interviewees also mentioned high upfront costs, low rate of return and local payment capacity (among others) as business associated risks that act as economic barriers to the expansion of DSES in the region. Indeed, DSES are often relatively small scale, costly and with a low rate of return. Due to these business risks, they fail to attract investors. Current policies and regulations have led fossil fuels to receive more subsidy support than the renewable sector. This has resulted in investors choosing to support the less risky subsidized energy sources instead of the unsubsidized emerging ones (Taghizadeh-Hesary and Yoshino 2020). For instance, *"Diesel is heavily subsidized as it is everywhere in the region [Southeast Asia] to varying degrees"* (Interviewee 3, 2022). Therefore, renewable energy projects always face the challenge of a low rate of return in comparison with subsidised fossil fuel based investment opportunities.

Although the price of solar PV has been falling dramatically, renewable energy projects still require a large upfront cost compared to traditional energy systems (fossil fuel) due to the high cost of technology (Lee and Zhong 2015): *"there's still a significant upfront investment required to set up these assets, even if they're decentralized"* (Interview 17, 2022). So new and expensive renewable technologies and access to expensive debt markets make return of investment (ROI) in renewable energy projects low compared to fossil fuel projects. Hence, the high upfront cost and low ROI are often hurdles for investors and developers of DSES (Lee and Zhong 2015).

Financial institutions will generally focus on financial return over other factors, telling us that, if financial institutions are to engage in DSES projects, the latter's implementation requires businesses to be able to present strong ROI numbers and discounted cash flow analyses. However, recent financial instruments and incentives don't favor the decentralized solar energy sector.

Another business risk in Cambodia, the Philippines and Indonesia is the customers' financial affordability: the longstanding issue of customers not being able to pay for the technology is still present in these countries. When asked about business risks one interviewee mentioned this point, stating that, as a project developer, *"you need to be sure that they* (local customers) *can afford it, that they can pay"* (Interviewee 5, 2022). Lack of payment may be a very serious risk for small companies that rely on steady payments, especially if they plan to expand. It results in a low ROI for DSES businesses and can cause them to exit the market.

These challenges show that the tangible aspects of shifting to DSES are being blocked by a number of business focused mechanisms or policies: for example, the lack of risk-sharing mechanisms for multi-stakeholders or the implementation of appropriate policies on subsidies and incentives for deployment of these systems has left many DSES businesses struggling to find financing as well as survive.

4.1.4 Limited Interest of Local Commercial Banks Blocks Foreign Investment to DSES

To avoid foreign investment risks with financing DSES, local banks need to get involved in designing and executing financing solutions, guarantee based loans, straight loans, credit notes or other special purpose vehicles that could be used to help finance these projects. Many interviewees pointed out that local commercial banks in Southeast Asia are still very conservative and only focus on economic return rather than ecological and social impacts. This leads to many of the commercial banks not being that interested in DSES as one of the economic barriers: *"we are not seeing support from local [commercial] banks for those sorts of things [small scale distributed solar]"* (Interviewee 15, 2022), because *"they [banks] are much more used to working with fossil fuel assets. And those are generally with big companies who already have a track record of working within the banking system, so it's much easier for them to tap into that financing"* (Interviewee 2, 2022).

As a result of the local banks' lack of support for the decentralized solar energy sector, foreign investment will also not favor DSES due to the risks at play, such as the high probability of default. This will draw back the energy transition at both the local, national and regional (Southeast Asia) levels. This study identified that the root cause of local banks' disinterest in DSES is their lack of knowledge on the benefits that decentralized solar solutions have. This is underscored by one interviewee, who states that *"the real problem is not their [banks] skepticism about the [decentralized solar energy] project, and it is really that they just don't know"* (Interviewee 16, 2022).

4.1.5 Consequences of a Lack of Capacity

A lack of capacity can be an important social factor to consider when talking about the implementation of solar energy in the region. What we categorize as capacity mainly relates to understanding and maintaining technology related to solar energy as well as financial literacy that relate to barriers within the social environment. However, it is not limited to the financial sector alone. It also has an effect on the capacity of the end user to properly maintain their DSES. The main issue here appears to be related to lack of technical understanding and maintenance of the energy system in their own village. If this is not a given then issues will appear over time. Here one interviewee mentioned that *"[this is] not sustainable, the project will not last long. For example, for the solar home system, if you donate this, then you don't have any technical assistance to maintain the system"* (Interviewee 5, 2022). This presents a large barrier for the longevity of any solar energy project as lack of maintenance is a main reason for failure and reduced efficiency in these systems (Baklouti et al. 2020). A global transition towards renewable energy requires developed capacities to implement and maintain these technologies. Failure to do so will lead to a slowed down transition to renewable energy systems and with it a future that will suffer starker consequences from climate related issues.

