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Navigating energy transitions in island states: a multi-level perspective on floating solar photovoltaic technology adoption in the Maldives

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Abstract

Small island developing states (SIDS) have serious difficulties with changing their electricity systems because of the lack of land, discontinuous geography, and large dependence on imported fossil fuels. The Maldives has a monopoly of diesel-based island microgrids as a result of which the production of electricity is high-cost, energy-insecure, and environmentally straining. The technology of floating photovoltaic (FPV) has proved to be one possible solution to these limitations, but has not yet found widespread application.

This thesis analyzes how FPV is a niche innovation in the Maldivian energy system through the Multi-Level Perspective (MLP) framework. The research is a qualitative case study that will incorporate document analysis and semi-structured interviews to examine the interactions between FPV initiatives, regime structures and landscape pressures in general.

It is found that FPV evolution in the Maldives has been based on context-specific adaptation that has been achieved in an incremental manner, as opposed to direct transfer of technology. Pilot projects especially those in the tourism sector have facilitated learning activities that led to technological confidence by the major players. But the regime level impediments in terms of financing arrangements, institutional capacity and standards of operations still limit broader scaling. Meanwhile, landscape pressures (vulnerability to climatic conditions and reliance on imported diesel) generate urgency and the need to be supported.

This thesis adds to sustainability transitions research by applying the MLP framework to a case of a fragmented islands environment and emphasizing the significance of adaptive governance and learning-by-doing as the way forward towards renewable energy solutions in infrastructure-restricted geographies.

Zusammenfassung

Kleine Inselentwicklungsländer (SIDS) haben aufgrund von Landmangel, einer unzusammenhängenden Geografie und einer starken Abhängigkeit von importierten fossilen Brennstoffen große Schwierigkeiten, ihre Stromversorgungssysteme umzustellen. Die Malediven haben ein Monopol auf dieselbasierte Insel-Mikronetze, welches zu hohen Stromkosten, Energieunsicherheit und Umweltbelastungen führt. Die Technologie der schwimmenden Photovoltaikanlagen (FPV) hat sich als eine mögliche Lösung für diese Einschränkungen erwiesen, jedoch noch ohne breite Anwendung.

Diese Arbeit analysiert mittels Multi-Level-Perspective-Rahmenwerks (MLP), inwiefern FPV eine Nischeninnovation im maledivischen Energiesystem darstellt. Die Forschung besteht aus einer qualitative Fallstudie, die Dokumentenanalysen und halbstrukturierte Interviews umfasst um die Wechselwirkungen zwischen FPV-Initiativen, Regimestrukturen und Landschaftsdruck zu untersuchen.

Es zeigt sich, dass die Entwicklung von FPV auf den Malediven auf einer kontextspezifischen Anpassung basiert, die schrittweise erreicht wurde, im Gegensatz zu einem direkten Technologietransfer. Pilotprojekte, insbesondere im Tourismussektor, haben Lernaktivitäten ermöglicht, die zu technologischem Vertrauen bei den wichtigsten Akteuren geführt haben. Hindernisse auf Regimeebene wie Finanzierungsvereinbarungen, institutionelle Kapazitäten und Betriebsstandards schränken eine breitere Skalierung nach wie vor ein. Unterdessen sorgen Belastungen der Landschaftsebene (Anfälligkeit gegenüber klimatischen Bedingungen und Abhängigkeit von importiertem Diesel) für Dringlichkeit und den Bedarf an Unterstützung.

Diese Arbeit leistet einen Beitrag zur Forschung im Bereich des nachhaltigen Wandels, indem sie den MLP-Rahmen auf den Fall einer fragmentierten Inselumgebung anwendet und die Bedeutung von adaptiver Governance und Learning-by-doing als Weg zu Lösungen im Bereich erneuerbarer Energien in Geografien mit eingeschränkter Infrastruktur hervorhebt.

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List of Abbreviations

ADB – Asian Development Bank
AIIB – Asian Infrastructure Investment Bank
ARISE – Accelerating Renewable Energy Integration and Sustainable Energy (World Bank program)
ASSURE – Accelerating Sustainable System Development Using Renewable Energy
BESS – Battery Energy Storage System
CO_2 – Carbon Dioxide
DC – Direct Current
DNV – Det Norske Veritas
EIA – Environmental Impact Assessment
EIB – European Investment Bank
EPA – Environmental Protection Agency
FPV – Floating Photovoltaic
GDP – Gross Domestic Product
GW – Gigawatt
HDPE – High-Density Polyethylene
IEA PVPS – International Energy Agency Photovoltaic Power Systems Programme
ILO – International Labour Organization
IMF – International Monetary Fund
IPCC – Intergovernmental Panel on Climate Change
IPP – Independent Power Producer
IRENA – International Renewable Energy Agency
NDC – Nationally Determined Contribution
NGO – Non-Governmental Organisation
O&M – Operation and Maintenance
PPA – Power Purchase Agreement
PPP – Public–Private Partnership
PV – Photovoltaic
POISED – Preparing Outer Islands for Sustainable Energy Development
RE – Renewable Energy
RP – Recommended Practice (by DNV)
RfP – Request for proposal
RWE – Rheinisch-Westfälisches Elektrizitätswerk (German utility)
SDG – Sustainable Development Goal
SEZ – Special Economic Zone
SIDS – Small Island Developing States
STELCO – State Electric Company (Maldives)
UNDP – United Nations Development Programme
URA – Utility Regulatory Authority
UV – Ultraviolet (Light)
WB – World Bank

Units and Symbols
% – Percent
km – Kilometre
kW – Kilowatt
kWp – Kilowatt-peak
kWh – Kilowatt-hour
MWh – Megawatt-hour
MW – Megawatt
m – Metre
m/s – Metres per second

1 Introduction

1.1 Background and problem statement

The small island developing states (SIDS) are highly vulnerable areas to global environmental pressures and thus, to disproportionate risks with climate change, as such areas are susceptible to sea-level rise, they lack the adaptation capacity and are reliant on fossil fuels imported (Sovacool, 2012). In most island settings, there are structural limits to energy transitions; small and often far-flung populations, fragmented grids, nominal economies of scale and excessive external financing. These dynamics are the case with the Maldives. The energy sector of the country relies virtually solely on imported diesel fuel that serves to generate microgrids on islands, which are expensive to maintain and subject local population to the vagaries of world fuels. Centralized electricity production at large scale or integration to the grid would be impractical because the country is highly fragmented with over 1,000 spatially dispersed islands functioning primarily as isolated microgrids.

Floating solar photovoltaic (FPV) is an option which has come up as potentially transformative in this regard. FPV can partially address land-use issues in solar growth by using artificial or near-shore water bodies otherwise unused in energy generation and possess other technical benefits. These are low operating temperatures of modules by evaporative cooling and less heat buildup than on land-based installations, which can result in small efficiency improvements in specific climatic conditions (Cuce et al., 2022). Simultaneously, this type of framing must be approached with caution because marine and lagoon settings are ecologically active areas and not necessarily empty surfaces.

The adoption of FPV has been growing several times faster worldwide with more than 3 GW of installed capacity in 2023 since the majority of freshwater reservoir projects are located in East Asia and Europe (World Bank & ESMAP, 2019; IEA PVPS, 2024). However, in Small Island Developing States (SIDS), it has not been widely adopted yet, with the majority of initiatives being pilot projects and small installations, especially in tourist facilities (IRENA & World Bank, 2021). FPV adoption is still in a niche position in the Maldives. High-end resorts with tourism purposes have been the pioneers of this, driven by the corporate sustainability agenda and guest demands on carbon emission and reduction as well as by national energy systems, instead of an integrated role within the energy system (Hotelier Maldives, 2024; Swimsol, 2023).

This scenario creates a paradoxical scenario: although technically viable, and appealing to the environment, FPV has not been embraced by the rest of the world beyond the first movers in the last decade. The continuation of this trend indicates that technical performance and financial feasibility are not enough to describe the FPV adoption in the Maldivian context and rather, institutional, regulatory, and socio-political factors that influence energy transitions. Rather, wider socio-technical and institutional aspects have to be taken into account. These are established diesel powered infrastructures, the regulatory and fiscal systems, donor interests, and the role of international tourism. Elucidating the dynamics involving such multi-layered factors is of high importance in assessing the possibility of FPV to move beyond niche adoption to the greater mainstreaming of the system in Maldivian energy system.

1.2 Research aim, objectives and research question

The purpose of this thesis is to explore the nature of development of the floating solar PV technology as a niche process in the Maldivian energy system and study the circumstances in which the technology could be implemented in the larger socio-technical regime. The paper analysed the FPV development through the Multi-Level Perspective (MLP) framework (Geels, 2002; Geels and Schot, 2007) to reveal the processes at the three analytical levels to assess the FPV development: niche-level innovation processes, regime-level institutional and infrastructural structures that are based on the diesel-based energy systems and the landscape pressures, such as climate change and donor agendas, which influence the possible transition paths in the Maldivian energy system.

This thesis pursues three objectives:

1. Determine potential issues and opportunities to FPV integration: the analysis of the enablers and barriers of technical, institutional and financial integration in the Maldivian context;

2. Study interactions between FPV niches and the socio-technical regime: exploring the role of actors like policymakers, utilities, private developers, international donors and the tourism industry in creating alignments or conflict between the innovation and current systems;

3. Evaluate the effects of landscape forces: analyze how exogenous processes, such as climate demands, financial processes in the world, and the geopolitical trends, predetermine the opportunities of FPV scaling.

The core research question of the thesis is:

How does floating solar PV technology develop as a niche innovation in the Maldives' energy transition?

Two sub-questions complement this question:

1. What are the challenges Maldivian energy systems inherently face to implement FPV, and what are the opportunities?

2. What are the interactions between niche level developments and regime structures and landscape pressures in creating potential pathways to transition?

Answering these questions, the thesis makes a contribution to the literature in two aspects. Theoretically, it generalizes the use of the MLP to non-Western and structurally fragmented island energy systems that are underrepresented in the literature on sustainability transition. In practice, it offers information for policymakers, practitioners, and investors on the circumstances that may promote or hinder the implementation of FPV in discontinuous geographies.

The thesis consists of seven chapters. Following the introductory part, Chapter 2 provides a literature review, focusing mainly on the MLP in terms of socio-technical transitions, transition dynamics and transition pathways, and the relevance of the MLP to decentralized island context. Chapter 3 outlines the research design and research methodology, including the choice of a case-study approach, data collection methods, data coding approaches, methods of analysis, and a discussion of limitations present in the research. In Chapter 4, the empirical background is provided, discussing the Maldives energy system and its dependence on diesel, the policy environment and donor pressure, and the latest developments in the solar photovoltaic (PV) technology, such as rooftop, ground-mounted, and floating systems. Chapter 5 provides the major overview of analysis of the application of floating PV (FPV) in the Maldives, which is structured around the notion of niche development, regime structures and barriers, and landscape pressures and facilitators. Chapter 6 elaborates on the discussion by clarifying barriers and enablers to the scaling of FPV, extending the MLP framework to fragmented island environments, and presenting implications to policy and investment. Chapter 7 is the final part to sum up the main findings and to think about their theoretical and practical implications. At the end, the references and appendices are provided.

2 Literature Review

To explain how societies can move through old systems to new systems that are more sustainable, it is necessary to have a theoretical model that can capture stability and transformation. Socio-technical systems are so interwoven with infrastructures, institutions, cultural practices and actor networks and therefore difficult to transform. Meanwhile, there are still innovations made in the sheltered areas, and external factors like the environmental pressure or global economical changes can open up systemic transformation possibilities. It is the very combination of these dimensions into the MLP that has made it a key framework in transition studies. The MLP provides an opportunity to study how large-scale changes can evolve over time by looking at the interactions among niche innovations, established socio-technical regimes, and larger landscape changes.

2.1 Multi-Level Perspective (MLP) on socio-technical transitions

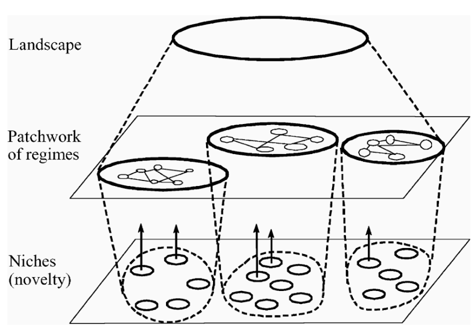
MLP has become one of the most powerful paradigms of socio-technical transitions analysis. It was first developed by Geels (2002), and was further developed by Geels and Schot (2007) who proposed alternative pathways of transition, and then later research by Geels (2011) improved the methodology based on the criticism of the agency, power, and contextual sensitivity. Instead of addressing the issue of transitions in a very narrow manner, i.e. by looking at the specifics of a particular technology, MLP views transitions as multifaceted processes that occur through the interaction of technological, institutional, cultural, and economic aspects.

Fundamentally, the MLP identifies three levels of analysis, namely, *niches*, socio-technical *regimes*, and the socio-technical *landscape* (Geels, 2002; Geels, 2011). Niches are secure areas in which radical innovations may develop and grow. These innovations are normally weak during their initial phases, and they need specific support, capital and networks to survive. In these niches, actors test new technologies, business models, and practices, and learning, expectation-building, and network formation processes slowly build the prospects of the innovation.

The socio-technical regime is the meso-level of analysis and is defined as the prevailing pattern of institutions, infrastructures, practices, and rules that stabilize the existing systems (Geels, 2004). Networks of actors, such as firms, policymakers, users, and professional communities keep regimes based on path dependencies due to routines and vested interests. These structures are inflexible to change because of a number of lock-in mechanisms including sunk investments, economies of scale, legal systems, and cultural norms (Unruh, 2000). Therefore, innovations have a high impediment in trying to oust or restructure the status quo.

The macro-level of the framework is the socio-technical landscape, which involves more global exogenous trends and advances that influence or limit transitions (Rip & Kemp, 1998; Geels, 2011). They are demographic changes, cultural values, macroeconomic trends, geopolitical changes and environmental pressures. In contrast to niches and regimes, the landscape is not in the short run directly influenced by actors, yet it puts pressure on regimes, and may open windows of opportunity to niche innovations. Landscape dynamics may be either gradual (e.g. demographic change or globalization) or disruptive (e.g. economic crisis, political shock or natural disaster).

Figure 1. The association of the three levels in the MLP (a nested hierarchy).



Source: Geels, 2002

The process of making transitions has been interpreted as the result of dynamic interactions between them. In the context of socio-technical change, innovations can be found in niches, yet these innovations are usually peripheral until under the pressure of the landscape level that shakes the regime and creates the opportunities of new structures (Geels, 2002). As niche innovations have gained enough momentum and the pressures of the landscape are aligned with the pressures of the regimes, the possibilities of systemic reconfiguration arise. Transitions in this sense cannot be described as being caused by one factor, but rather a multi-level process convergence.

With this conceptualization, the MLP is capable of both modeling stability and change. Regimes describe the reason why socio-technical systems are so persistent and can be very recalcitrant to innovations. Meanwhile, niches point to where newness is generated, whereas landscapes are used to indicate the external forces that may ultimately initiate change of regime. The MLP helps to establish a systematized method of analyzing the long-term, systemic changes that cross boundaries of technology, institutions, and society by integrating these dimensions.

Although the MLP has had a large-scale implementation, it should be emphasized that it is a heuristic tool rather than a model. It is not predictive of when and how transitions will happen, but it helps the analyst in determining the primary processes and mechanisms. This is in line with the fact that the MLP as framed by Geels (2011) is a middle-range theory: wide enough to be generalized to recurrent patterns across cases, but at the same time flexible to the point of being tailored to the particular empirical contexts. Consequently, MLP has been greatly utilized in energy, transport, agriculture, and other sustainability studies (Verbong & Geels, 2007; Smith, 2007) where MLP has been used to elucidate the dynamics of niche formation, regime defiance, and landscape pressures.

2.2 Transition dynamics and pathways within MLP

MLP is the conceptualization of transitions based on the non-linear development, which is a result of the interaction of the developments in the niche, regime, and landscape level. Instead of being motivated by an individual cause, transitions occur when processes on various levels become coordinated and support each other. Niches gain momentum by learning, networking and expectation building whereas landscape developments put external pressure on regimes. Under these tensions or destabilization, a space can open up in which niche innovations can propagate more broadly and in certain instances, a system can be changed (Geels, 2002; Geels, 2011).

Analytical heuristic models of transitions often take the form of a sequence of phases, whereas the underlying dynamics are non-linear, iterative and based on feedback between the niche, regime and landscape levels. Rotmans et al. (2001) define them in terms of emergence, take-off, acceleration and stabilization. At an early age, niches are small and rely on a protective environment like subsidies or pilot projects. In the long run, they might go through a take-off stage, in which they learn to perform better, expectations become more credible and actors' networks broaden. When the landscape influences are coupled with the increasing niche momentum, then acceleration can take place, over which the regime is reconfigured or replaced. However, with time, a new socio-technical set-up becomes stable, creating the foundation of a new regime (Geels, 2002). This dramatized version emphasizes how transitions are path-dependent and cumulative, and can be many decades long.