Another capacity-related issue identified by interviewees is the lack of financial literacy. Consumers in remote areas can lack an understanding of installment payments, loans and even savings. As one interviewee put it, *"Financial literacy is key. How do people understand what it means to take a loan? Taking a loan for two-three years is quite a long period for them [...] People will be thinking more in the short term, and will also have immediate needs, such as putting their children in school, to produce more etc."* (Interviewee 2, 2022). As a result,

companies might experience problems when it comes to securing financing as well as getting payments for their DSES. Looking at it from a sustainability standpoint also makes it obvious that cooperation on a local level is likely lacking here. People are currently just not properly equipped with the tools needed to face the issues they are faced with. Thus, the education for financial literacy can be seen as an important barrier that urgently needs to be addressed in order to ensure success of these projects.

4.1.6 Effects of the Short-Term Mindset on DSES Projects

Interviewee 2 spoke at length about another barrier: the mindset of the people and the related short term thinking that is inherent in the current system. It is difficult for companies to present the consumer with a payment plan and show the long-term benefits of using solar energy if they are unwilling to adopt this long-term way of thinking. This barrier may very well have its root cause in a lack of trust, as this tends to result in a more short-term way of thinking (Jachimowicz et al. 2017). Trust within communities generally appears to be important for these projects as it helps with long-term thinking as well as acceptance of companies acting in the region (Moffat and Zhang 2014). Some areas in Cambodia seem to struggle with this due to the history of the Khmer Rouge regime eroding solidarity links. As one interviewee pointed out, *"Solidarity at grassroot level is problematic in most of these countries, because they have been through 50 years of Communism so it is rather difficult. [...] especially Cambodia [...]"* (Interviewee 12, 2022). However, lack of trust and consequent short-term thinking is not limited to the consumer or the region of Southeast Asia. It is an issue that permeates and degrades socio-ecological systems all over the world. Both lack of trust and short-term thinking can be seen as a root cause for a lot of issues we face today. An example that five of our interviewees spoke about is the perception of the transition costs towards renewable energy. In line with a short term thinking perspective, fossil fuel-based forms of energy generation might be perceived by the local population as much cheaper, easier to access and more affordable: *"In terms of financial investment, sometimes dirty energy is actually more affordable than renewable energy systems [...] renewable energy systems might be more expensive than a diesel engine, at least in the short-term"* (Interviewee 2, 2022). A mindset like this might lead to the complacency of just using diesel generators instead of upgrading to solar energy systems. This in turn can be traced back to the issue of short term thinking in the current system. If no systems change will take place then consequently this short-term thinking is likely to persist and will slow down the transition towards a sustainable future.

4.1.7 Energy Storage as a Bottleneck to the Expansion of the DSES

Aside from the short-term thinking approach and the preference of fossil fuel-based energy sources there are major technology-related barriers that might significantly impede the transition towards renewable energy. One of them is the still relatively high price of energy storage systems, mostly in the form of lithium batteries: *"The battery cost ends up being as much as your solar installation. So it doesn't make financial sense"* (Interviewee 14, 2022). What is more, the limited durability of some of the batteries might also increase the total amount of financial resources needed: *"One problem with the solar home system is that you need a battery. This is the bottleneck, the weakness of the system because it doesn't last long"* (Interviewee 5, 2022).

The high cost related to the purchase of batteries might deter local people interested in small-scale home solar installations, as it often represents a significant portion of the whole investment. At the same time, it stands in stark contrast to the affordability of the solar photovoltaic (PV) panels thanks to their falling prices in the last couple of years: "*the (PV) cost has come so far down, that it can be a kind of a cash consumer product"* (Interviewee 4, 2022).

The barrier related to the energy storage systems is a significant one due to the intermittent character of solar energy generation and the resulting need to store it, particularly at the time of limited sunlight availability. It can significantly delay the energy transition, especially in remote areas, where decentralized energy systems might seem to be the only viable option. What is more, it can also widen the social inequality gap related to energy poverty as those who need it most will not be able to afford it due to the lack of financial and educational resources. It also highlights the intricate and complex nature of the energy poverty issue: technological innovation can definitely help us move in the right direction and increase the speed of the transition. However, collaborative and socially inclusive approaches should be fostered in order to fully address the issue.

Another important aspect of energy storage is the relative scarcity of natural resources needed for the battery manufacturing process, in particular lithium, which emphasizes the direct dependency of the transition to DSES in Southeast Asia on complex global supply chains. The limited availability of raw materials might have far-reaching consequences and affect prices of other natural resources or utility costs. Apart from that, it might also have repercussions at a larger, geopolitical scale: *"We're also going to have a geopolitical problem around it [availability of resources] because we're looking at the behavior again, in Russia and in parts of China. You can see that these moves are also strategic in terms of where some of these mines are and how these resources move across continents"* (Interviewee 17, 2022). It strongly emphasizes the global, interconnected character of the energy challenge and highlights the issues of local responses to it, when local systems remain reliant on resources and influence often beyond their control.