Based on these observations, Geels and Schot (2007) have been able to come up with a typology of transition pathways that identify various patterns of change based on the timing and nature of the multi-level interactions. There are four pathways which are ideal types. Geels and Schot (2007) demonstrate each pathway by means of material on historical case studies, which are largely based on energy or transport transitions, but are examples of a stylised illustration, as opposed to empirical validation.

The former is the *transformation* pathway, when the moderate landscape pressure arises at the time when the niche innovations are yet underdeveloped. In these circumstances, the regime actors themselves react to the external pressures by restructuring the innovation activities, which results in the gradual restructuring of the regime. Niches can affect this process indirectly, such as by translating ideas or adopting restricted practices, but the process of systemic change is slow and mostly incumbent-led.

The second is the *reconfiguration* pathway, in which niche innovations have evolved to the extent where they can be taken up by regime actors as an add-on to specific regime issues. These niche innovations were originally integrated in symbiotic manner and they can subsequently lead to additional adaptations and can slowly change the basic structure of the regime. This route places greater importance on gradual change, old and new interacting over a long duration of time before reconfiguration builds up into a larger change.

The third pathway is *technological substitution* that occurs when relative niche innovations are relatively stable and when the powerful landscape pressures upset the regime. In this scenario, the window of opportunity is broad enough to allow niches to penetrate it and displace the ruling regime in a very short period. This is the most dramatic type of transition, where there is a change in one hegemonic position to another, and usually there is conflict between incumbents and challengers.

Lastly, there is the de-alignment and re-alignment pathway where some key landscape shocks destabilize and ruin them. This destabilization leaves this vacuum, where several niche innovations can exist in the meantime and it is uncertain as to which one will be permanently obtained. In the long-run, there is some process of re-alignment when one such innovation dominates and becomes the essence of a new regime.

It is a heuristic not prescriptive typology. Empirically, in fact, transitions can be of hybrid character or they can change direction and follow a different pathway as circumstances vary. However, it is a useful framework to examine the dynamics of transitions because it emphasizes the role of time, strategy of actors, and level of niche maturity in determining the outcomes (Geels & Schot, 2007).

Besides pathways, the literature on MLP also focuses on those mechanisms that define transition dynamics. These are a fit-and-stretch processes, in which initially, innovations adapt to the existing regimes, followed by breaking out beyond those regimes; hype-disappointment cycles, in which new processes are initially enthusiastically embraced but subsequently encounter setbacks before stabilizing; and innovation cascades, where changes in one aspect of the system trigger further changes in other aspects (Geels, 2005b). These mechanisms describe transitions as complex, iterative, and highly disputed, which must strengthen the notion that socio-technical change is not linear and straightforward.

In general, the research on transition dynamics in the MLP framework offers means of explaining how the stability is maintained in socio-technical systems, as well as how cracks, tensions, and alignments at different levels ultimately may result in systemic change. The MLP allows a systematic way of studying the diversity of possible trajectories that transitions may take as it combines phase-based sequences, pathway typologies, and mechanisms.

2.3 Relevance of MLP for fragmented island and archipelagic energy systems

Multi-Level Perspective (MLP) has been extensively used in the investigation of sustainability transitions in energy, mobility, agriculture and water management (Verbong and Geels, 2007; Smith, 2007; Elzen et al., 2011). Although the early work mostly concentrated on transitions within large and industrialized economies, there is increased awareness that the framework is also applicable in offering useful insights with spatially fragmented and small-scale island systems such as small island developing states (SIDS). Such settings have structural features, which not only point out but also challenge the ability of MLP to analyze.

The first aspect of relevance is that of the nature of socio-technical regimes within the context of islands. The regimes of SIDS can seem very different compared to the large industrialized nations in terms of the size, infrastructure, and constellation of actors. Isolated, small-scale systems such as the island-based microgrids are often structured around energy regimes, in which there is heavy reliance on imported fossil fuels (Sovacool, 2012). The lack of alternatives, financial limitations and institutional structures that stabilize fossil-based infrastructures make these regimes firmly embedded. The development of path dependence, lock-in mechanisms and regime resistance to change given by the MLP is thus especially applicable in understanding transitions in these settings.

Second, the framework attracts attention to spaces where experiments are welcome, i.e. niches. Niche innovations typically appear in the form of externally-backed pilot projects, donor-financed demonstrations or efforts by private entities seeking a way out of the reliance on fossil fuels in island settings (Blechinger et al., 2016). These niche activities are useful in terms of learning, and in the event of good conditions, it may diffuse into bigger regimes. Scaling niche innovations is often limited, however, by the small size of markets, the geographic spread of communities, and the local resources that are available. These initiatives can be understood as socio-technical experiments, combining technological testing with institutional learning and actor coordination.

Thirdly, the landscape level is particularly significant in the context of island scenarios. There are numerous SIDS who experience acute external stressors, such as the effects of climate change, unstable international fuel costs, and global donor agendas (Fuenfgeld, 2012). Such landscape dynamics tend to put much pressure on the existing regimes and provide the opportunities of niche innovations. Meanwhile, islands are very reliant on global finances, transfer of technologies and geopolitical relationships that influence the circumstances in which transitions could be followed. The fact that the MLP explicitly incorporates the landscape dimension renders it highly appropriate in capturing such influences, which in many cases, take place outside the immediate influence of local actors.

Lastly, MLP applies to the case of island contexts that are decentralized as it enables the assessment of different transitions at their various scales. The specificities of energy systems on the islands are local at the same time as they are dependent. The framework helps in studying the way global and regional processes and interactions relate with the local practices, institutions and infrastructures. In this manner, it contributes to a more subtle conceptualization of how changes in islands do not just happen due to internal influences, but also due to a wider socio-technical process.

Altogether, the MLP framework is particularly well suited to examine the sustainability transitions in the island states. Although the MLP does not explicitly theorise geographical scale or place, it is involved in these dimensions indirectly because it has concentrated on the actor networks, institutional structures as well as infrastructural configurations which are functioning at varying levels. These spatial features are especially acute in the context of islands, where socio-technical change is determined by the interrelation between local experimentation and national government processes, and between the local and global financial and policy flows.

3 Research Design and Methodology

3.1 Case study approach and case selection: the Maldives

The qualitative case study methodology was selected due to facilitating an extended and contextualized insight into the socio-technical transitions as it is practiced. The use of case studies is especially appropriate when it comes to investigating the modern phenomena in their real-life setting in which the boundaries between the phenomenon itself and nature are unclear (Yin, 2018; Baxter and Jack, 2008). Such methods are used in research about sustainability transitions when the detailed examination of technological, institutional, and social dynamics decisive in adoption of innovations over time is needed (Creswell and Poth, 2018; Sovacool, Axsen and Sorrell, 2018).

This paper will take the Maldives as the critical and revealing case of an island country interested in decarbonization with severe resource limitations and under a single-case design. The chapter describes the research design, case selection, data sources, and analytical approach that is employed to study the FPV development in the Maldives based on the MLP approach.

Empirical and theoretical relevance are the reasons behind the choice of the case. The Maldives is empirically a good place to study the process through which socio-technical systems change in SIDS, where energy, geography and governance are closely interconnected. The inhabited islands have their microgrids, which are controlled by the state-owned utilities and largely rely on the imported diesel fuel (ADB, 2021). In that regard, the Maldivian energy system is centralised neither in governance nor in financing, but decentralised in its physical structure, consisting of physically independent island microgrids that depend mainly on foreign diesel fuel. In theory, the Maldives would be a critical case that Flyvbjerg (2006) characterizes: a case that would provide an excellent understanding of how transition mechanisms work in land-and resource-constrained circumstances.

The timeframe of the given study is 2015-2025, which is the decade after the Paris Agreement where the Maldives has initiated significant renewable energy initiatives, reformulated its Nationally Determined Contribution (NDC), and presented FPV pilot projects. The years of analysis of the policy evolution and the experimentation with technologies can be considered as well as the innovations of hybridization programs which are supported by donors and the first steps of the FPV spread.

A case study approach allows to capture these developments by the interactions of actors, institutions and technology at varying levels of analysis. The benefit of the approach is that it combines different types of evidence such as policy documents, donor reports and interviews into a consistent story of transition processes. This design, therefore, complies with the current methodological advice in transition studies that underlines the importance of contextualized, theory-based, and empirically based research on socio-technical change (Sovacool et al., 2018).

The choice of data sources offers a variety of empirical foundations on the analysis of FPV development on the levels of niche, regime, and landscape. This methodological strategy allows considering socio-technical dynamics in a systematic way but being strongly anchored in empirical material.

3.2 Data collection approach

This study draws on documentary analysis and semi-structured interviews, which were conducted between June 2024 to November 2025, to examine FPV development in the Maldives. Since the study is exploratory and the researcher is interested in the contextual interaction between policy, technology and actors, information utilized in the study was gathered through a combination of several supplementary sources. It is a strong and context-based analysis based on best practices in sustainability transition research because of this triangulation of evidence that includes documentary, secondary, and stakeholder-based data (Creswell and Poth, 2018; Sovacool, Axsen and Sorrell, 2018).

The research is based on documentary data (policy documents, reports by donors, publications in the industry) and qualitative transcripts of the interviews, which were coded in a systematic manner to detect common themes and patterns.

The empirical investigation was based on the documentary analysis. It entailed the systematic review of policy and regulatory reports, program reviews, donor project reports and institutional publications pertaining to Maldivian energy sector. The official and publicly available repositories, such as the websites of the Ministry of Environment, Climate Change and Technology, the Utility Regulatory Authority (URA), the Asian Development Bank (ADB), the World Bank, and the International Renewable Energy Agency (IRENA) were used to obtain documents. In order to be comprehensive, the sources were selected using mainly Scopus and Web of Science and Google Scholar was occasionally used to find cross-reference citations. Search queries were such as the word combinations of Maldives energy transition, floating solar, island microgrids, and renewable hybrid systems. The documents were chosen according to their topicality to the purpose of the research, the period of time (2015-2025) and the credibility and reliability of the source.

Although it was the academic databases that were chiefly utilized to facilitate the literature review (Chapter 2), the identification of the empirical materials to be analyzed was based on the same systematic approach. To ensure a multi-perspective and recent picture of the Maldivian energy transition, the policies of the government, submissions of the NDCs, and the feasibility studies of a donor, and technical evaluations were included. All the documents were examined based on their content related to institutional structure, deployment of technology, and the roles of stakeholders and then assigned metadata to be identified in the analysis. Each document was put into context by using metadata (publication year, author affiliation, source type and geographical focus) and this was used to cross-source in the coding process. This helped in extracting the patterns in time and the institutional view on the dataset.

Secondary data were used to supplement the qualitative information and to give a quantitative background in order to make a description. These data consist of the formal energy data of installed capacity, generation mix and renewable penetration mainly obtained through the IRENA (2022), ADB (2023) and the World Bank (2020). The findings of the qualitative analysis were contextualised and supported by quantitative figures of the selected reports and not to perform independent quantitative modelling. Such triangulation with the use of numerical information is consistent with the qualitative criteria of the case study that focuses on validity in terms of convergence of numerous pieces of evidence (Baxter and Jack, 2008).

The interview data was used to supplement the documentary analysis in order to gain a local opinion, implementation experience, and perceived barriers and enablers. The interviews were focused on local stakeholders such as the professionals of the energy sector of the public sector, the representatives of FPV developers, private investors, and managers of resort islands that have used or launched the solar technologies. The interviews were meant to provide an insight into the perceived barriers, opportunities, and conditions of governance that influence FPV development in the Maldives. To ensure the opportunity to be flexible and give participants a chance to discuss their experiences, a semi-structured format was selected to ensure that the data would remain consistent with the overall themes of the research (Bryman, 2016). All the interviews were performed based on the informed consent process and necessity of confidentiality.

The period of data collection was June 2024 to November 2025, the time when the Maldivian energy sector was performing significant policy and programmatic changes, such as the release of Energy Policy and Strategy 2024-2029 and the implementation of the ADB program of ASSURE. This time frame made sure that the research captured the latest institutional and technological advancements as far as the aims of the research were concerned.

Lastly, the use of artificial intelligence (AI) tools should be mentioned as it is used in the research process. AI was used only for auxiliary functions, namely, the arrangement of bibliographic data and its formatting, translation of non-English texts (using DeepL translator) where needed, including the abstract to this work, as well as consistency checks of abbreviation. AI tools did not create any automated coding, interpretation, or other analytical decisions, the researcher performed all the coding and analysis manually, which aligns with the current ethical guidelines of digital research support (Else, 2023).

Generally, the method of data collection was aimed at providing the analytical depth and at the same time having its foundation on the empirical material. The combination of documentary analysis and interviews would introduce triangulation of views on the same issue at the institutional, technical, and social levels, making the findings stronger and more credible.

3.3 Data coding and analysis

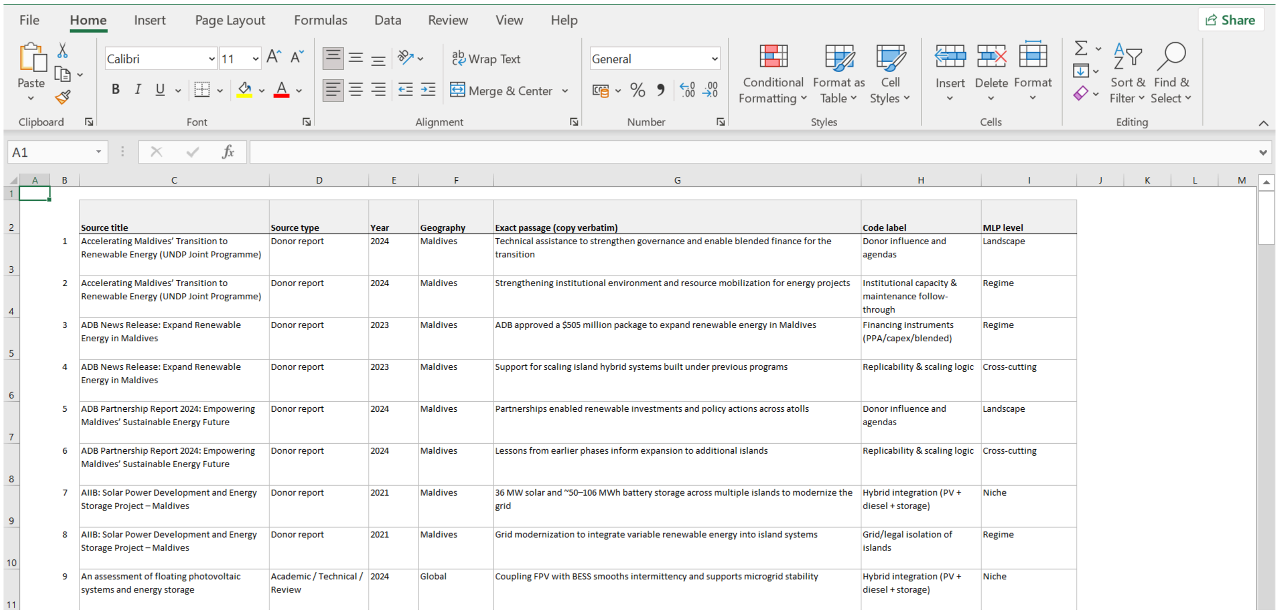
This paragraph describes the qualitative analytical plan, according to which the empirical material was interpreted, which was the systematic coding and thematic organisation of the documentary sources and the interview transcripts. This was done to structure and make sense of the gathered empirical data in such a manner that it shows how niche-level innovations, the incumbent regime, and the broader landscape dynamics influencing the Maldivian energy transition interact with each other. This was done by combining thematic content analysis and theory-based coding to maintain empirical foundation and conceptual fit (Fereday and Muir-Cochrane, 2006; Braun and Clarke, 2019).

All documentary, interview, and secondary resources have been imported into a systematic database and coded. The coding was carried out in three cycles.

In the first phase, the comprehension of all texts was done to have a general idea of the text and its context. This step made it possible to single out repetitive themes and trends that can be applied to the research goals, including institutional obstacles, the impact of donors, the adoption of technologies, and attitudes toward FPV. At this stage, a preliminary list of descriptive codes was produced inductively-generated out of the data instead of being based on a priori theoretical categories. This open code was used to identify surface meanings and it was employed to divide the material into units that can be analyzed analytically (Saldana, 2021).

The second stage saw the analysis move towards theoretical categorization as enlightened by the MLP framework, instead of the open coding. All the coded passages were re-read and divided into three general analytical levels: niche, regime and landscape as conceptualized by Geels (2002; 2011). Subcodes were designed within each of the levels in order to represent more specific phenomena. To take an example, codes concerning pilot projects, technological learning, and actor networks were grouped at the niche level, policy structures, subsidies, and institutional inertia were found at the regime level, and external pressures, climate commitments, donor finance, and global trends in energy, were found at the landscape level. This hierarchical coding system allowed a systematic mapping of the dynamics of transitions in the three strata of analysis. An example of the system of coding passages by the spreadsheet system is shown in Figure 2.

Figure 2. Example of spreadsheet-based coding system used for qualitative analysis



	Source title	Source type	Year	Geography	Exact passage (copy verbatim)	Code label	MLP level
1	Accelerating Maldives' Transition to Renewable Energy (UNDP Joint Programme)	Donor report	2024	Maldives	Technical assistance to strengthen governance and enable blended finance for the transition	Donor influence and agendas	Landscape
2	Accelerating Maldives' Transition to Renewable Energy (UNDP Joint Programme)	Donor report	2024	Maldives	Strengthening institutional environment and resource mobilization for energy projects	Institutional capacity & maintenance follow-through	Regime
3	ADB News Release: Expand Renewable Energy in Maldives	Donor report	2023	Maldives	ADB approved a $505 million package to expand renewable energy in Maldives	Financing instruments (PPA/capex/blended)	Regime
4	ADB News Release: Expand Renewable Energy in Maldives	Donor report	2023	Maldives	Support for scaling island hybrid systems built under previous programs	Replicability & scaling logic	Cross-cutting
5	ADB Partnership Report 2024: Empowering Maldives' Sustainable Energy Future	Donor report	2024	Maldives	Partnerships enabled renewable investments and policy actions across atolls	Donor influence and agendas	Landscape
6	ADB Partnership Report 2024: Empowering Maldives' Sustainable Energy Future	Donor report	2024	Maldives	Lessons from earlier phases inform expansion to additional islands	Replicability & scaling logic	Cross-cutting
7	AIIB: Solar Power Development and Energy Storage Project – Maldives	Donor report	2021	Maldives	36 MW solar and ~50–106 MWh battery storage across multiple islands to modernize the grid	Hybrid integration (PV + diesel + storage)	Niche
8	AIIB: Solar Power Development and Energy Storage Project – Maldives	Donor report	2021	Maldives	Grid modernization to integrate variable renewable energy into island systems	Grid/legal isolation of islands	Regime
9	An assessment of floating photovoltaic systems and energy storage	Academic / Technical / Review	2024	Global	Coupling FPV with BESS smooths intermittency and supports microgrid stability	Hybrid integration (PV + diesel + storage)	Niche

Source: own analysis

The third stage involved the analysis of the coded data by an iterative process of comparison and interpretation. The relationships between codes were studied to discover the interaction of niche activities and their connections with regime elements and the impact of landscape pressures on both. This analytic synthesis sought to find how socio-technical change can or cannot take place in the Maldivian context. Triangulation of the patterns in the various data sources (policy documents, interviews, and secondary data) was performed to promote reliability and minimize the possibility of researcher bias (Baxter and Jack, 2008; Creswell and Poth, 2018).

In order to make the analysis transparent and replicable, every piece of data that was a part of the analysis was cited with the source and the date. The process of coding was performed by hand based on the spreadsheet-based system using MS Excel which provided complete transparency of the categorization process and gave an opportunity to continuously revise it as new knowledge was gained. Although qualitative coding is usually conducted with the help of software like MAXQDA, QCAMap or NVivo, the comparatively limited data set and single-case paradigm explained the application of a manual system. This approach as well made sure that the interpretive decisions were not made far apart from the theoretical framework but dictated by the automated coding algorithms.

Both inductive and deductive reasoning were used in the process of interpretation. The inductive dimension was necessary to make the local emergent phenomena invisible to the existing theory, whereas the deductive dimension was necessary to allow the theory to keep up with the conceptual categories of MLP. This two-fold strategy promotes what Fereday and Muir-Cochrane (2006) define as theory-based thematic analysis, where the empirical evidence informs as well as develops the guiding scheme.

In the process, credibility and confirmability, which are major qualitative validity criteria, were prioritized (Lincoln and Guba, 1985). Data triangulation and cross-source checks on consistency were also used to strengthen credibility. Confirmability was ensured by having the audit trail which recorded all interpretation processes, coding iterations, and theoretical choices. This manner of analyzing is therefore systematic and reflexive and can be seen to combine the rigor of empirical analysis and the richness of interpretation.

Altogether, the qualitative analytical process was planned to harmonize the rigor of the systematical approach and the flexibility of the interpretive approach. The study ensured transparency and traceability of findings through cross-source comparison and careful documentation of analytical decisions, which was done through the iterative coding. This methodology increases credibility and confirmability of the analysis while remaining sensitive to the contextual and spatial specificities of the Maldivian energy transition.

3.4 Limitations

The research is limited by a number of factors associated with its qualitative research design and case-study nature. Since the case study is a single country, the analysis is not intended to generate statistically generalisable results. Rather, it gives context-specific information about FPV development in the Maldivian energy system that can be analytically extrapolated to other island settings that share structural features.

The empirical data is grounded on the mixture of documentary materials and semi-structured interviews. Although the cross-comparison of documents of various institutions and types of sources help to achieve triangulation, the analysis will be dependent on the accessibility and quality of publicly available sources. On the same note, the sample of the interview is consciously small and narrow. The study consequently targets the very learned population who have been directly engaged in FPV development and renewable energy application in the Maldivian energy transition instead of the study attempting to represent the rest of the population.

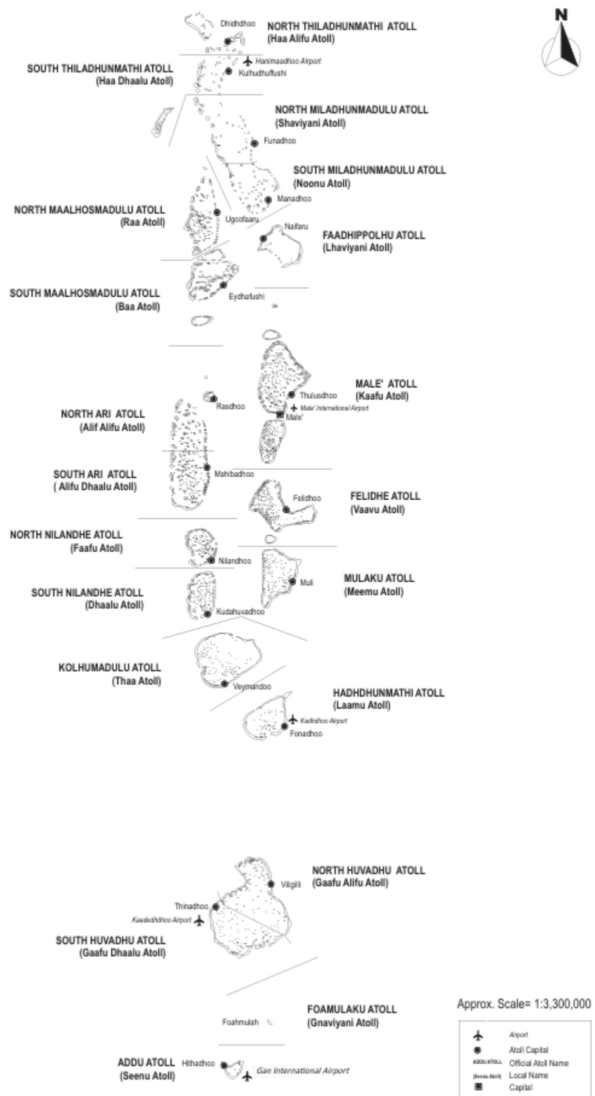
Digital tools were applied only to assist with administration, including organising documents and formatting them. The researcher conducts all analytical choices, coding, interpreting the data, and validation of sources manually.

Lastly, credibility of the study is not based on proclaiming objectivity or completeness but rather the transparency of the research process. By properly recording sources of data, coding processes and analysis choices, the thesis gives readers the information required to determine the strength and reliability of the results.

4 Empirical Context

The Maldives is a small island based country found in the Indian Ocean, south west of Sri Lanka and India. It consists of 1,192 islands that are organised in 20 natural atolls and are located across 860 kilometers in a north-south direction but hardly more than 120 kilometres in any one way (Figure 3).

Figure 3. Map of the Maldives



Source: Statistical Yearbook of Maldives, 2011, Department of National Planning

Among these islands, 187 are formally populated with local population and around 170 are built as the exclusive resort island only to accommodate international tourism (Table 1 for details).

The existence of the inhabited and resort islands is one of the features of the society and economy of the Maldivian islands. Maldivian citizens are accommodated on local islands where the clinics, schools, and community councils are publicly held whereas resorts are privately managed commonly through international hotel chains and have their own infrastructures of energy, water, and waste management. The difference between these two kinds of islands is an indication of more general socio-economic disparities, as resorts are the foundation of the tourism industry and inhabited islands are the source of the labor force and services.

Table 1. Comparison of local inhabited islands and resort islands in the Maldives

Feature	Local inhabited islands	Resort/private islands
Number of islands	~187	~170
Primary function	Residential communities for Maldivian citizens	Exclusively for international tourism, managed privately
Population	Permanent residents, majority Maldivian citizens	No permanent local population; staff often live on-site temporarily
Services & infrastructure	Public services (schools, clinics, utilities, local councils)	Self-sufficient infrastructure (power, water, waste, transport), designed for tourists
Related economic activities	Fishing, small-scale agriculture, local services, some migration to Malé	High-end tourism, generating foreign exchange earnings and employment
Connectivity & logistics	Dependent on ferries, speedboats, and cargo vessels for groceries and goods	Resorts import directly (international supply chains) or purchase in bulk via Malé

Source: Author's compilation based on National Bureau of Statistics (2023)

There is low connectivity between the archipelago and it is expensive. The combination of ferries, speedboats, and domestic flights is offered to provide inter-island transport. Ferries or speedboats are used to cover short distances between islands within central atolls, with longer routes between the north and south atolls often having to be covered by air. These services are relatively cheaper and more frequent: remote islands are more expensive and unreliable. The transportation of goods is also influenced by logistics: goods such as groceries and daily supplies are usually transported to the capital Male and increase the cost of living in the outer islands. The resorts, on the other hand, usually import goods or buy them in bulk at Male, which shields them from some of these logistical problems (Shareef and McAleer, 2007).

The Maldives is a country with a population of slightly more than 500,000 residents, with nearly a third of them residing on Male Island and the adjacent islands, which forms a strong urban-rural population separation (World Bank, 2020). The people are mainly Maldivian though the migration has greatly impacted the work force. Over the past two decades, the Maldives has experienced a significant inflow of migrant labour, primarily from South Asia, working in the construction sector, services, and the tourism sector in the country (ILO, 2021). Internal migration also worsens the overpopulation and infrastructural pressures of Male, and most outer islands are in depopulation patterns.

Tourism is a very important sector of the Maldivian economy, offering approximately one-quarter of the GDP and most of the foreign exchange income (IMF, 2022). Fishing and agriculture are also still significant in livelihoods of the local islands but contribute a minimal amount to national GDP. The reliance on tourism creates vulnerability to external shocks like global financial crisis, pandemics or climate related disruptions.

This is a critical geographic and social-economic situation that can be used to realize the energy system of the country. The spread of small communities on almost 200 inhabited islands, coupled with the preeminence of resort islands in the economy and the logistical drawbacks of inter-island transport, is why they have decentralized energy systems. It also identifies the structural obstacles that make it difficult to transition off of fossil fuel reliance.

4.1 The Maldivian energy system and diesel lock-in

The high decentralization of the energy system in the Maldives has been determined by its socio-geographic form of dispersed population, and a parallel system of individual resort islands. The Maldives uses hundreds of isolated microgrids, unlike continental states, which can use more integrated national grids, designed to serve single islands. Such fragmented design has traditionally anchored the use of imported diesel fuel, which is still a dominant factor in the production of electricity despite an increasing international and national awareness of integration of renewable energy sources (World Bank, 2020).

The supply of electricity is controlled majorly by two state owned utilities. The State Electric Company (STELCO) provides service to the capital Male and a few surrounding islands where the rest of the outer islands are supplied by Fenaka Corporation. The two companies use diesel generators as their primary electricity production sources with just a small margin of renewable energy. Although the nation has reached the goal of universal access to electricity by 2008, it has been supported by the mass importation of fossil fuel and massive state subsidies (ADB, 2021).

The statistics in recent years point to the pre-eminence of diesel. The Maldives had an estimated 600 MW of total installed generation capacity in 2022, with only about 11 percent of this renewable capacity (mainly solar PV, but also some wind, biomass, and hydropower). Regarding electricity generation, renewable sources included only 5-6 percent of the total output, and the remaining 90 percent of the total demand was supplied by diesel-power generation. The dependence is especially high in smaller islands, where the number of renewable sources is low and the only type of energy available in ordinary operation is diesel (ADB, 2023).

The structural and institutional factors, which establish lock-in, support the persistence of diesel. Technically, the system is constructed based on diesel generator sets (gensets) and diesel networks, which are sunk investments and routine. Economically, the cost of electricity production caused by small loads, poor functioning of the generators, and expensive transportation of fuel to the remotely located islands are not transferred to the final users as the government subsidizes them. Tariffs are kept at standard and reasonable rates throughout the country, yet, it is only due to the fact that the government subsidizes the utilities in regard to the gap between the actual generation costs and the earned income. This type of subsidy makes it affordable, but creates a fiscal reliance on diesel because the shortfall between the imports of fuel and the costs of the operations are funded by the national budget (World Bank, 2020).

The incumbent regime is strengthened by institutional and cultural practices. Utilities have become specialists in diesel-powered systems, regulators have built structures around fossil-based supply and consumers have now been conditioned to steady tariffs regardless of fluctuations in global oil prices. Such a constellation of actors, infrastructures and rules can be described to be what transition studies refer to as a socio-technical lock-in (Unruh, 2000). And despite the growing availability of renewable technologies, this system reinforces itself by creating an institutional inertia and system of financial support that encourages continuity.

International partners have been helping to end the reliance on diesel by hybridization and the use of renewable sources. Examples include the Preparing Outer Islands to

Sustainable Energy Development (POISED) program by the Asian Development Bank which has already implemented solar PV and battery storage on over one hundred islands, which have led to a quantifiable decrease in fuel usage. Likewise, renewable capacity under grid connections has been increased in selected islands by the World Bank via its ASPIRE and ARISE programs (ADB, 2021; World Bank, 2020). Such projects indicate that substitutes are technically viable and are slowly growing. Nevertheless, they are not incremental as compared to the total size of fossil fuel consumption and have yet to supplant the center stage of diesel in the national energy system.

In a nutshell, the Maldivian energy system is characterised by microgrids on islands which are decentralized, the deep dependence on imported diesel and fiscal subsidies that normalise the fossil regime. Please refer to Appendix A for a comparative description.

The use of renewable energy is on the rise and it is still peripheral which supports the description of the system as being locked in to diesel. This lock-in is the starting point where any discussion of innovation and transition in the Maldives has to start.

4.2 Policy landscape, donor influence, and tourism sector role

The major objectives of the energy policy of the Maldives are to lessen fiscal exposure through reliance on imported fuel and fulfill global climate change obligations. The Energy Policy and Strategy 2024-2029 proposes a five-year plan, which focuses on the deployment of renewable energy, integration of storage and modernization of the grid. Its goals are in line with the Third Nationally Determined Contribution (NDC) of 2025 submitted by the Government of Maldives which is set to increase the renewable proportion considerably by 2035 and to decrease the overall dependence on imported fuels (Government of Maldives, 2024; Government of Maldives, 2025). These reports bring out the paramount role of the energy sector in the fiscal resource management and climate adaptation that makes renewable energy just a strategic national initiative and not merely an option.

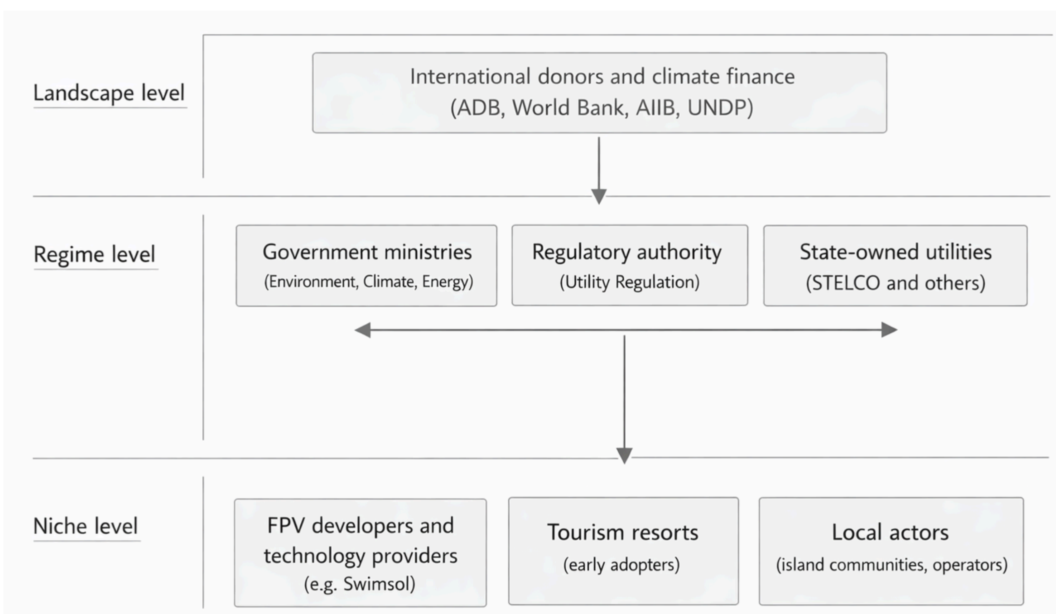
The institutional system is founded on the Utility Regulatory Authority (URA) which was created in 2016 to control the tariffs, the quality of the service, and the technical requirements. The URA is also important in finding a balance between affordable and financial sustainability of the utilities, especially with subsidy reform debates (URA, 2023). The URA has also established the basis of independent power producers (IPPs) to participate in the Maldivian market previously controlled by state-owned utilities as it offers a more transparent structure to power purchase agreements (PPAs) and licensing.