The availability of natural resources also appears to be tightly connected to another crucial issue, namely the disruption within global supply chains caused by the Covid-19 pandemic. It took its toll on the availability and prices of the battery units. It also translated into significant delays in the implementation of decentralized solar energy projects and raised significant concerns among local partners: *"Every house will have a battery. Lithium prices within battery prices [...] we're pretty worried about that. The chip shortage affected us. A lot of kinds of supply chain dynamics have definitely gotten worse in the pandemic"* (Interviewee 14, 2022). The severe global supply chain disruption highlighted the need for approaches based on strategic and systemic thinking, among which tight regional and interregional collaboration, decentralization and preparedness for unknown future events are essential. It also showed that the seemingly infinite financial growth might reach its limits when each country tries to pursue its own economic agenda without having a clear shared goal for sustainable development with its neighbors and other countries at a global scale.

Another technology-related issue is the rapid accumulation of disposed PV panels and batteries, often due to the lack of environmental awareness among local people which ultimately might lead to a serious ecological threat: "*I think one of the challenges is actually waste disposal, that end of life cycle"* (Interviewee 8, 2022). It is of particular significance in remote settings, such as mountainous areas or little islands, with limited capacities to utilize discarded PV panels and

batteries. The issue of waste disposal might serve as a prime example of the complexity of the energy challenge and of the importance of capacity building among the local population. Often it is not enough to only provide local communities with access to innovative technological solutions. It is more about building a shared vision, shared understanding of what might be needed for each of the communities to thrive in harmony with the environment in a long-term perspective at the same time satisfying their needs.

The physical environment, including extreme, tropical weather conditions also plays a very important role when it comes to energy storage systems. The technology often will not last long in such an environment which might translate into shorter battery life, need for regular service, often limited in remote settings, and ultimately much higher costs of the solar project for the local population: "*batteries in the tropics tend not to go very well. So some of the really early entry systems suffered after about two years. They just stopped operating"* (Interviewee 15, 2022). This issue might be particularly important when addressing the energy poverty challenge in remote, rural areas which are often deprived of financial resources. In order to face this challenge systemic solutions should be prioritized - combining local capacity building, financial poverty alleviation and setting in place adequate regulatory frameworks at all levels of the system - ranging from local to national.

4.1.8 Summary of Key Findings (Barriers)

This section has outlined the main political, economic, social, technologic and environmental barriers to financing DSES in Cambodia, the Philippines and Indonesia. The discussion highlighted how political corruption can lead to the monopolization of the energy market and to a lack of enabling governmental regulation that could incentivize the transition to DSES in the region. It outlined how the lack of appropriate regulation also contributes to the business risks associated with DSES for investors, and how a lack of knowledge on the benefits of DSES among local bankers exacerbates these risks. The discussion also addressed how a deficiency in financial literacy and maintenance capacity among local actors can be an issue for the life-span and effectiveness of DSES deployments. Finally, this section set out the energy storage systems issues related to DSES, namely their still relatively high price, availability of natural resources required for their manufacture and their direct dependence on the global supply chains. Most importantly, the interconnections between these barriers were highlighted to emphasize how they all contribute to slowing down the transition to renewable energy in the region (and hence impact global society's transition to sustainability).

4.2 Enablers to Financing DSES in Southeast Asia

This research has taken a systemic approach to understanding the barriers inhibiting the uptake of DSES in SE Asia. A wide scale understanding of the sustainability challenge and some of the systemic barriers and enablers are important elements for regional policy makers, investors, developers and local actors to drive the regional expansion of the DSES sector.

The following chapter will discuss the possible solutions / enabling conditions that this study identified to help scale up the region's adoption of DSES and speed up their transition to renewable energy.

4.2.1 Policy to Drive the DSES Sector

The first political enabler identified by this study is regulation to shine a light on corruption. Although the latter is a complex issue that is often deeply-rooted in a country's history, institutions and policies, some interviewees suggested possible solutions to mitigating the risk that corruption poses for project developers and foreign investors. Interviewees 2 and 15 state that identifying trusted local partners can help: issues posed by corruption "*can be solved by navigation with a local partner, just as long as you've got someone with integrity"* (Interviewee 15, 2022) who knows the country and the sector. At a governmental level, the most straightforward (yet challenging) solution identified by interviewees is introducing strict anti-corruption regulation and establishing related task-forces/government bodies designed to implement such policies. Cambodia started to do so in 2010 by introducing an "Asset Declaration Law" and "Anti-Corruption Law" (OECD 2018). However, the potential effects of these policies are not yet visible in the country's corruption statistics, and it is not hard to see why: why would a corrupted system want to shine a light on its own corruption?