Diesel has been outrun through donor-sponsored programs. Hybrid solar-diesel-battery systems on outer islands have been funded through the POISED program of Asian Development Bank, funded by concessional loans and grants offered by various partners, such as the European Investment Bank and the Islamic Development Bank (ADB, 2021). Significantly, POISED has also provided institutional reforms, through unifying procurement and technical designs, which cost less and less uncertainty in future projects. The newer ADB program called ASSURE specifically deals with storage procurement because energy storage is a precondition to scaling renewables above pilot level (ADB, 2023).

Similar initiatives by the World Bank have focused on the involvement of the privates. ASPIRE program came up with a scheme that IPPs should install top and ground mounted solar with a World Bank guaranteeing facility and concessional finance. ASPIRE reduced entry costs among the investors by standardising contracts and risk sharing arrangements which led to a pipeline of projects financed by both local and foreign developers. Its successor, ARISE, carries this model to a greater scale of solar and storage, and the foreign direct investment is made through competitive bidding (World Bank, 2020). These systems are one of the first links at the organized FDI in the Maldivian energy sector other than the tourism industry, and a move towards a different financing approach to the infrastructure.

Other than development finance, the Asian Infrastructure Investment Bank (AIIB) has also co-financed renewable and storage infrastructure and this has contributed to the diversification of funding sources (AIIB, 2021). The existence of AIIB, together with ADB and the World Bank, indicates an increased involvement of the Maldives in the global flows of climate finances. In the case of a small island economy, the presence of such a variety of actors both opens opportunities and makes the situation more dependent on external expertise and concessional resources, thus the role of institutional coordination becomes essential. Figure 4 highlights the major actor groups influencing the Maldivian electricity system and renewable energy pathway such as governmental entities, utilities, donors, and developers of the private-sector.

Figure 4. Overview of key actors in the Maldivian energy sector and FPV-related initiatives



Source: own analysis

This policy and financing environment is determined indirectly by tourism. Solar PV and storage have been an early-mover solution by resort islands, which have autonomous energy systems on their corporate sustainability agendas. Home based hotel chains have also embarked on renewable technology to lower their operational expenses, counter fuel price fluctuations and consumer demand towards sustainable tourism (Shareef and McAleer, 2007). Although they are not directly related to the field of the work of a utility, they are considered a kind of foreign direct investment in renewable infrastructure to supplement efforts that are made by the donors. Besides, tourism plays a significant role in GDP, and most of the foreign exchange earnings are contributed by the tourism sector (IMF, 2022). The economic burden places the industry with an indirect control over the national energy planning because the affordable and stable supply of electricity is a preliminary condition to competitiveness on the international tourism markets.

Together, these dynamics provide an idea of how the Maldivian energy transition is being organized as a result of a collision of policy targets, donor-sponsored funding instruments and signals used by the private sector. Domestic policies provide ambition, the donors offer concessional finance and institutional models and the tourism sector manifests market-based uptake of renewable solutions. Collectively, they are open to change, although the system might be bound by its structural lock-in and financial reliance on subsidy at the same time.

4.3 Solar PV developments (rooftop, ground-mounted, floating)

Given its rapid cost decreases, technological development, and mass scaling-up of operational models, solar photovoltaics (PV) is the area of rapid development in the world that inherently follows the global shift towards renewable technologies. As of the year 2023, the worldwide cumulative totals of PV capacity had come to an approximate of 1.6 terawatts, and this was a considerable leap compared to 1.2 terawatts in 2022, and it ranks higher than any of other generation technologies that add to its overall quantity (IEA PVPS, 2024). Conventional applications like rooftop and ground-mounted PV have been the major expansion promoters and they combine to form the major capacity of installed capacity. Rooftop PV has proliferated under net-metering, self-consumption, and corporate-procurement schemes but ground-mounted PV is currently more common with utility-scale schemes built across the deserts, plains and on brownfields.

The size of deployment has led to an increasing role and significance of land availability especially in populated areas and small island states where there is little land and strong competition of use. In reaction to this, there has been a shift to using floating solar photovoltaic (FPV) systems whereby PV modules are placed on floating bodies placed on water. FPV does not need to increase land-use and can improve the performance of conventional systems, like cooling of water surfaces, and can in certain cases coexist with other infrastructures, such as hydropower reservoirs, ports, or coastal lagoons (World Bank/ESMAP, 2019a). Because of its initial commercial applications in Japan during the early 2010s, FPV is no longer a niche application system, with over 3 GW deployed globally by 2023 and a technical capacity of at least 400 GW projected as specifically applicable to man-made reservoirs (World Bank/ESMAP, 2019b).

It is possible to identify three levels of technological maturity, each with three categories of FPV sightings. The most commonly used systems are found on freshwater lakes which include drinking-water basins, irrigation reservoirs, and hydropower dams – the *on-shore or freshwater FPV*. The hydrodynamic conditions are relatively mild and, therefore, standardized float systems and easier solutions to anchor systems can be used in this environment. Freshwater FPV is already in commercial maturity, and such projects as installing a 320 MW placement in Dezhou Dingzhuang and 72 MW Ilots Blandin have already taken place (GlobalData, 2023; Ciel et al., 2024). In addition to the supply of electricity, freshwater FPV can minimize evaporation and supplement hydropower by sharing the transmission facilities and smoothing seasonal output.

The second category includes the close or sheltered ocean waters like lagoons, harbors and coastal waters covered by reefs – the *near-shore FPV*. These areas also present problems of salt water corrosion, change in tidal, and average wave action that demands modified mooring systems, and electrical equipment in marine standard. However, they have a good opportunity in coastal states with limited land. The 60 MW Tengeh Reservoir in Singapore is probably one of the largest demonstrations of tropical FPV, setting the standards in the operation of large-scale FPV even in humid equatorial environments (Sembcorp, 2021). *Swimsol*, a private renewable energy firm from Austria, specialising in marine FPV systems for island and resort contexts, and others have been first movers in island near-shore FPV tourism resort platforms. It has been released in the Maldives with the SolarSea(r) units, which are being installed at resorts, such as OZEN LIFE Maadhoo and LUX* South Ari Atoll, which are using floating systems alongside rooftop PV and diesel generators to minimize the usage of fuel (Swimsol, 2023). These projects show the contribution of the innovation of the private sector in adopting FPV in markets in which the use of diesel is still prevalent in the utilities of the people.

The third most technologically challenging type is *offshore FPV*. These systems need to be able to withstand high winds, long period swell, and severe weather conditions and therefore need high and stiff platform structures, strength multi-point moorings, and corrosion-resistant components. Offshore FPV is still in its pilot phase however early project developments in the North Sea have indicated increased feasibility. Test systems have already been installed by Oceans of Energy that has survived multi-meter waves and winter storms and SolarDuck, a Dutch-Norwegian developer, placed the 0.5 MW pilot known as

Merganser in partnership with RWE in 2024 to test its survivability and plans to operate in severe waters (RWE, 2024). These initiatives are a step in the direction of FPV, as certification standards, including the Recommended Practice of the DNV (DNV-RP-0584) start offering engineering standards of offshore designs (DNV, 2021). Some renewable energy initiatives have also integrated local technical training elements, especially on operation and maintenance of hybrid systems and the FPV systems, though again these initiatives are not uniformly distributed between islands.

The further development of FPV has been followed by the growth in professionalism and standardization of the design and operation. In 2021, the launch of DNV-RP-0584 was a significant step in the direction to provide extensive advice on structural integrity, hydrodynamics, and mooring, electrical safety, and operation and maintenance. The standard is the result of an industry effort that saw close to 20 stakeholders collaborate to develop a standard that has increased investor confidence and enabled the bankability of bigger FPV projects (DNV, 2021). The increasing number of established specialized firms demonstrates the differences in approaches: Ciel & Terre already handles one of the most popular modular high-density polyethylene (HDPE) float systems used in freshwater systems worldwide; Sembcorp already has created one of the biggest tropical FPV plants at Tengeh, and Swimsol has specialized in near-shore platforms serving resorts in the Southeast and the Indian Ocean, with SolarDuck and Oceans of Energy leading designs capable of operating offshore in Europe.

The chapters above have highlighted the technological development of FPV, the energy setting of the Maldives, and the present situation with the implementation of renewables. The less explored part, which the further analysis covers, is the interaction of these elements in the framework of a socio-technological transition. Instead of dwelling on technical specifications, or the description of the project, the next chapter views FPV diffusion as a process that is influenced by multi-level dynamics: local experimentation, institutional regimes, and external pressures.

In chapter 5, then, the analysis is shifted to description. It looks at the manner in which the Maldivian FPV pathway is formed as a result of the interactions between niche innovations, regime structures, and landscape drivers. Based on this, the following chapter uses MLP framework to generalise the empirical results at the niche, regime and landscape levels, defining the key barriers, enablers, and transition processes that define FPV scaling in the Maldives.

5 Analysis

The data to be coded was the empirical material, which was analysed using a hybrid inductive-deductive coding method as a combination of data-driven interpretation and theory-informed categorisation. It was analyzed based on 38 documentary sources and seven semi-structured interviews, which resulted in a total of 94 coded passages. Each passage was an analytically significant fragment- normally a statement, paragraph or a passage with a claim about the development of FPV that could be analyzed.

Three attributes were assigned to each coded unit so as to guarantee transparency and traceability:

(1) a code label (indicating the substantive issue) (e.g. technical reliability, donor influence, policy fragmentation);

(2) an MLP level, which attributes the passage to analytical strata of niche, regime, or landscape;

(3) an influence tag, which referred to whether the passage had a barrier, enabling or mixed influence on FPV diffusion.

The coding was done in two phases. To begin with, the common themes were observed in the interviews and documents through an open inductive reading (Saldana, 2021). Second, the codes that had emerged were deductively rearranged into the MLP (Geels, 2002; 2011) framework categories which was able to interpret the codes at different levels of structuring. The emerging themes were triangulated across data types (interviews, donor reports, and policy documents) in order to validate the analytical claims, where at least two different sources of information were used to support claims.

The last dataset consisted of 24 different codes categorised in five macro-themes in relation to the key socio-technical dimensions of FPV development. Table 2 displays these themes and positions them analytically, which is further discussed in Sections 5.1-5.3.

Table 2. Macro-theme clusters analysis summary

Macro-theme	Dominant MLP Level(s)	Influence Type	Description
Technological Reliability & Integration	Niche, Cross-cutting	Enabler	Marine-grade adaptation, hybrid integration, and learning-by-doing through resort pilots
Financial Mechanisms & Scaling	Regime, Cross-cutting	Enabler	Blended finance, PPPs, and donor programs supporting replication
Institutional & Policy Frameworks	Regime	Barrier	Fragmented mandates, limited policy adaptation, and weak institutional capacity
Donor & Global Influence	Landscape	Mixed	Donor finance, global standards, and fossil dependency as dual pressures
Social & Environmental Dynamics	Cross-cutting, Niche	Mixed	Social acceptance, communication, and environmental safeguards as conditions for legitimacy

Source: own analysis

The rest of this chapter has been organized based on the three levels of the MLP analysis.

Section 5.1 focuses on niche analysis of FPV development, including initial experimentation, learning of technology as well as networks of actors that are formed around resort- and donor-driven projects.

Section 5.2 focuses on regime structures and barriers and examines how institutional fragmentation, procurement arrangements and financing practices are important to scaling or limiting scaling.

The next section (5.3) goes over the landscape pressures and enabling factors, in which the global technological tendencies, agendas of donors, and climate-related weaknesses are listed in the context of influencing the national transition context.

The combination of these passages gives a consistent, multi-level explanation of FPV diffusion in the Maldives and forms the empirical basis of the analytical discussion of the findings which will be developed in Chapter 6.

5.1 Niche development of FPV in the Maldives

Small, experimental installations in the Maldives have been the main venue of the diffusion of floating photovoltaic (FPV) systems as these systems appear at the nexus of the private tourism industry, donor-funded technical assistance, and local policy environment. The growth path is in line with the initial stage of the niche of sociotechnical innovation where experimentation, learning among actors and technological adjustments prevail rather than standardized and wide-scale dissemination (Geels, 2002). In this setting, the Maldives has become an example on how market-based projects can develop new types of renewable energy that are appropriate in geographically limited, marine environments.

The major technology in this niche development is the modular near-shore FPV systems, where Swimsol was a market pioneer. Hybridized microgrids are resort-based systems, like OZEN LIFE Maadhoo and LUX South Ari Atoll that use floating arrays and rooftop PV, and incorporate additional diesel generators to form the systems. These were the projects that were constantly brought up in the interview material as points of reference to technological credibility and operational learning. They are of small scale - and in fact usually weaker than a single megawatt - which fits with the experimental reasoning of niche development, where stability and data gathering is more important than raw (capacity) growth.

The technology learning processes that have supported these initial projects have focused on marine grade durability, mooring design (the arrangement of anchors, ropes and attachments that hold floating solar platforms in position) and corrosion management. According to one of the interviewees who has been directly engaged in deploying FPV, the primary issue here is the longevity in the marines, that is, you should have floats that are UV-resistant, links that are not corroded, and alternative anchors (Interview I6). Instead of bringing in a totally standardised foreign design FPV development has been incrementally adapted in the Maldives, as developers and operators adapted anchoring systems, material and maintenance practices to local sea conditions. This process is more of progressive niche learning and not a one-off technology transfer. These points are related to the cluster of Technological Reliability & Integration that was found during the coding analysis and is the accumulation of results in interviews, vendor documentation, and resort case studies. The technological niche in the Maldives, therefore, has developed through progressive adaptation and not by importing foreign know-how at once.

There is more than just engineering that goes on around FPV in the Maldives. The operator of the resort has become the focal point of the relationship, taking up a lot of risk in initial investment and creating a social presence of FPV. The incorporation of floating solar platforms in the visual environment of luxury tourism has necessitated a close control of the perception of the guests, aesthetic positioning, and communication. According to interview accounts, the resort marketing strategies over and over again talked about FPV being a symbol of environmental responsibility and innovativeness. This is directly connected to the Social and Environmental Dynamics cluster where social acceptance and trust-building were mentioned as cross-cutting enablers. By placing FPV within the popular sustainability discourse of tourism, in which resorts operate, the introduction of renewable infrastructure into the maritime environment has become normal.

The chain of actors constituting this niche is still rather small but very interactive. Swimsol, Ciel & Terre, ADB and UNDP are all examples of global vendors, donor agencies and intersecting with private developers who include Swimsol, global vendors and policy dialogues. The various stakeholders bring in their own unique learning inputs - technological standardisation, financial structuring or environmental monitoring which cumulatively bring about the legitimacy of the niche. Table 3 is a synopsis of the technological and social factors that have given rise to the FPV niche in the Maldives.

Table 3. Technological and social dynamics of FPV niche development in the Maldives

Macro-theme	Codes Included	Dominant MLP Level(s)	Influence Type
Technological Reliability & Integration	Technical reliability (marine grade), Hybrid integration (PV + diesel + storage), Maintenance burden & lifecycle costs, Site suitability (lagoon/reef)	Niche, Cross-cutting	Enabler
Social & Environmental Dynamics	Social acceptance & trust-building, Guest/consumer perception, Equity/benefit-sharing, Communications & education,	Cross-cutting, Niche	Mixed

	Environmental co-existence (micro-ecology), Environmental safeguards & monitoring		

Source: own analysis

The available empirical data reveal that technological and social factors are mutually reinforcing. The apparent existence of FPV arrays, proactive communication by resorts has established a kind of demonstration legitimacy (Schot and Geels, 2008), which reduces the perceived risk of novelty with regard to future adopters. Simultaneously, the sense of technical stability and integration - especially hybrid microgrids - reinforces the investment confidence of the feasibility of FPV in saline and tidal locations. Nevertheless, it is a weak niche though it has been somewhat successful. Most projects are run in remote privatized settings, which are not connected to national energy planning and regulatory mechanisms. The scaling capability thus depends on the ability of the learning acquired in the niche to be institutionalised at a regime level in terms of formal standards, procurement template and financing mechanisms.

To conclude, FPV in the Maldives has gone beyond being an experiment to a valid technological and social choice, as discussed in the niche layer. However, these initial projects may create technical credibility and social presence, but they are structurally separated from the national energy structure. The knowledge gained in this part thus preconditions Section 5.2, which is dedicated to the analysis of the institutional and financial regime, according to which the existence of such niche learning can be translated into the diffusion system-wide.

5.2 Regime structures and barriers

The Maldivian energy regime institutional and regulatory frameworks is both the best source of inertia and the key determinant of whether the FPV niche will be able to evolve into stable diffusion or not. In the MLP, the regime level is associated with the prevailing pattern of actors, policies, market logics and infrastructural norms that stabilize the system (Geels, 2011). Historically, which is also the case in the Maldivian case, this stability has been centered around generation based on diesel, centralized procurement, and project implementation mediated by donors. Even though such arrangements have been effective in providing basic access to energy to a dispersed archipelago, they also limit the integration of modular site-specific technologies such as FPV.

There are a number of institutional barriers that both interview evidence and analysis of policy documents point towards. To start with, the system of regulations is still divided between various organisations, among them the Ministry of Environment, the Environmental Protection Agency and the Maldives Energy Authority. Both have overlapping or not clearly defined mandates in relation to environment, grid interconnection, and the private sector involvement. The lack of a specific regulatory framework of FPV projects implies that the processes of approvals should be adjusted to use the templates that were initially formulated in reference to the ground-mounted or rooftop PV. This institutional fragmentation was cited as a major constituent of the Institutional Policy Frameworks cluster, which incorporates the policy vacuity, undefined jurisdictions, and deficient inter-agency coordination. This has led to procedural doubt and project delays by developers especially those who install in areas which are intersected by maritime, tourism or environmental jurisdictions.

Second structural constraint is on the procuring and financing systems under which renewable projects are accomplished. To the eyes of the private operators, financial feasibility is the decisive one – it depends on the payback (Interview I4). Despite the successive beneficiary programs of the Maldives, such as the Preparing Outer Islands to Sustainable Energy Development (POISED) of ADB and the more recent Accelerating Sustainable System Development Using Renewable Energy (ASSURE), the programs have generally been run on a public-donor basis, as opposed to a market-driven program. Power Purchase Agreement (PPA) and commercial investment model standardization has not yet reached an advanced stage, especially for the floating systems. The interviewees stated that PPA is technically feasible, yet not yet designed to be used in FPV, as the broader issue is the mismatch between the prevailing procurement templates and novel technologies.

More so, the low investments required to invest in island grids and their physical position prevent large investors due to the small scale and geographic dispersion. This is the reason why in the majority of FPV developments so far, the development has taken the form of resort-based self-generation, or donor-funded pilots, instead of the so-called commercial independent power producer (IPP) schemes. This organizational trait comes in the form of a dual regime in the Financial Mechanisms and Scaling cluster, where one of them is a donor-based, institutionalized regime, and the other is a private, experimentational regime. The distance between these spheres forms what can be called an institutional bottleneck in the transition process - at which the knowledge possessed by pilots cannot be readily converted into bankable and replicable models regulated under national regulations.

This bottleneck is further supported by the issue of institutional capacity. The interviews showed that there were no trained staff among the government and utility organizations to address FPV-related environmental analysis, grid integration, and O&M planning. In some donor reports, it was stated that the weakest point of the outer island renewable deployment was maintenance and aftercare for the installations (ADB, 2023). This issue corresponds with the code of Institutional capacity and maintenance follow-through, which states that, whereas the technical design has been improved under the influence of international assistance, the operational expertise in the form of long-term experience is yet to be instilled into local institutions.

These two interconnected institutional and financial aspects can be generalised with the use of Table 4, which summarises the essence of the themes of the regime level and their impact on FPV scaling.

Table 4. Regime structures and barriers affecting FPV development in the Maldives

Macro-theme	**Codes Included**	**Dominant MLP Level(s)**	**Influence Type**
Institutional & Policy Frameworks	Policy clarity and stability, Permitting complexity / institutional fragmentation, Institutional capacity & maintenance follow-through, Grid/legal isolation of islands	Regime	Barrier
Financial Mechanisms & Scaling	Financing instruments (PPA/capex/blended), Replicability & scaling logic, Corporate strategy & KPIs (resorts), Procurement and tendering practice	Regime, Cross-cutting	Enabler

Source: own analysis

As illustrated in the above energy regime, the energy regime is reflective of a structural ambivalence. The theme of Institutional and Policy Frameworks operates in an inhibitory manner with inertia, disjointed governance, and insufficient policy adjustment being its dominant features. Financial Mechanisms & Scaling, in its turn, is also a potential enabler, but an element that is limited by the deficit of the regulatory maturity and the institutional coherence. It is the combination of these two themes that characterizes the transition corridor of FPV in the Maldives: scaling is technically easy but administratively hard.

This regime stability is supported by the continuation of the diesel dispensability. The current system of energy supply is maintained at subsidised fuel prices, with the old infrastructure and interests, which avoids systemic change. Meanwhile, the policy documents like the Energy Policy and Strategy 2024-2029 already express the ambitions towards diversification and involvement of the private sector, which implies the partial liberalization of the regime. Nonetheless, policy vision translation into action instruments is not yet aligned well enough. The Maldives Energy Act (2021) aims to offer a legal basis of renewable integration, but fails to specify the secondary laws and standard procedures that will lead to the utilization of FPV.

Therefore, the regime is the point of contact and the point of constraint of the Maldivian energy transition. It is stable and ensures continuity at the expense of transformation. These institutional frictions must be understood, since they interpose the conversion of donor and technological pressures into concrete policy change. Section 5.3 builds on this observation by examining the larger landscape forces economic, climatic, and geopolitical forces that form and, in some cases, destabilize such structures of regimes.

5.3 Landscape pressures and enabling factors

The Maldives is a country where the energy transition is being executed in the context of a larger global, climatic and economic forces, which are limiting and fuelling the adoption of floating photovoltaic (FPV) systems. Landscape dynamics in the multi-level approach form the exogenous environment which puts long-term pressure on the regime which redefines the incentives and expectations but which cannot be directly controlled by actors (Geels, 2011). In the case of island systems, such pressures are especially sharp because of high levels of fuel dependency, donor conditionalities and global environmental discourses that place the Maldives at the centre of the front lines of climate vulnerable countries. The combination of these forces creates a structural tension between vulnerability and opportunity: as much as the landscape reveals systemic vulnerabilities, it also authorizes renewable innovation as a demand and not a choice.

The most glaring of these forces are the reliance on imported diesel, the source of power generation in the isolated grids of the whole nation. The volatility of prices, logistical limitations and the environmental price of marine fuel transportation are documented (IRENA, 2015). The interviewees stressed more than once that diesel dependency is not only economic, it determines the energy system structure. According to one of the interviewees, the engine would stop or fail to receive enough diesel on time once or twice a month particularly in rainy seasons (Interview I2). This is in line with the Donor and Global Influence cluster which links fossil vulnerability to external support systems. The repeated peaks in the world fuel costs and the global discourse of decarbonization have stimulated donor agencies to focus on the implementation of renewable deployment schemes like POISED, ASSURE, and Accelerating Maldives to Renewable Energy (UNDP, 2024). These projects will act both as a reaction to external shocks and as a tool by which global institutions influence the local change directions.

The influence of donors in the Maldives case is complex. On the one hand, the hybridization and scaling of solar that has been made possible by concessional loans and technical assistance of ADB, AIIB, and UNDP would have been impossible under the conditions of domestic financing. Instead, this donor assisted architecture has institutionalized a different type of dependency, that based on financial and procedural conditionalities. Such a conclusion means that actors do not only restrict the implementation of FPV, but actually form the circumstances in which the implementation of niche innovations can be considered compatible with the regime structures.

In the MLP framework, this dynamic illustrates the top-down pressure of change and reproduction of new forms of lock-in of institutions at the landscape scale, using standardized funding tools.

The enabling environment is further created by global technological and market trends. The coming of age of FPV technology, the uniformity of architectural processes (DNV, 2021), and the global acceptance of an offshore prototype, namely the Merganser pilot produced by SolarDuck (RWE, 2024), are among the factors contributing to increased validity of marine-based photovoltaics. These international cues make their way into the Maldivian environment, both in terms of vendor interaction and in terms of donor discourse, FPV is being marketed as a technological solution that has been proven to be viable in coastal and island states. Meanwhile, international certification and vendor specialization (e.g., Ciel & Terre, Swimsol) also help decrease the uncertainty of investors and help strengthen the image of marine solar as having left the experimental phase. This technological maturity is an enabler of the landscape, an adjunct of the confidence gap between local experimentation and institutional adoption.

In addition to economic and technological forces, socio-environmental stories have taken the centre stage in the Maldives positioning in the discourses of global sustainability. The climate diplomacy of the government based on existential vulnerability and the goal of carbon neutrality forms a general discourse that promotes the growth of renewable energy. According to interview content, the perception of being held as a renewable leader is equal to the reality of the megawatts installed. This visibility creates symbolic value which enhances alignment of the donors and policy momentum. At the same time, there is increased environmental awareness and environmental protection of coral reefs, which increased attention to scrutinizing marine installations, leading to increasing requirements of the monitoring and Environmental Impact Assessment (EIA). The change of the environment was also discussed in the interviews as one of the increasingly important concerns(Interview I3). Social and Environmental Dynamics clusters reflect this two-fold impact: the environmental stewardship legalizes FPV and makes it difficult to legalize by means of ecological protection.

Table 5, which is based on the cross-level interaction matrix derived during the coding analysis summarises the vertical interactions between these landscape forces with the lower levels of analysis.

Table 5. Cross-level interactions shaping FPV transition dynamics in the Maldives

Macro-theme	Niche	Regime	Landscape
Technological Reliability & Integration	Pilot learning, site selection, durability innovations	Procurement specs, O&M standards*, hybrid grid rules	Global certification, vendor design evolution
Financial Mechanisms & Scaling	Resort/private investment models, PPP trials	PPA frameworks, tenders, portfolio aggregation	Donor funding, blended finance, global de-risking
Institutional & Policy Frameworks	Permitting challenges, unclear jurisdictions	Policy gaps, institutional inertia, fragmented governance	National commitments, regulatory pressure from SDG/SEZ frameworks
Donor & Global Influence	Donor-supported pilots, technical training	Alignment with donor roadmaps, procurement conditionalities	Macro donor influence, fuel price shocks, tech trends
Social & Environmental Dynamics	Community participation, resort visibility, local jobs	EIA norms, benefit-sharing schemes, communication	Public discourse on climate, sustainability narratives

		programs	

**O&M standards* are the guidelines and steps that are set in order to be able to operate and maintain the energy infrastructure, setting up of inspection schedules, monitoring of performance, and repair procedures

Source: own analysis

This matrix shows the impact of forces at the landscape level on forces that reinforce and disrupt the bottom strata. The forces of scaling and standardization brought about by donor and market trends (as well as compliance costs and regulatory caution), are subject to socio-environmental expectations. That context of Maldivian transition can be thus characterized as a scenario whereby there is what may be described as managed vulnerability; a situation where external forces (climate urgency, energy insecurity, global finance) cause action but do so in a strictly bound local context. For example, Maldivian energy insecurity is influenced by the global volatility in the fuel market as well as the reliance on imported diesel to produce electricity in the islands.

Taken together, these results conclude that the landscape does not only put restrictions in place but also generates the momentum, which drives the Maldivian transition forward. They are external donor structures, climate urgency, and world technological maturity which serve as catalysts and dependencies. The discussion chapter (Chapter 6) will summarise these multilevel understandings, and evaluate the interaction of the barriers and enablers to establish the practical and theoretical inferences of FPV scaling in small-island systems.

6 Discussion

6.1 Barriers and enablers of FPV scaling

The FPV evolution in Maldives analysis shows that the technological preparedness, institutional inertia, and the external dependency are rather complicated. The barriers and enablers that were identified in the coding process do not work alone, instead, they comprise an interdependent network of forces at the niche, regime, and landscape levels. These interrelations are important to understand why FPV, however technically appropriate and attractive as a policy, is still in its infancy of diffusion.

The greatest enablers at the niche level are the aspect of technological reliability and integration of hybrids. Tests run by private developers and resort operators have shown that FPV can be able to perform stably even in salty and tidal waters. The Swimsol and resort-based FPV projects mean that technological confidence has already been established among local and international stakeholders. This experience in the form of learning-by-doing is a key contributor to scaling because it creates not only technical sense but also legitimacy (Schot and Geels, 2008). Social acceptance- as indicated by the positive perception of guests and the local community enhances this impetus by incorporating FPV in the public sustainability discourses of the tourism industry. A combination of such niche-level effects forms a base of so-called proof of concept on which larger spreading may be constructed.

The enablers however face fierce barriers at the regime level. Maldivian energy system is still organized around the centralized and diesel-based generation and decentralized institutional accountability. Even though the Energy Policy and Strategy 2024-2029 expresses the ambitious renewable targets, the lack of a consistent secondary legislation, permitting procedures and standardised Power Purchase Agreements (PPAs) hinders the commercial replication of FPV. Interviews could tell that developers are uncertain about the responsibilities of the agencies and schedules of the approvals, which does not encourage private investment. Such disintegration supports a reliance on donor-supported, project-oriented models as opposed to the market-led growth. This barrier is further enhanced by the weakness of domestic institutional capacity especially in grid integration and maintenance control. Essentially, it is in the niche that the technology has created technological momentum, but the regime has not yet offered the formal scaffolding upon which scaling can be based.

Financial structures lie in the middle between the enabler and constraint. Concessional finance and hybrid system designs have been made available as donor programs like POISED and ASSURE (ADB, 2023), which have helped to reduce entry barriers at the early deployment. However, such arrangements are frequently time based and externally operated and little is translated into self sustaining financial mechanisms. The absence of standardized PPAs and access to long-term credit is a limiting factor to the participation of the private sector. This means that the financial regime acts as a semi-permeable gateway: it helps when it comes to demonstrations but lacks institutionalisation to an extent that would allow it to stimulate mass dissemination.

Some of the factors on a landscape level serve as structural change enablers. The increase in diesel prices and climate risk combined with pressure in decarbonization across the globe, have rendered renewable diversification a geopolitical and ethical necessity. Perceived risk has been greatly decreased by donor and multilateral programs, as well as innovations in the FPV technology and certification globally (DNV, 2021). The further mobilization of political will and donor alignment is done through international awareness of the Maldives as a climate-vulnerable country. This set of circumstances places FPV in a wider "momentum of inevitability" of transition being not simply an option but a developmental requirement.

However, the same landscape which gives momentum creates new dependencies. The high level of donors imposes external decision-making and procedural patterns to the domestic policy implementation. According to the donor reports and the interview evidence, the projects tend to represent the global funding logic rather than the local energy requirements. This may yield what can be termed as structural asymmetry- with the scaling being anchored on the external financing cycles and international designing standards as opposed to endogenous governance capacity.

The presence of balance between the barriers and enablers identified in the course of the analysis is thus not balanced. The technological and financial aspects are largely in favour of enablers, whereas the institutional and governance frameworks of the regime are still barriers. The interplay between these levels creates an effect of a bound transition: FPV develops in discrete niches, externally-funded programs but seldom finds its way into the mainstream system of energy. The vertical allocation of the significant barriers and enablers by the layers of the MLP is summarised in Table 6 (based on the thematic synthesis conceptually), which displays the layers.

Table 6. Dominant enablers and barriers identified

MLP Level	**Dominant enablers**	**Dominant barriers**
Niche	Technological reliability, hybrid integration, social legitimacy, pilot learning	Limited diffusion beyond resorts, weak policy linkages
Regime	Financial mechanisms (donor finance, PPA templates)	Institutional fragmentation, procedural complexity, low capacity
Landscape	Donor alignment, global technological maturation, climate pressure	External dependency, procedural rigidity, vulnerability to funding cycles

Source: own analysis

The synthesis highlights the fact that the main issue of FPV scaling in the Maldives is institutional translation, that is when the learning and legitimacy acquired in the niche level is transferred and institutionalized in those formal structures of the regime. In the absence of such translation, FPV will continue to be dependent on external players and industry-specific opportunities.

The total experience of the Maldives suggests that the scaling of FPV needs more than technical adaptation or support by the donor, it needs building of domestic institutions, financial standardization, and the coherence of the regulators. The following part expands on these discoveries into a much wider theoretical and contextual scope by talking about how the MLP can be applied to fragmented island environments in which spatial and institutional fragmentation is redefining the traditional borders between niche, regime, and landscape.

6.2 Extending the MLP to fragmented island contexts

When the MLP framework is applied to the energy transition in the Maldives, there are a number of contextual peculiarities that undermine the conventional assumptions of the framework. To analyse transition in relatively coupled socio-technical systems, including national electricity sectors, the MLP was initially formulated where actor networks, infrastructures and governance mechanisms are spatially and institutionally cohesive (Geels, 2002; 2011). Small-island systems such as the Maldives, on the contrary, are fragmented by nature; geographically, institutionally, and infrastructurally. Such fragmentation essentially changes the interaction of niche, regime, and landscape dynamics which generate new hybrid transition pathways that are not based on the conventional hierarchical order of niche - regime - landscape reconfiguration.

The former break comes as a result of spatial discontinuity. The Maldivian electricity network consists of over two hundred island grids which are semi-independent socio-technical regimes. As a result, the diffusion of innovation process is not systematic but is made up of modules, as it progresses based on the site-specific imitations instead of a national unification. The coded data indicates the evidence that FPV projects develop as individual clusters of pilots in resorts, donor-funded hybrid systems, and sites of public demonstrations with different actors, contracts, and technical conditions. This fragmentation suggests that it is by horizontal imitation and no longer vertically through scaling, but that innovations move between islands and not up to a unified national regime. According to MLP, in fragmented island energy systems, FPV scaling takes place through a place-specific process influenced by constraints and configurations of actors and not by a linear technological diffusion pathway. This case of the Maldivian shows how such channels are created by negotiated alignment between niche innovation, regime institutions and outside pressures.