Not only could policy help in combating corruption, but it could be crucial for attracting foreign investment into the DSES sector. The appropriate regulation designed for making sure a given country has an open economy with limited restrictions makes it easy for a foreign investor to join the market. Interviewee 4 (2022) states that this is actually the case in Cambodia, because "*regulatory burdens and restrictions are lower"* making it "*one of the easier countries to invest in".* The same cannot be said for Indonesia and the Philippines however, where "*regulation in relation to foreign investment is not super clear, it's like a nightmare*" (Interviewee 14, 2022). In order to attract foreign investment, not only do governmental policies need to encourage their markets to be open, easy and non-restrictive, but they also have to implement checks and balances to ensure transparency from local companies and project developers. Hence, interviewees point to certificates, metering and "*strong supervision systems with incentives and penalties"* as regulations that should be put in place to ensure transparency and provide guarantees to investors (Interviewee 12, 2022). The appropriate subsidy and incentive policies could also drive the price of DSES down and reduce the risk for developers. A combination of these policies (low restrictions on foreign investors, transparency from developers and subsidies to drive the price of DSES down) has the potential of encouraging a rapid expansion of the DSES sector in Southeast Asia, thus swiftly addressing the issue of energy poverty, and contributing to speeding up the transition to renewable energy in the region.

Interviewees also identified clarity and standardization in policy at both national and regional levels as an enabler to the expansion of the DSES sector. In the realm of permits / authorizations for DSES projects, standardized policies are needed to establish what requirements need to be fulfilled by a DSES to be authorized and allowed to connect to the main grid. This point is eloquently outlined by interviewee 16 (2022): "*a lot of decentralized energy developments that are being looked at in Southeast Asia don't have homogenous technical standards. There's a lot of delays in permitting, because governments are still trying to figure out what those standards should be and how they should be applied*". Clear and standardized policy on the matter can enable a more efficient and homogenous planning for the deployment of DSES locally, nationally, and across the region. In fact, shared regulatory frameworks that are implemented in a region can lead to international collaborations for speeding up the transition to renewable energy and electrifying communities living in energy poverty. The inter-ASEAN partnership to create an internationally connected energy grid exemplifies this: ASEAN member states have set out to construct an integrated Southeast Asia power grid system aimed at providing

expanded and more stable access to energy (APAEC Drafting Committee 2020). Clear and standardized regulation across ASEAN member states could allow for a coordinated effort between constructors of the Southeast Asia power grid and DSES project developers. This could be a significant step forward for the electrification of off-grid communities and for the transition to renewable energy in the region.

4.2.2 Blended Finance De-risking for Private Investment in DSES

Lack of policy attention (such as subsidies for fossil fuel energy which influence the ROI for DSES businesses) can contribute to exacerbating the business risks for DSES projects. This results in DSES not being attractive to investors. Blended finance will form a risk-sharing mechanism to financing DSES in Southeast Asia as an economic enabler to address this issue. Blended finance entails using mixed public and/or philanthropic funds to raise additional private capital which enables a de-risked condition of engaging private investment to DSES. One of the most compelling aspects of blended finance is that it uses relatively small amounts of public investment/donor funding to rebalance a project's risk profile. One interviewee suggested that *"the solution is possibly blended finance using a mix of public investment/philanthropy, venture philanthropy plus private investment. That is not just a feature of electricity, we see that everywhere across the impact investing so far for numerous business models, not just last mile energy"* (Interviewee 12, 2022). Blended finance has emerged as a catalytic tool that can address some of the market failures and uncertainties that impede private investment in low-and-middle-income countries (Choi and Alicia 2020).

Blended finance can be leveraged to de-risk private investments to DSES as well as improve energy affordability for communities particularly in remote or rural areas. The strategic use of blended finance is critical for scaling up the deployment of DSES in Southeast Asia which can help the transition to renewable energy in the region. To make it happen, governments and development finance institutions have to work together to make private capital mobilization a key part of their policies and strategies. This requires local, national and regional leaders to develop and implement proper policies to support the application of blended finance in DSES in the region. This point is eloquently outlined by one interviewee: *"I think there is a role for government money working as a catalyst for promoting private investment in blended finance"* (Interviewee 11, 2022).

It is important for all stakeholders to have a clear understanding of (and shared language around) blended finance to achieve the necessary scale and desired impact that could contribute to the energy transition (IDFC 2019). While blended finance is a promising catalytic tool towards sustainable development, it cannot solve the problem as a whole. One must keep in mind that business is embedded in society which is embedded in the environment. Therefore, social and environmental aspects must be taken into account while developing enabling strategies or tools.

4.2.3 Financing Guarantees for Microfinance Institutions Create a Pathway for Last Mile Delivery

In the past two decades, countries in Southeast Asia made great strides in electrification by expanding the grid. However, the last mile delivery is still a problem, since "*you actually have lots of households that are still not connected to power"* (Interviewee 2, 2022). To address this

issue, the special financing guarantee scheme among microfinance institutions (MFIs), communities and engineers, procurement and construction (EPC) contractors can be considered an economic enabler. This scheme consists of lending money *"to EPC contractors who are going to implement the DSES for the last mile to communities. So the lending will take place between MFIs and communities themselves, but the cash actually doesn't go into the community, and it goes straight to the EPC contractor"* (Interviewee 16, 2022). This removes the default risk for MFIs and addresses the financial needs of the people trying to borrow money for their last mile connection as well. Given its risk-sharing structure, it encourages more agreements to happen which result in more DSES projects running for last mile connectivity.

This enabler offers a very scalable solution for the following reasons: firstly, it quickly improves the relationship between MFIs and communities which creates possibilities of replication of the agreements; secondly, it actually massively simplifies the financing problem by involving EPC contractors who are linked to several MFIs instead of having individual agreements. If scaled, this solution has the potential to play a significant role in enabling a wider adoption of DSES as well as a faster regional transition to renewable energy.

4.2.4 Innovative Business Models Aid the Implementation of DSES

DSES businesses are often facing the challenge of non-payment of their customers (consumers) especially in rural communities in Southeast Asia. One solution to this issue would be innovative business models as the economic enabler that enhances the consumers' ability to afford their solar energy. Pay-as-you-go (PAYG) business models offer an example. The PAYG model allows consumers to pay their solar energy in weekly installments or whenever they have the financial liquidity. It is an innovative credit system that removes the initial financial barrier to solar energy access by allowing consumers to make a series of modest payments to purchase time units for using solar electricity instead of paying upfront for the entire solar system (Rolffs, Ockwell, and Byrne 2015). One interviewee pointed out that *"what we also see that is working more and more is the PAYG system [...] you have different installments that you set up front and using digital reimbursement solutions you pay as you go […] combining installments mechanism with technologies to cover the reimbursement. So that works well for individual beneficiaries"* (Interviewee 2, 2022). With the PAYG model, DSES consumers will be able to make the payment for their solar energy which will mitigate the non-payment for DSES businesses.

PAYG models enable customers to transition away from fossil fuel-based energy sources to solar energy, as PAYG models spread the system's cost over a longer period of time. This model can be implemented at both the individual household and community levels, thus enabling the consumers' access to electricity in remote areas through the use of a DSES (IRENA 2020b). Therefore, the PAYG model can both help the government achieve electrification goals and play a significant role in enabling the adoption of DSES.

PAYG business models can also be extended to implement other technology-enabled business models that will lead to an increase in renewable energy integration. Multiple solar PV systems can be connected to form a microgrid, which can further enable peer-to-peer energy trading. The excess energy produced can be traded with other consumers within the same community in exchange for a fee. Such systems can generate an additional source of revenue for consumers with solar PV systems.

Overall, PAYG models could serve to empower both DSES and local communities who are then able to remove their dependence on fossil fuel-based energy systems that are detrimental to them both financially and from a health perspective.

4.2.5 Education Helping with Lack of Capacity

One solution to social issues such as the present lack of capacity in financial literacy and maintenance is education. For example, on capacity building for local commercial banks, one interviewee commented that "*what we found is that simple things like training credit committees in commercial banks has had a remarkable impact on the willingness of the banks to get involved in this asset class. This is particularly for rooftop solar, which is going to be a very, very significant piece of Southeast Asia's renewable energy landscape in the coming 2030"* (Interviewee 16, 2022). If something similar like this could be implemented to improve the financial literacy of the general population as well it would help DSES projects in the region. It is also important to note that if capacity building for local companies with proper documentation about finances and environmental impacts would exist, then it would be very likely that more investments would be happening in the region. This is also reflected in the literature (Skordoulis, Ntanos, and Arabatzis 2020). By equipping everyone who needs it with the necessary tools to deal with financing these projects, the rate of successfully funded solar energy projects is likely to increase. In fact, there have already been pushes towards it but *"[western] institutional buildings and capacity enhancement […] have in the last [...] five years plus they have been progressively compelled back and the relationship with the government is now not a positive"* (Interviewee 12, 2022). If something like this would be successful in the long term then this will assist with the global energy transition towards renewable energy.