The second change is related to institutional multiplicity. The regime level in fragmented island situations is not a unitary form of regime but a combination of mixed jurisdiction: ministries, utilities, municipal councils, resort operators, and so on, each holding half the power. The case of the Maldives shows that the lack of coordination between energy, tourism, and environmental agencies is caused by overlapping jurisdictions. This institutional diffusiveness produces what may be referred to as a polycentric regime, that is, a state of stasis and change together. Institutional gaps that enable donor and private-sector actors to execute experimental FPV models are contented by public agencies through procedures of permits and tenders. This leaves a dynamic balance that niche innovations will persist because they find their way through the regime and do not change it. In the context of extension of the MLP framework, this implies that the regime layer of an MLP in an island setting must not be seen as a monolithic entity but as a mosaic of semi-autonomous governance nodes, which are networked.

Third, the role played by landscape is more direct and repeated when compared to continental systems. There are no macro-level pressures in the Maldives which do not just produce long-term selection pressures: climate vulnerability, fossil-fuel dependence and donor intervention, but actively influence everyday governance and investment choices. Evidence on the interview and documents shows that donor conditionalities and global financing standards are drilling their way to the interior of the project design, and are in effect eroding the gap between landscape and regime. To take it as an example, concessional loan schemes by ADB or AIIB are both at once financial instruments (regime mechanism) and external policy pressures (landscape influence). This confusion of levels creates a blur to the boundary of analytical levels and implies that in systems which are extremely aid-dependent the MLP is to be modified to absorb vertical compression in which landscape drivers directly replace missing domestic regime functions.

The following contextual adaptations are conceptualised in Table 7 that compares the classical MLP set-up with the altered features in the Maldivian case.

Table 7. Extending the MLP to fragmented island contexts

Analytical Dimension	**MLP Assumption**	**Island Adaptation (Maldives)**
Spatial structure	Single integrated national system	Disaggregated micro-grids, diffusion through horizontal replication (“scaling-out”)
Institutional configuration	Cohesive regime with dominant incumbents	Polycentric regime composed of overlapping agencies and semi-autonomous actors
Niche–regime interaction	Vertical upscaling from protected niche to dominant	Cross-island replication and hybrid coexistence of multiple

	regime	micro-regimes
Landscape influence	Slow, exogenous macro-pressure	Immediate and directive due to donor dependence and climate vulnerability
Transition pathway	Sequential (niche → regime → landscape)	Compressed and recursive, constant feedback between levels

Source: own analysis

This theoretical extension narrows down to the application of transition frameworks to the small-island developing states (SIDS). Systemic change cannot always arise in such scenarios as out of the progressive replacement of one regime within a growing niche. Rather, it is an extended process of distributed experimentation, external steering and institutional negotiation within fragmented spaces of governance. The FPV development in the Maldives represents an ideal example of this scaled down transition logic: it is spatially decentralized, externally funded and institutionally hybrid.

Conceptually speaking, the findings suggest a wider consideration of the adaptability of the MLP. By identifying spatial and institutional fragmentation as part of the regime apparatus, the explanatory scope of the framework is made more broad than continental infrastructures. It underscores the fact that, in the case of SIDS, transition management has to focus on coordination, replication and absorptive capacity instead of competitive substitution of past regimes. Therefore, the projection of the MLP to fragmented island settings does not only explain the context of the Maldivian experience but it also leads to a re-thinking of how global transition theory can be made to accommodate the diversity around the peripheral and small-system transitions.

6.3 Policy and investment implications

These research results have shown that the scaling of floating photovoltaic (FPV) systems in the Maldives does not depend on the technological readiness but on the correspondence between institutional, financial, and governance processes. The policy and investment interventions, therefore, should fill in the structural gaps between niche experimentation, regime coherence and the dependency at the landscape level. By this means, the Maldivian case can offer general implications to small-island energy transitions, with the problem of spatial dispersion, institutional fragmentation, and dependence on donors coexisting with the opportunities of specific innovations.

The closest impact is at the policy level, which is institutional integration. It has been revealed in the analysis in Chapter 5 that FPV diffusion is limited by overlapping mandates and vague jurisdictional areas between the Ministry of Environment and the Maldives Energy Authority and the Environmental Protection Agency. These agencies need to shift to a coordinated model of governance that creates a single permitting and regulation framework of marine renewables in order to make them scalable. There should be specific FPV guidelines, which would stipulate technical, environmental and safety specifications, thus enhancing administrative obscurity and fast-tracking of individual investment. An inter-agency or so-called renewable taskforce, which has been piloted occasionally through donor programs, would offer a temporary coordination platform through which the approvals process can be streamlined and environmental and energy goals harmonised.

The second priority is associated with financial standardisation and de-risking. The evaluation found out that a majority of FPV investments are donor-based, and there is a small involvement of commercial players. The predictability that would be needed in attracting independent power producers (IPPs) would be achieved through institutionalising renewable procurement based on standardised Power Purchase Agreements (PPAs) and long-term offtake contracts. Co-financing by the multilateral institutions could also be achieved by the establishment of a renewable investment facility in the Ministry of Finance or a national development bank. Over the longer run, shift to programmatic financing (as an alternative to project-based) with several (or more) islands being aggregated by the same procurement or blended finance would serve to attract economies of scale and consistency in operations.

The role of donor institutions will remain decisive, and their involvement may change to implement direct projects to capacity-building and the support of the system. Alternatively to coming up with discrete interventions, external partners might direct resources into domestic planning, monitoring, and maintenance buildup. This implementation is consistent with the more general theoretical observation that in a small-island system, sustainable transitions are more reliant on the absorptive capacity than on technological transfer. The success of donor programs, as is shown by ADB and UNDP programs, mainly depends on the success with which the local institutions internalise operational experience and financing know-how.

The resort industry at the investment level provides a poorly exploited channel of linking the privatized capital and the state goals. Resorts are already using FPV and hybrid microgrids as a demonstration site, but they are only involved in self-generation. Data, technical experience, and brand visibility of resorts could be used to inform national renewable planning through the establishment of public-private knowledge partnerships. An information structure shared, perhaps under the Maldives Energy Authority, could be used to transfer experience of resort-based FPV to grid standards, safety guidelines, and certification of components to be widely replicated.

Environmental governance should also increase with technological and financial reforms. The two-sidedness of environmental protection both as a legitimacy requirement and as a bureaucratic bottleneck requires that the regulation is crystal clear and balanced. Enacting marine spatial planning principles to avert the majority of uncertainty and keep ecological control would involve setting up FPV areas that are pre-identified with the help of usual Environmental Impact Assessment (EIA) templates. This would also make the Maldives a leader in the process of merging marine conservation and renewable implementation, which is a strategic consideration in donor negotiation as well as global climate negotiations.

Lastly, the shift to FPV and hybrid renewables has to be conceptualized as part of long-term strategic vision of energy independence at the national level. Even though donor finance will be needed at least in the short term, structural independence will be impossible without the renewable investment being the part of wider industrial and educational strategies. Diversifying the local technical training, certification, and O&M will not just decrease the dependency-based maintenance but also generate the skilled job, which will anchor the transition in the domestic-based value creation.

Overall, the policy and investment implications of this study suggest a two-fold change in the form of the fragmented forms of governance into the coordinated kinds and the project-based forms of financing into the systemic ones. The case of the Maldivian experience is that the viability of FPV scaling is not entirely limited to technology, but rather determined by the institutional design and financial architecture. The Maldives can turn its existing state of experiment into a lasting leadership role in marine solar installation by investing in integration, capacity, and standardisation; providing a useful case study of how other small-island states can make the same transition.

6.4 Synthesis and outlook

The FPV development in the Maldives discussion indicates that technological innovation can never be enough to promote systemic change in the low energy systems of small islands. The spread of floating solar technology is rather a result of the constant compromise between external forces, institutional adjustment, and local exploration. Throughout the three analytical layers, there was one distinct trend in the study: niche enablers are robust, regime barriers are deep-rooted, landscape pressures are increasing.

The extension of the MLP framework to fragmented island settings enabled this study to reveal that the process of transition in the archipelagic systems takes place through the distributed replication instead of centralised transformation. Transformation moves horizontally around detached islands and centers of governance, on the bases of donor networks and privatization projects, instead of vertically through the replacement of regimes. The fact that this adaptation of the MLP highlights is that in small-island developing states, spatial and institutional discontinuity can be no less influential on energy transitions than technology and policy.

The policy and investment recommendations based on the analysis lead to the fact that the strategy needs a re-orientation: the project-based intervention is needed to be replaced by coherent governance, the donor-dependent intervention is needed to be replaced by domestic, and the ad-hoc pilots are needed to be replaced by scalable programmatic models. The Maldivian example demonstrates that FPV has ceased being an experimental technology to be a viable way of diversifying energy as long as institutional coherence and financial standardisation are able to keep up with technical advancements.

All in all, the Maldivian FPV shift indicates the prospects of the small-island energy systems as well as the weaknesses of these power systems. It is a narrative of adjustment and not upheaval, of local learning, bargained government, and coordinated accommodation both between local innovation and the external world. Although context-dependent, these dynamics provide more general information about other island states that desire to strike a balance between environmental vulnerability and energy independence.

7 Conclusion

The study aimed at examining the development and the scaling of floating photovoltaic (FPV) systems in the fractured Maldives socio-technical context using the Multi-Level Perspective (MLP) as the key analytical tool. The research integrated qualitative data of 7 semi-structured interviews and 38 documentary materials in a systematic way by coding them into 94 analytical units in the scope of niche, regime, and landscape analysis. The aim was to establish the interactions between technological innovation, institutional structure, and global influence as specified to determine the potential and the limitations of the renewable energy transitions in the small-island developing states (SIDS).

It was found that the diffusion of FPV within the Maldives is non-linear and distributed across a transition path. On the niche end, resort-based players and individual developers have been pioneering in exploring hybrid microgrids consisting of a combination of FPV, rooftop solar and diesel generation. There has been technological and operational learning through these projects which show that FPV can work in tropical marine environments reliably. Nevertheless, they are spatially limited by the fact that Maldivian energy system has been structurally fragmented into various microgrids.

The institutional inertia and fragmentation of the procedures appeared to be the most crucial impediments at the regime level. Though the policy has committed to the renewable expansion, lack of clarity of FPV regulations, Power Purchase Agreements (PPAs) and inter-agency coordination have been keeping the niche learning translation into systemic deployment. Assistance programs like POISED and ASSURE have offered some much-needed monetary and technical aid but remain externally administered, disjointed, ad hoc programs instead of part and parcel of a consistent national system.

On the landscape level, both enablers and dependencies have been global pressures, such as increasing fuel prices of fossil fuel and vulnerability to climate, and conditionalities of donors. The fact that the Maldives is a climate-prone state and thus has attracted international attention and investment has also polarized the underprivileged nature of the state to a dependency that continues to encourage external control of the project agenda and how to carry it out. It brings about externally energised internal constrained transition and it is moving forward as donor and private-sector initiatives with no internal coordination.

The other theoretical value of the study is that it will generalize the MLP to fragmented island settings. The conventional transition frameworks take into account infrastructures that are spatially integrated and cohesive regimes; this study shows that the latter are not applicable in SIDS. Transitions in the Maldives are horizontal and not vertical regime change--FPV innovations spread at the level of the individual islands and not at the expense of the centralised incumbent regime. Besides, the regime itself is not a single, stable entity, but a polycentric structure of partially overlapping authorities and actors. These structures are directly penetrated by landscape pressures, especially donor power and climate vulnerability and create a kind of vertical compression, where macro-level drivers replace the absent domestic capacities. These modifications provide a fine drum of analytical prism on comprehending the shifts in other fragmented or peripheral settings.

There are also policy and investment implications of the empirical and theoretical results. The institutional coherence, financial standardisation and domestic capacity building are identified to be important preconditions of FPV scaling. A centralized permitting scheme, standardised PPAs and combining both environmental and energy regulation would reduce the transaction costs and make it easier to invest privately. At the same time, by changing the focus of donor engagement towards institutional enablement instead of implementation of the project, there would be an increase in the absorptive capacity and long-term sustainability. The already existing Maldivian resort industry as an innovation niche can be used as a transition zone between the private investment and the public policy and transfer the local experimentations into the national standards and demonstration value.

In addition to the Maldivian case, the study has made a contribution to the bigger sustainability transitions research area by showing the possibility of the MLP to be operationalised in a small, spatially discontinuous, system. It demonstrates that the change of energy in the SIDS is less reliant on technological disruption as compared to institutional learning and integration of governance. Those findings confirm that energy transitions cannot be defined as discrete technological events, but as processes negotiated socially in relation to certain political and spatial circumstances.

Lastly, the research creates future research directions. The generalisability of the proposed concepts of scaling-out and polycentric regime can be tested by comparative studies across island states, i.e. the Seychelles, Mauritius or Caribbean microgrids. The qualitative information obtained in the current study would be supplemented with quantitative measurements of FPV economics on alternative financing models. Community-based and tourism-based energy governance also has potential to be assessed and explored further to understand the role of non-state actors in influencing small-island transitions.

In conclusion, the Maldivian experience has shown that FPV is not simply the technological reaction to the shortage of land, but a socio-institutional experiment, which is integrated into place-specific governance, infrastructure and configurations of actors. It shows that innovation, which is orchestrated and embedded within an institution, may overcome fragmentation to establish sustainable energy sources of independence. The Maldives offers an interesting study on how peripheral systems can be turned into laboratories of transition to the wider global energy domain by coming up with the global logic of renewable expansion and local realities of small-island governance.

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Appendices

Appendix A. Maldives Energy System: Island types comparison summary

Feature	Local inhabited islands	Resort/private islands
Electricity supply	Provided by state-owned utilities (STELCO in Male, Fenaka in outer islands)	Independently managed by resort operators
Primary technology	Diesel generators, supplemented by small solar PV and hybrid mini-grids	Diesel generators, increasingly combined with rooftop/ground solar and batteries
Renewable share	≈ 5–6% of total generation nationally (IRENA, 2022)	Higher share in some resorts due to sustainability goals; no official national statistics
Tariffs	Uniform national tariffs, heavily subsidized by the government	Costs internalized by resort operators; passed on indirectly through tourism pricing
Fuel logistics	Diesel shipped from Malé and distributed by sea to outer islands, high costs and vulnerabilities	Resorts arrange direct imports or bulk purchases from Malé
System scale	Small isolated microgrids, typically <1 MW capacity per island	Larger local systems relative to demand, often with backup redundancy
Governance	Regulated by the Utility Regulatory Authority (URA); national energy planning led by Ministry of Environment, Climate Change and Technology	Operated autonomously; regulated indirectly through environmental and business licensing

Appendix B. List of sources used for coding

#	Type	Title	Year	Geography	URL
1	Donor report	Accelerating Maldives' Transition to Renewable Energy (UNDP Joint Programme)	2024	Maldives	https://www.undp.org/maldives/projects/accelerating-maldives-transition-renewable-energy
2	Donor report	ADB News Release: Expand Renewable Energy in Maldives	2023	Maldives	https://www.adb.org/news/adb-approves-support-expand-renewable-energy-maldives
3	Donor report	ADB Partnership Report 2024: Empowering Maldives' Sustainable Energy Future	2024	Maldives	https://www.adb.org/multimedia/partnership-report2024/our-stories/empowering-maldives-a-sustainable-energy-future-for-everyone-through-renewable-innovations/
4	Donor report	AIIB: Solar Power Development and Energy Storage Project – Maldives	2021	Maldives	https://www.aiib.org/en/projects/details/2021/approved/Maldives-Solar-Power-Development-and-Energy-Storage.html
5	Academic / Technical / Review	An assessment of floating photovoltaic systems and energy storage	2024	Global	https://www.sciencedirect.com/science/article/pii/S2590123024001932
6	Private sector / Resort	Anhenunfushi Solar Roof Hybrid Installation	2023	Maldives	https://swimsol.com/solar-projects/anhenunfushi-maldives-solar-roof-swimsol/
7	Donor report	ASSURE – Main Report	2023	Maldives	https://www.environment.gov.mv/v2/wp-content/files/publications/20250422-pub-accelerating-sustainable-system-development-using-renewable-energy-project-main-report.pdf
8	Vendor / Global reference	Ciel & Terre Company Profile (2025)	2025	Global reference (Tech/Vendor)	https://ciel-et-terre.net/wp-content/uploads/2025/02/English_Company-profile_Ciel-et-Terre.pdf
9	Vendor / Global reference	Ciel & Terre Îlots Blandin Floating Solar Project (France)	2024	Global reference (Tech/Vendor)	https://ciel-et-terre.net/project_category/quarry-&-mining/
10	Academic / Technical study	Comparative assessment of offshore floating photovoltaic systems using thin-film and pontoon systems	2022	Global / Maldives	https://www.sciencedirect.com/science/article/pii/S2213138822005409
11	Academic / Technical study	Developing reliable floating solar systems on seas: A review	2025	Global	https://www.sciencedirect.com/science/article/pii/S0029801825002409
12	Governmental report	Energy Policy and Strategy 2024–2029	2024	Maldives	https://www.environment.gov.mv/v2/download/4182/