4.2.6 The Importance of Community Engagement for Trust and Adoption of DSES

Community engagement could be positively affected by this, as they could organize repairs by themselves more easily. One interviewee also evaluated that *"[…] community engagement is a challenge for those projects. So financially, even if the government gives you a good purchase rate, as an entrepreneur or a developer, you'd have to be pretty confident that the community is actually part of the project"* (Interviewee 8, 2022). Therefore, an important answer to decreasing barriers related to the success of DSES appears to be community engagement. This is also supported by other studies (Ramachandra and Mansor 2014). Involving the community in these projects really seems to be important for them as another benefit would be an increase in community trust. This increased trust would then address the barrier of short term thinking that is currently present in the system (Jachimowicz et al. 2017). So increasing community engagement is an important leverage point for DSES projects in the region that should be utilized. A participatory approach will pay off in the long run. If these projects are successful then they are also likely to be adopted more, potentially increasing the scale and speed of the energy transition towards sustainability. This holds especially true for Southeast Asia, as *"Southeast Asia is a region where people and businesses do copy each other very quickly, when there are successes and they can get replicated very swiftly. That type of model and so on could be extremely helpful to encourage other places to be emboldened. This also helps to unlock financing in new ways, especially where financing institutions have not been typically involved in this asset class before"* (Interviewee 16, 2022). Therefore, some successful approaches here

are likely to be implemented all over the region which will help improve the socio-ecological system. This might be also relevant for other aspects of the energy transition such as technology.

4.2.7 Technology Can Circumvent Lack of Capacity

The diffusion of technological innovation, based on copying a particular behavior within communities might be observed with the relatively widespread implementation of hybrid energy systems i.e. combining renewable and diesel-based energy sources. This approach appears to be particularly apt for remote locations, such as mountainous areas or small islands in Indonesia or in The Philippines. It could be a promising alternative - an intermediate step towards fully renewable sources of energy in the future - mainly due to the already existing infrastructure and lower financial burden for the local population: *"In the Philippines there are a lot of small islands in Indonesia as well. And they start to replace diesel power plants with off grid solar and with hybrid technology"* (Interviewee 9, 2022). This type of solution could be regarded as a leverage point on the societal way to energy transition. Although it is not the ultimate vision of success, it is a significant step which, thanks to a more strategic and inclusive approach, could reach wider social groups, in particular people who cannot afford fully renewable systems due to their lack of capacities or financial resources. It seems important to keep in mind that, while striving for ambitious long-term goals leading to a sustainable and thriving society, one should consider a stepwise approach. One example would be to plan small short-term goals which might be easier to achieve by the local population and which might be helpful with building up the momentum towards the energy transition.

Another potential solution for the energy storage challenge is related to technological innovation. The rapidly falling prices of PV panels in recent years helped to significantly increase the scale and pace of solar energy systems implementation. It is expected that in the near future battery prices will follow a similar trajectory, unlocking the current barrier related to their limited affordability and availability, particularly in remote areas i.e. places where decentralized systems are needed most. The improved performance of future batteries could also translate into other crucial aspects of the energy transition, namely energy efficiency: *"So I can foresee that tomorrow's solar home systems will be using lithium batteries that can contain a lot more energy or can be more efficiently controlled*" (Interviewee 12, 2022). This issue is closely related to another one discussed above i.e. capacity building among the local population. Often it might not be enough to provide local people with a decentralized solar system but it might be equally or even more significant to raise awareness among them when it comes to the efficient use of the energy generated in their small-scale installations.

Apart from innovative solutions in the lithium battery sector, another promising pathway leads to hydrogen as an alternative way for energy storage as highlighted by the significant increase of investments going into this field: *"We're seeing a little bit more interest in sort of different types of battery systems and different types of storage. Storage is one but the other one is actually looking at hydrogen"* (Interviewee 16, 2022). However, hydrogen-based systems require a considerable amount of financial resources and capacity building in order to run them smoothly which despite their high potential, might be a significant barrier for communities experiencing energy poverty in remote settings.

A promising way to address the intermittent nature of solar-based energy generation is related to the implementation of alternative grid systems, such as micro-, mini- or mesh grids:

"Microgrid is something that we will see more and more, like the DC microgrid where also you can connect different solar home systems [...] it seems like a very good [type of] project for the future" (Interviewee 6, 2022). They could significantly reduce the need for energy storage by enabling energy exchange between households within each community. It could also help each of the communities to become independent from the main, national grid and at the same time increase their resilience and energy security by implementing decentralized, community-driven and community-led solutions: *"Utility scale batteries together with these decentralized solar installations would be quite powerful because you can then build localized grids that can have that kind of demand side response within like a village or a set of households as opposed to trying to force through a massive grid that isn't possible to be built, for example, in a place like Cambodia"* (Interviewee 17, 2022).

Finally, another technology-related issues of solar energy systems which led to their widespread and rapid implementation are their modular character, the relative ease of their installation and their comparatively effortless maintenance: *"Solar is quite easy to understand: you buy a solar panel connected to a battery, and then you have the DC that you can use. Solar is passive, you don't need to do anything except cleaning the solar panel"* (Interviewee 6, 2022). The relatively simple nature of DSES highlights the importance of easy, scalable solutions that could be implemented in diverse settings without the need for extensive capacity building and expensive infrastructure development. It could be essential to leapfrog some of the developmental steps and errors related to them committed in the high-income settings of the past, such as setting up the whole infrastructure primarily aimed at fossil fuels based solutions.

4.2.8 Recommendations for Implementation

There are several recommendations that can be made as a result of the enablers presented. For one, it appears crucial that more transparent, standardized and efficient policies regarding financing DSES in the region be implemented. Policy that combats corruption, attracts investors and reduces business risks for DSES could have a major impact on speeding up the transition to renewable energy in the region. The introduction of such regulatory frameworks could happen if the region's political systems were to improve the relationship between themselves, businesses and the local population through partnerships that offer strategic leadership on the significant issue of clean energy futures in Southeast Asia. Providing better transparency and dialogue between all actors involved in the energy sector could help drive the implementation of such regulation.

One more suggested action for the region's leaders is to start a slow and calculated shift from subsidizing fossil fuels towards renewable energy (with a focus on solar). The financial capital is already in place and would only be needed to be shifted around. While this should be done over a longer period of time to avoid a harsh disruption of the current system, it would be necessary to start now before the consequences of climate change become irreversible.

An emphasis on education could also aid the transition to renewable energy in the region: improved financial literacy and technical skills for the maintenance of DSES would allow for more durable projects and empower local communities to run their systems more efficiently. Finally, community engagement aimed at fostering trust between all parties involved in energy generation, distribution and consumption (political institutions, businesses, investors, and locals) would also make the push towards a decentralized renewable energy paradigm stronger.

4.4 Strengths and Limitations of the Study

One of the main strengths of this study lies in the fact that we interviewed a diverse group of experienced stakeholders active in Southeast Asia - ranging from policy makers to investors and local partners implementing DSES on the ground. Such a variety of interviewees enabled the study to approach our research topic from a wide range of perspectives. Another strength of this study stems from applying semi-structured interviews as a way to collect and systematize our data: this method allowed for consistency throughout the data collection process. It provided a solid scaffolding for each of the interviews while allowing a certain degree of freedom. It also provided space for the emergence of unexpected new themes that had not been already identified during the literature review. What is more, the split of our research process into a first phase of exploratory interviews and then a second of semi-structured interviews proved to be useful for orientation and the formulation of ideas.

The fact that the research team consisted of four individuals with different academic and professional backgrounds meant that this project was approached with the use of different lenses, resulting in a more nuanced and versatile perspective. This also allowed for a cross-checking of individual work at various stages of the project, and for the co-creation of space for reaching shared understandings. Finally, the use of the PESTLE analytical framework proved to be a robust method for the exploration and categorization of the interrelated systems at play in the realm of DSESs in Southeast Asia.

The primary limitation of this study is the relatively small number of experts who were able to join the interviews. While the material collected was rich and diverse enough to identify key factors related to the energy transition in the region, the research could have benefited from more nuanced and in-depth insights resulting from a broader spectrum of participants. Despite the diverse range of stakeholders who participated in this study, many of them represented areas related to financing or implementing solar energy projects in Southeast Asia. This might have introduced a certain bias to the research stemming from a focus on the financial side of DSES projects, with some other equally important aspects receiving less attention. Another potential limitation lies with the fact that only people who actively invest in Southeast Asia were interviewed -it would be interesting to explore the reasons why other financial actors are not investing in the region. Another possible source of bias is the fact that this is a qualitative study (only interviews were used to gather data): this opens the floor to some subjectivity or bias both on the part of the interviewees and the research team, despite extensive efforts to safeguard quality. Finally, the geographic scope of the study - with focus on Cambodia, Indonesia and the Philippines - might affect the generalizability of findings to other countries within Southeast Asia.

4.5 Recommendation for Future Studies

This thesis identified some key barriers to financing DSES in Southeast Asia, as well as some enablers that present opportunities which could lead to a faster and wider transition towards renewable energy.

By implementing additional qualitative measures, future research projects could investigate in detail both the barriers and enablers for financing decentralized solar projects discussed in the

study. Another potential angle for future research would be to interview stakeholders working in the energy field who are not yet active in Southeast Asia, and to explore their reasons for preferring other geographical contexts.