13	Private sector / Resort	Floating Solar Expands in Maldives (1 MW Swimsol Project)	2025	Maldives	https://www.offshore-energy.biz/floating-solar-expands-in-maldives-with-1-mw-swimsol-project/
14	Academic / Technical study	Implementing Sustainable Tourism Practices in Luxury Resorts of Maldives	2023	Maldives	https://arxiv.org/abs/2311.18453
15	Vendor / Global reference	List.Solar: Ciel & Terre 11 MW Project Announcement	2025	Global reference (Tech/Vendor)	https://list.solar/news/ciel-and-terre/
16	Governmental report	Maldives Energy Act (Law No. 18/2021)	2021	Maldives	https://policy.asiapacificenergy.org/node/4478
17	Governmental report	Maldives Gazette: Presidential Declaration on Renewables	2024	Maldives	https://storage.googleapis.com/gazette.gov.mv/docs/iulaan/200462.pdf
18	Policy / Investment plan	Maldives Investment Framework for Net Zero Clean 2023 (ARISE)	2023	Maldives	https://www.environment.gov.mv/v2/wp-content/files/publications/20230701-pub-maldives-investment-framework-for-net-zero-clean-2023-1.pdf
19	Policy / News release	Maldives Signs Investment Agreement for 100 MW Floating Solar	2025	Maldives	https://investmaldives.gov.mv/maldives-signs-landmark-investment-agreement-for-100mw-floating-solar-city-project-under-sez-framework/
20	Donor / Project document	Maldives: Accelerating Sustainable System Development Using Renewable Energy (project document)	2021	Maldives	https://www.adb.org/sites/default/files/project-documents/55191/55191-001-sddr-en.pdf
21	Academic / Technical / Review	Offshore floating photovoltaics system assessment in worldwide perspective	2023	Global	https://onlinelibrary.wiley.com/doi/pdf/10.1002/pip.3723
22	Donor / Policy / Technical report	Offshore Wind and Floating Solar PV – Support & Financing in SIDS	2021	SIDS / Global	https://islands.irena.org/-/media/sids/files/events/accelerating-the-development-of-offshore-wind/5-offshore-wind-and-floating-solar-pv-world-bank.pdf
23	Private sector / Resort	Patina Maldives USD 3M Solar Project	2024	Maldives	https://hoteliermaldives.com/patina-maldives-3m-swimsol-solar-panel-installation-heralds-new-dawn-for-perpetual-clean-energy/
24	Governmental report	Paving the Way for a Just Energy Transition in the Maldives	2024	Maldives	https://www.environment.gov.mv/v2/en/download/30059
25	Academic / Technical study	Powering an Island Energy System by Offshore Floating Technologies	2021	Regional (SIDS)	https://www.sciencedirect.com/science/article/pii/S0306261921016056

26	Donor report	Preparing Outer Islands for Sustainable Energy Development (POISED)	2019	Maldives	https://www.pacificclimatechange.net/sites/default/files/documents/maldives-deploying-hybrid-renewable-energy.pdf
27	Governmental report	Procurement Notice: Solar Program (Gazette)	2024	Maldives	https://storage.googleapis.com/gazette.gov.mv/docs/iulaan/237129.pdf
28	Vendor / Project plan	Project Solar City – Abraxas Power (100 MW Floating Solar City)	2024	Maldives	https://www.abraxaspower.com/projects/project-solar-city/
29	Donor report	Renewable Energy Roadmap: The Republic of Maldives (IRENA)	2015	Maldives	https://www.irena.org/-/media/Files/IRENA/Agency/Events/2015/Sep/17/Maldivesroadmapbackgroundreport.pdf
30	Academic / Technical / Review	Review of Recent Offshore Floating Photovoltaic Systems	2024	Global	https://www.mdpi.com/2077-1312/12/11/1942
31	Vendor / Global reference	RWE & SolarDuck Merganser Offshore FPV Pilot	2024	Global reference (Tech/Vendor)	https://www.rwe.com/-/media/RWE/documents/07-presse/rwe-offshore-wind-gmbh/2024/2024-07-04-solarduck-and-rwe-successfully-install-offshore-floating-solar-pilot-merganser.pdf
32	Academic / Technical study	Scaling Up Renewables in Maldives (REGlobal Report)	2024	Maldives	https://reglobal.org/scaling-up-renewables-in-maldives-report/
33	Vendor / Global reference	SolarDuck Official News: Merganser Offshore Pilot	2024	Global reference (Tech/Vendor)	https://solarduck.tech/solarduck-and-rwe-successfully-install-offshore-floating-solar-pilot-merganser-off-dutch-coast/
34	Vendor / Global reference	SolarDuck Prototype Certification Announcement	2024	Global reference (Tech/Vendor)	https://www.offshore-energy.biz/solarduck-wins-worlds-first-prototype-certification-for-floating-solar-technology/
35	Private sector / Resort	Swimsol SolarSea FPV – LUX* South Ari Atoll	2023	Maldives	https://swimsol.com/solar-projects/offshore-solar-panels-sea-maldives-lux/
36	Private sector / Resort	Swimsol SolarSea FPV – OZEN LIFE Maadhoo	2023	Maldives	https://swimsol.com/solar-projects/offshore-floating-solar-maldives-taj-resort/
37	Private sector / Resort	W Maldives RoofSolar System	2025	Maldives	https://swimsol.com/solar-projects/w-maldives-resort-roofsolar-swimsol/
38	Donor report	World Bank ASPIRE and ARISE Project Overview	2020	Maldives	https://documents1.worldbank.org/curated/en/099081824223038840/pdf/P172788-94e79dde-5dd2-463f-a6cb-ff74049ae9d7.pdf

Appendix C. Coding guideline

Code label	Definition	Anchor example	Coding rule	MLP level
Pilot/demonstration projects	Small, first-of-kind deployments used to prove technical/social fit	Interviewee 5: Policy clarity and local participation Right now, innovation depends on isolated pilot projects — one by a donor here, one …	Include pilot/demo/trial; exclude full national rollouts	Niche
Site suitability (lagoon/reef)	Physical conditions affecting FPV siting (depth, exposure, seabed, currents)	Interviewer: Have you ever heard of floating solar - installations which can be placed on the lagoon rather than on the rooftop?	Include depth/waves/reef/seabed; exclude generic aesthetics	Niche
Technical reliability (marine grade)	Hardware/design enabling durability (UV, corrosion, moorings, redundancy)	Pilot gathers knowledge on offshore installation and maintenance	Include cleaning/moorings/storm survival; exclude non-marine durability	Niche
O&M capability and local training	Availability/transfer of skills for routine O&M and troubleshooting	Interviewee 4: Not, but it is getting better. The domestic talent is good in operations, but the renewable maintenance technicians remain foreign …	Include training/manuals/response times	Niche
Hybrid integration (PV + diesel + storage)	Integration into island microgrids (load matching, genset dispatch, batteries)	Interviewee 5: Potentially, yes If excess power could be shared with nearby inhabited islands through mini-grids or battery exchanges, it would be …	Include capacity/load matching	Niche

Guest/consumer perception	Reactions of guests/locals to visible assets; 'green aesthetic'	Interviewee 1: We have our mini generator, which is linked to the island grid. The island runs on diesel. The boat comes …	Include aesthetics/education/ acceptance narratives	Niche
Environmental co-existence (micro-ecology)	Local ecological interactions (shading, seagrass/coral, marine fauna)	Interviewee 1: Yes, in case they recognize it as beneficial People are practical In case it provides cheaper power or employment, they …	Include EIA specifics; seagrass/coral notes	Niche
Permitting complexity / institutional fragmentation	Multi-agency approvals; unclear/overlapping standards for FPV	Interviewee 4: It is contingent upon the payback In case you can demonstrate a 5-7 year payback, we will take it into …	Include EIA/agency roles/case-by-case approvals	Regime
Policy clarity and stability	Presence/absence of explicit FPV policies/standards; predictability of rules	Policy 2024–2029 sets strategies to diversify energy mix and reduce diesel dependence	Include acts/strategies/policies notices	Regime
Financing instruments (PPA/capex/blended)	Mechanisms enabling adoption (direct capex, PPA, blended donor finance)	ADB approved a $505 million package to expand renewable energy in Maldives	Include paybacks/tariffs/guarantees/ risk allocation	Regime
Grid/legal isolation of islands	Legal/technical separation limiting power sharing/net-metering	Grid modernization to integrate variable renewable energy into island systems	Include interconnection limits	Regime
Institutional capacity & maintenance follow-through	Ability of agencies/utilities to maintain assets beyond pilots	Strengthening institutional environment and resource mobilization for energy projects	Include O&M budgets/spare parts/roles	Regime

Procurement and tendering practice	Public-sector tendering details shaping tech choices/timelines	Public-sector tendering details shaping tech choices/timelines	Include RfP specifications/evaluation/local content	Regime
Corporate strategy & KPIs (resorts)	Company-level goals (payback, brand, reporting) guiding adoption	Company-level goals (payback, brand, reporting) guiding adoption	Include payback/brand/reporting thresholds	Regime
Diesel dependence and price volatility	Exposure to imported fuel costs/logistics/outage risks	Interviewee 1: We have our mini generator, which is linked to the island grid. The island runs on diesel The boat comes …	Include price shocks/supply risk/logistics	Landscape
Climate impacts and reef stress	Heatwaves, bleaching, storms, sea level shaping choices	Heatwaves, bleaching, storms, sea level shaping choices	Include bleaching/storms/sea-level notes	Landscape
Donor influence and agendas	Roles of UNDP/ADB/AIIB/WB/IRENA in pipeline, standards, finance	Technical assistance to strengthen governance and enable blended finance for the transition	Include grants/loans/roadmaps/conditionalities	Landscape
Global FPV technology maturation	Falling costs, certification, offshore pilots, vendor learning	Offshore pilot tests structural, mooring and electrical designs ahead of scale-up	Include pilots/certifications/standards	Landscape
Social acceptance & trust-building	Participation, transparency, co-design with stakeholders	Resort-based FPV projects visibly demonstrate benefits to communities and guests	Include meetings/jobs/demos	Cross-cutting
Equity/benefit-sharing	Distribution of benefits (jobs, lower bills, skills, data)	Distribution of benefits (jobs, lower bills, skills, data)	Include tariffs/training/data-sharing	Cross-cutting

Communications & education	Visibility of actions and technical literacy efforts	Visibility of actions and technical literacy efforts	Include signage/workshops/visitor programs	Cross-cutting
Environmental safeguards & monitoring	EIAs, ecology checks, materials, incident reporting	EIAs, ecology checks, materials, incident reporting	Include baselines/thresholds/reporting cadence	Cross-cutting
Replicability & scaling logic	Conditions to scale from pilots to portfolios (standards, finance, SEZ)	Support for scaling island hybrid systems built under previous programs	Include standards/portfolio tenders	Cross-cutting
Maintenance burden & lifecycle costs	Cleaning, biofouling, spares, replacement cycles, TCO	Cleaning, biofouling, spares, replacement cycles, TCO	Include OPEX/warranties/performance guarantees	Cross-cutting

Appendix D. Interviews summary table

Interview ID	Interviewee	Affiliation / Sector	Date	Format	Duration	Consent Type
I1	Local island guest house manager	Resort/Private	18 July 2025	In-person (local island)	20 min	Verbal
I2	Local island shop worker	Private	20 July 2025	In-person (local island)	15 min	Verbal
I3	Local island diving centre owner	Private	20 July 2025	In-person (local island)	15 min	Verbal
I4	International private resort manager	Resort	23 July 2025	In-person (private island)	30 min	Verbal
I5	International private resort on-site marine biologist	Resort/Academia	24 July 2025	In-person (private island)	40 min	Verbal
I6	International private resort engineer	Technical	25 July 2025	In-person (private island)	30 min	Verbal
I7	International floating PV developer representative	Technical	15 October 2025	Online (via MS Teams)	45 min	Verbal

Appendix E. Interview transcripts

Interview I1

Interviewee 1: Local island guesthouse manager

Date: 18 July 2025

Location: Local island, Maldives

Format: In-person interview (20 minutes)

Duration (edited transcript): ~10 minutes (non-relevant parts omitted)

Context note:

The interview was held in the living room of a small family-owned guesthouse. The manager is a Maldivian male and is in his early 40s with more than a decade of experience in the business and is conversant with tourism as well as local energy realities. Topics such as life in the community, tourism dependency, local energy practices, knowledge about renewables, and perception of the potential implementation of floating solar technologies were discussed.

Interviewer: Thank you once again for taking the time to meet. What is the life of the island like, particularly on your side as a person who owns a guesthouse?

Interviewee 1: Life is easy, and you see, it is not easy. We depend a lot on tourism now. Before, everyone fished. My father was a fisherman. However, now the majority of the youth are employed in the tourism business - on the resorts, or in small guesthouses, airports. It carries with it some cash, yet all is too costly as well. Food, electricity, fuel – we have it all imported and it is not cheap.

Interviewer: What is your source of energy in the guesthouse?

Interviewee 1: We have our mini generator, which is linked to the island grid. The island runs on diesel. The boat comes once every few weeks with the fuel and when there is bad weather it may come later. Then we make an attempt to conserve energy, switch the air conditioning off, and request guests to wait. Some understand, some don't.

Interviewer: Reliability of electricity is a problem then?

Interviewee 1: Yes, particularly during monsoon season. There might be higher risks of power cuts. The machines are non-modern and repairs are slow. Diesel prices are also expensive and they continue to fluctuate. During the COVID when tourism was slow, it was extremely difficult. Even when we did not have any guests, we still had to pay the electricity bills – as we still needed to maintain the building.

Interviewer: What about renewable energy? Do the people on the island discuss solar or other solutions?

Interviewee 1: Yes, we hear about it. Our school has something I think, small solar panels on the roof. And, perhaps, the administration’s office too. But for us, it's expensive. You will have to purchase panels, batteries, inverters - we cannot afford that at once. No one gives loans for that. And there are times when people do not know whether it will last long with all the salt and wind.

Interviewer: Have you ever heard of floating solar - installations which can be placed on the lagoon rather than on the rooftop?

Interviewee 1: Floating? Oh, that's interesting. I had read about it on television, somewhere in Singapore or somewhere. But here the sea is by no means always smooth. When you put it in the lagoon, it must survive storms, salt and fishing or swimming people. You must select the appropriate location.

Interviewer: Do you believe that such a notion would be endorsed by people on the island?

Interviewee 1: Yes, in case they recognize it as beneficial. People are practical. In case it provides cheaper power or employment, they would like it. But they'll be afraid first. We admire the lagoon so much - that is our life. Then you need to make it clear, demonstrate that it does not hurt the reef or prevent fishing.

Interviewer: How do you feel the government or the councils contribute towards such projects?

Interviewee 1: On the local, especially small, islands we do not see much so far despite the government chattering about green energy. All this is determined in Male. The island councils lack budget and power to undertake big projects. Other times, donors arrive, complete a given project, and move on. It serves some months and then it is left unattended. That's the problem.

Interviewer: That is a significant fact. What would people put more trust in a project such as floating solar?

Interviewee 1: I believe it is local participation. In case the project employs local labour, trains, demonstrates. People believe what they see. One little system here and everyone will come and watch the panels floating and the lights on and it will go. Islanders speak to one another - that is how things are developed.

Interviewer: Demonstration and trust-building are the important ones?

Interviewee 1: Yes, exactly. Do not simply come and install something and leave. We've seen that many times. People feel used. Yet, in case the project remains, educates us, brings few things - even smaller bills or employment - then it will belong to us.

Interviewer: That is quite brilliant. And one final question: do you think the younger generation is more interested in sustainability or climate issues?

Interviewee 1: Yes and no, the young people are more educated, they have access to the internet, they are observing the way the world is becoming. They are aware of climate change, however, they desire good employment, consistent income as well. When renewable energy is included in that - not merely talking, but actual possibility - then they will be more concerned.

Interviewer: Thank you. That was really helpful.

Interviewee 1: You're welcome. I wish your project would add some light - literally! (laughs)

Interview I2

Interviewee 2: Local island shop worker

Date: 20 July 2025

Location: Local island, Maldives

Format: In-person interview (15 minutes)

Duration (edited transcript): ~12 minutes (non-relevant parts omitted)

Context note:

The interview was conducted in the shade by the side of a small local shop at the end of the afternoon when a few local residents on the island went in and out to get groceries. The interviewee is a middle-aged woman in her early thirties who assists in operating the family-owned shop and knows almost everyone on the island. She received higher education in Male, but came back to live with her parents and run the family business. The debate also covered the daily energy consumption, household expenses, attitude to renewable energy, and national anticipations by both governmental and personal efforts.

Interviewer: Oh, once again, thank you, for agreeing to talk to me. To begin with, can you tell me what life is like in this place, and particularly in relation to the usage of electricity and energy?