A country-specific analysis guided by our research question could also be useful for comparing the situation across different Southeast Asian countries. It would be also extremely beneficial to better understand how Southeast Asia compares to other regions (Africa or South America for example) in terms of renewable energy market profile; political, regulatory and social environment and type of financial instruments involved in the implementation of renewable energy systems.

Another interesting layer of complexity could be added by performing a comparison study of different types of decentralized renewable energy systems and/or exploring innovative approaches to energy storage and energy efficiency, both of which are tightly related to addressing the sustainability challenge.

Finally, one potential direction for future studies could involve analyzing different types of infrastructure used for decentralized systems e.g. examining the different types of grid (micro, mini versus mesh).

5 Conclusion

In its path to addressing the complexity of the sustainability challenge, modern society is faced with a multitude of barriers that inhibit its transition towards sustainability. This thesis was designed to contribute to addressing some of these issues by zooming into the barriers and enablers that affect the implementation and success of decentralized solar energy systems (DSES) in the Philippines, Cambodia and Indonesia. To this end, using the PESTLE framework helped structure the study findings and categorize the main themes that came up during our interviews. It also made it possible to appreciate and examine the interconnections between these spheres. Hence, the PESTLE framework provided this study with a robust understanding of and the ability to map the current reality of DSES in Southeast Asia.

The results and discussion of this thesis outlined that the main barriers and enablers to financing decentralized solar energy systems are found in the legal, economic and social spheres. In the legal category, the most important barrier identified is regulatory frameworks. The data collected highlighted how policy in the Philippines, Cambodia and Indonesia is currently not accommodating enough for positive change to occur, as it generally does not provide easy access to national energy markets for foreign investors; does not ensure enough transparency due to a lack of strict supervision on local actors; and lacks standardization for authorizations / permitting of DSES projects. The biggest barrier in terms of the economic environment is high business risk. Since projects are often too small and costly with a low rate of return, they fail to attract investors. An enabler here would be blended finance as a catalyst tool to engage private investment. For the social sphere, the biggest barrier we identified was lack of capacity among local actors: a lack of technical and financial literacy among users and companies deters investment and leads to shorter lifespans for DSES.

This thesis also identified the most promising enablers for financing the transition towards renewable energy in Southeast Asia: while the blended financing approach decreases risk for investors, improved regulatory frameworks can incentivize and enable DSES deployment. Technological innovation can improve solar energy systems in terms of reliability and efficiency, and a consequent increase in manufacturing can lower the price. This will hopefully make it only a question of time until the region is not only fully electrified, but also well on the way to achieving a higher share of sustainable energy in its energy mix. To achieve this, strategic actions in the areas identified by this thesis could contribute to transforming the global energy state resulting in significant social and ecological benefits.

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Appendices

Appendix A: Semi-structured Interview Questions

P - Political, E1 - Economic, S -Social, T - Technological, L - Legal, E2 - Environmental

1. What are the barriers to financing decentralized solar energy systems in Southeast Asia? *(P), (E1), (S)*

2. What types of risk (geopolitical, financial, social) are you faced most often with? *(P), (E1), (S), (E2)*

3. How much do local governments influence the national guidelines? What is their relation? *(P), (S), (L)*

4. What is the role of governmental subsidies towards the energy transition? *(P), (E1), (L)*

5. To what extent is the (conservative) banking hindering the energy transition? *(P), (E1), (L)*

6. What are the main factors deterring foreign investors from investing? *(P), (E1), (L), (E2)*

7. What do you think are the potential ways to overcome them? *(P), (E1), (S), (T), (L)*

8. Are there any challenges related to the currency exchange? *(P), (E1)*

9. What are the ways of de-risking the investments into renewable energy? *(P), (E1), (S), (L)*

10. Can you see any disruptive technologies, innovative business models, innovative financing schemes that could help with the energy transition? *(E1), (S), (T)*

11. How long will it take until all of Southeast Asia is electrified? *(P), (E1), (S), (L)*

12. How does the local culture/community acceptance influence the outcomes of your projects? *(P), (S)*

13. How does trust affect the outcome of your projects? *(P), (E1), (S), (L)*

14. How do you ensure the correct use and maintenance of the equipment? *(S), (T)*

15. What is the most common storage solution for energy? *(E1), (T), (S)*

16. Could resource shortages like lithium become a problem for the rate of electrification? *(P), (S), (T)*
17. Are there any new efficient ways of storing energy you are aware of? *(T)*

18. Are there any innovations that improve energy efficiency? *(P), (T), (L)*

19. To what extent is last mile delivery an issue? What are the ways to tackle it? *(P), (E1), (S), (L), (E2)*

20. Can you see any other ways of improving the pace and scale of the energy transition? *(P), (E1), (S), (T), (L), (E2)*

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