Interviewee 2: It is an expensive yet peaceful life here. We have nothing, except that which we get to eat, drink, or drive on. The generator provides us with electricity at all times, only that it is not cheap. You can hear it buzzing day and night. When it falls silent it becomes weird (laughs).

Interviewer: So what happens in the event of a power outage?

Interviewee 2: Depends on the length of time. In case it is just one hour, we simply wait. However, when it is more, the ice in the fridge melts, beverages become warm, and people are complaining. We must get rid of rotten stuff now and then - yogurt, milk. It's a waste. In the houses, individuals simply use candles or venture out. It is natural here, but it is not supposed to be so.

Interviewer: What is the frequency of that?

Interviewee 2: Once or twice a month, occasionally during the rainy season. The engine stops, or diesel fails to get in time. You see, when the sea is rough the supply boat cannot arrive in days. It is not the fault of anybody, that is the way things are on the islands. But it is costing us money in the process.

Interviewer: Are other forms of energy discussed here such as solar panels?

Interviewee 2: A bit, yes. There are those who came across them in Male or in schools. They believe it to be good - silent, dusted. But to purchase it is itself too high. You have to get all of those components, and then also someone needs to come and install it - it is not as simple as buying a fan. In the case of normal families, impossible. Maybe with government assistance.

Interviewer: Finance is the key obstacle then?

Interviewee 2: Yes, that and maintenance. We do not have people who understand how to repair those things. When it is broken you must wait till someone comes from another island, or from Male. It is time-consuming, and it makes people lose faith.

Interviewer: Have you heard of solar panels that are capable of floating on the sea?

Interviewee 2: Floating? At sea? No, it is new to me. That would sound pleasant, but how does it withstand storms? The sea here is strong. And what about the fish? We go round the lagoon a lot- swimming, boats. I believe that people would not only be interested, but also afraid that it could disturb something.

Interviewer: What do you believe can make people accept it more easily?

Interviewee 2: Oh, well... when it is proven that it is safe and we actually see that it is. Here people believe in what they see. Similarly, as long as there is another island that possesses it and it is working with them, then others will also begin demanding it. Better still, when it produces electricity at a lower cost, then that is great.

Interviewer: What about the government? Do you believe that they are doing enough to encourage renewable energy?

Interviewee 2: They discuss a lot. I read Facebook posts by the Ministry of Green Islands and all that. But we don't see much here. Perhaps a single project, and that is all. The council does not have funds to do big things. I believe that the government ought to support to a certain degree - not to everybody, but to initiate small projects.

Interviewer: Do the people here care much about climate change or the environment in general?

Interviewee 2: Yes, we all see it. The beach has become smaller and it floods during rain. According to the old folks, the sea was calm once, now it is varying. But we can't do much about it. People are caring but they must consider the day to day stuff - food, school, electricity bills. People will listen when something is beneficial to the planet and our wallets.

Interviewer: That is a very good observation. Therefore, what would you want to say to the people who desire to introduce new technologies such as floating solar to the islands?

Interviewee 2: Do not come and go, work with people. Hire locals, illustrate, demonstrate how it works. Don't make it too complicated. When it feels like it is part of us we will take care of it. Otherwise, it would be another failed initiative.

Interviewer: That makes total sense, thank you!

Interview I3

Interviewee 3: Local island diving centre owner

Date: 20 July 2025

Location: Local island, Maldives

Format: In-person interview (15 minutes)

Duration (edited transcript): ~7 minutes (non-relevant parts omitted)

Context note:

The interview was held by the beachside diving centre overlooking the lagoon. The interviewee is a middle-aged (around 35 years old) Maldivian man who owns diving and snorkelling tours for tourists and is highly interested in the health of the reefs and marine conservation in the area. The talk surrounded environmental awareness, the dependency on tourism, and the perception of renewable and floating solar projects.

Interviewer: Thank you for finding a minute to talk to me. Can you begin by telling me how your business is relying on what we have to offer in this environment?

Interviewee 3: Oh, all is on the sea. Without the water being clear, and the reef having been killed, we have no business. Tourists are here to dive not to hear diesel noises and swim in bad water. We have everything to do with the environment.

Interviewer: Are there any changes in the reef or the environment over the years?

Interviewee 3: Yes, big changes. The coral bleaching - that we had seen many times now. After 2016, it was really bad. The fish also moved away. It came back gradually, however, not as before. And the heat is worse. The visitors themselves sometimes say that the sea is too warm. (laughs)

Interviewer: Is climate change or renewable energy discussed by people on the island?

Interviewee 3: They do it, but rather, they discuss the changing of the weather. Everyone does not refer to climate change, but they are aware that something is happening. The thing is, we do not think that we can do anything. Everything comes from Male. Here, people just adapt.

Interviewer: How do you power your diving centre?

Interviewee 3: Diesel, just like all people. In our place, there is one generator, which we mostly use in the evening and in the morning. In the case of air tanks we shall require power of the compressor - heavy stuff. So the cost is high. As fuel price increases, we make less money.

Interviewer: Does it make you consider switching to solar energy?

Interviewee 3: Yes, of course. This will be great but it should be reliable. With divers coming regularly, we cannot risk power cuts, oxygen tanks, computers – we need energy daily. And solar batteries cost a lot. Those in some resorts, but with local islands it is more difficult.

Interviewer: What are the floating solar - panels in water, perhaps around the lagoon?

Interviewee 3: I have heard about it, there are some in the Maldives, right? It might be a good idea, but I would have been concerned over the lagoon. The reef is fragile - it may die in case of the block of sunlight or the current alternation. We have also boats arrival and departure, tourists swimming. Location would be very important. Perhaps in deeper places, not house reef.

Interviewer: That would be a major issue of environmental influence?

Interviewee 3: Yes, absolutely. I'm not against it. I believe that we should get new concepts - diesel does not last forever. However, when something kills the reef, then it is not worth it. We already lost too much. Perhaps begin with a single floating platform, experiment with it.

Interviewer: What might the community bring in such a project? What do you think?

Interviewee 3: Involve us. Those familiar with the sea ought to make the selection of a location. There are cases when foreign projects are brought in and locals are not consulted. Then they fail. Including the fishermen, divers, council - it will go better.

Interviewer: That is very informative. Any other points you would like to add?

Interviewee 3: That we all desire a more stable system which is cleaner. But we must save what we breathe life with -the ocean. It is good because renewable energy must co-exist with the reef and not fight.

Interview I4

Interviewee 4: International private resort manager

Date: 23 July 2025

Location: Private resort island, Maldives

Format: In-person interview (30 minutes)

Duration (edited transcript): ~20 minutes (non-relevant parts omitted)

Context note:

The interview took place in the office of administration of the resort. The interviewee is a European Male who is in his early 40s and has been in charge of the running of the resort as well as the sustainability strategy. The topics discussed were energy management, corporate sustainability, financial, and the possibility of floating solar PV to play a role in the operations of the resort.

Interviewer: Thank you, it is my pleasure today. Would you mind providing me with a general review of the management of energy at the resort?

Interviewee 4: Sure. We are off-grid like most other resorts in the Maldives and that means that we generate all our own power. This is diesel generators at the present, three of them in rotation. They're reliable, but costly. The second-largest expense after staff cost is fuel.

Interviewer: What do you think is your operational budget on energy?

Interviewee 4: It is approximately 15-18 percent, which varies with the season and the world oil prices. That's quite high. In 2022, our expenses increased by almost 30 percent, due to oil spiking that year-on-year. It is a huge revelation to an industry that is expected to be a low impact and environmentally friendly one.

Interviewer: Have you ever thought of renewable energy?

Interviewee 4: We have. As a matter of fact, the corporation head office has been urging us to have more renewables. Our small rooftop solar array is in place of approximately 80 kilowatts, primarily used as daytime base load. It however only serves a portion of total demand. The remainder is powered by diesel. The problem is availability of land. The island is small with space being one of the main factors in hospitality and aesthetics are important. You cannot simply nail down all the roofs, and say it is finished.

Interviewer: What of floating solar systems? Have you ever considered the possibility of that?

Interviewee 4: Yes, we have addressed it at corporate level. Suppliers have provided some feasibility studies. The concept is very sensible to the Maldives: there are no land restrictions, high radiance, and serene lagoons. However, we have issues, such as visual impression, perception of guests, and operation in a salty environment. Besides this, everything that is floating in the lagoon must be synchronized with the Ministry of Tourism and the Environment Authority hence the permitting can be very complex.

Interviewer: Is the regulatory environment a problem then?

Interviewee 4: Yes. Enthusiasm is high at the top level, but it is a disjointed process. An example is the Environment Ministry which encourages renewables and the Tourism ministry which limits installations that can be seen by the villas. So we end up in a grey area. Nobody would want to give something a go-ahead.

Interviewer: Interesting. What do you think might be your sustainability strategy of floating solar?

Interviewee 4: When it is properly done, it has the potential to be a game changer. Our type of resorts are in high demand on a daily basis where cooling, desalination, heating of water, etc. are needed and this is high, predictable demand, and this is done in the daytime when the sun works best. With batteries, floating PV would potentially save 20-30 percent, or potentially even more, of diesel consumption. It would enhance our marketing value and carbon reporting as well. These are issues that are sensitive to the guests.

Interviewer: You have referred to guest perception. Do you believe that visitors would be in a negative view of floating panels?

Interviewee 4: This is dependent on the way it is designed. I believe that it is all right when you set it close to the staff jetty or where it cannot be seen by the villas. But when it is in the centre of the lagoon, seen upon the beach, then it becomes an aesthetic problem. Sustainability and experience must balance to satisfy our guests who are paying to see a perfect view. That's always the challenge.

Interviewer: Do you believe you have sufficient technical capability in the area to support and run such systems?

Interviewee 4: Not, but it is getting better. The domestic talent is good in operations, but the renewable maintenance technicians remain foreign contractors. That makes it both more costly and less reliable. Training and local ownership means that any floating PV project can only be effective in the long run. Otherwise, it is simply another donor-funded project that ceases after several years to exist.

Interviewer: What of financing? Do resorts wish to spend money on such systems?

Interviewee 4: It is contingent upon the payback. In case you can demonstrate a 5-7 year payback, we will take it into consideration. However, it is hard over a longer period since the period of ownership contracts is shorter, between 25 and 30 years, and capital investments in infrastructure and renovations are in place. The idea of Power Purchase Agreements might be intriguing, although the regulation framework does not permit the independent producers to sell electricity just yet.

Interviewer: Do you believe that the government can have a role to play in that?

Interviewee 4: Definitely. A more definite policy on the investment in renewable energy by individuals would help in a greater manner. One of the examples may be the standardization of permitting or allow net metering between resort islands and surrounding inhabited islands by the government. At this moment, all is secluded, both technically and institutionally.

Interviewer: What is your overall forecast on the renewable adoption of the Maldives?

Interviewee 4: Hopeful yet reserved. The possibilities are gigantic, yet the implementation is slow. Everybody is desiring to be green yet when you consider the number of megawatts that are actually in place, it is still very small as compared to the potential. Island energy transition may become a demonstration of the Maldives, yet it requires coordination between ministries, investors, and the private sector.

Interviewer: Well, thank you, that was a comprehensive one.

Interview I5

Interviewee 5: On-site marine biologist, international private resort

Date: 24 July 2025

Location: Resort island, Maldives

Format: In-person interview (40 minutes)

Duration (edited transcript): ~30 minutes (non-relevant parts omitted)

Context note:

The interview was held at the marine biology office of the resort. The interviewee is a Female, an experienced marine scientist from Sri Lanka with work experience in the Maldives ranging several years and his duties include monitoring the marine, educating the guests, and communication with conservation NGOs and donor-sponsored sustainability initiatives. It discussed the topics of environmental governance, resilience of coral reefs, perceptions of renewable energy infrastructure (especially floating solar), and the extent to which sustainability is incorporated into the operations and policy systems of resorts.

Interviewer: I would like to thank you for agreeing to meet me. To begin with, what is your position here at the resort?

Interviewee 5: Of course. My role involves research, conservation, and education. My responsibilities include coral restoration program, lagoon health monitoring, and communication with local authorities, as well as NGOs. Another activity I engage in is giving talks to the guests on the topic of ecology and climate change in the Maldives. It is a combination of science and communication.

Interviewer: Please explain the present environmental situation of the island?

Interviewee 5: The reefs have been highly strained. Since 2016 we have observed recurrent bleaching since then. Certain recovery is occurring though it is uneven, the shallow reefs are more susceptible particularly around the resort infrastructure. The water nowadays reaches temperatures of more than 31degC several times per year and that is really worrying. On top of that sedimentation, anchoring, and the occasional problem of waste management, and it is a shaky system.

Interviewer: And what are the ways that energy systems fit into that environmental picture?

Interviewee 5: They are related in a variety of ways. Local warming is also an indirect result of the use of diesel due to the heat of the generators and leaks of oil. Whenever fuel is supplied, spills always have a minor possibility. In addition, there is diesel storage and noise pollution which impacts coastal fauna. The fact that small islands are interconnected means people usually view energy as a distinct thing, and ecology is another one.

Interviewer: Have you participated in the discussion regarding the renewable energy of the resort?

Interviewee 5: Yes, to some degree. The sustainability department is exploring how to cut down on emissions. There is already a small rooftop solar array, primarily symbolic. But there is a shortage of land,

and thus floating solar is brought up on several occasions. I believe it will be fruitful when it is done cautiously.

Interviewer: What do you mean by done carefully?

Interviewee 5: Well, the first one is site selection. Areas of various ecological importance are found in the lagoon - seagrass beds, coral bommies, fish nurseries. When such are shaded by some floating system, it may interfere with primary production or fish behaviour. However, the effect may be slight in where the sand is deeper and benthic life is sparse. Those zones should be mapped out with a proper environmental impact assessment carried out before installation.

Interviewer: In theory, therefore, it can be compatible with marine conservation when it is planned adequately?

Interviewee 5: Yes, absolutely. Indeed, it may even have incidental benefits, such as the fact that the shading will help cool the water in the area in case it is designed in small clusters. The materials matter, though. To prevent toxic antifouling paints, non-reflective surfaces, moorings will not drag over the seabed, all these are important design considerations.

Interviewer: What are the local laws, which deal with such issues?

Interviewee 5: That is where the problem is. The control of the environment in this case is dynamic, yet rather reactive. The Environment Protection Agency needs EIAs, but there is no capacity and no particular framework of floating solar yet. The evaluation of projects is done on a case-by-case basis, which is a slowing factor and creates uncertainty.

Interviewer: Do you believe that resort operators are truly encouraged to invest in cleaner energy or is it primarily image-related?

Interviewee 5: A bit of both, honestly. Sustainability has become a marketing tool, but that's not necessarily bad — it creates pressure to act. The real test is whether it goes beyond the "symbolic solar panel" phase. In my experience, resort management wants renewable energy, but they fear technical failure and visual disruption. The "green aesthetic" has to be invisible, which is paradoxical.

Interviewer: That's interesting. How do you see donors or international actors fitting into this picture?

Interviewee 5: Donors have been crucial in piloting renewables on inhabited islands, but less so in the resort sector, because resorts are private and profitable. However, there's a growing push for blended finance models — public–private partnerships where donors fund initial feasibility and monitoring, and resorts handle installation and maintenance. That could work well for floating PV if positioned as a demonstration with shared data.

Interviewer: Would local communities benefit from such resort-based projects?

Interviewee 5: Potentially, yes. If excess power could be shared with nearby inhabited islands through mini-grids or battery exchanges, it would be fantastic. But at the moment, there's no infrastructure or legal framework to allow that. Still, indirect benefits exist — capacity-building, local employment, and better awareness. The symbolic effect also matters: when a high-end resort adopts something innovative, it normalizes it socially.

Interviewer: How do guests usually respond to sustainability initiatives like coral restoration or energy efficiency measures?

Interviewee 5: They're generally very positive, especially European guests. Many are surprised to learn that the Maldives runs on diesel. When they hear about renewable options, they're supportive. Some even donate to our marine fund. I think visible actions — solar arrays, coral nurseries — create educational value. Floating solar could fit into that narrative, if communicated properly.

Interviewer: So communication and transparency are part of environmental acceptance?

Interviewee 5: Definitely. If guests or locals see new technology and understand its purpose, it builds trust. The opposite — secrecy or rushed implementation — breeds suspicion. The same goes for government projects. A floating solar platform can be a scientific opportunity, an educational tool, not just an energy source.

Interviewer: From a scientific perspective, do you see any long-term risks with floating solar deployment in lagoons?

Interviewee 5: Technically, the biggest risks are structural degradation and anchoring. If materials corrode or anchors fail, debris could damage reefs. But those are manageable with proper design and monitoring. Ecologically, the risk is shading if scaled up excessively. But again, if limited to small areas and paired with restoration projects, it could be balanced.

Interviewer: Finally, what do you think it would take for the Maldives to mainstream technologies like floating solar?

Interviewee 5: Policy clarity and local participation. Right now, innovation depends on isolated pilot projects — one by a donor here, one by a resort there. There's no system to learn collectively. If the government created a framework encouraging data sharing, technical standards, and training programs, adoption would accelerate. The Maldives could lead the way for small island states.

Interviewer: Thank you. That was incredibly valuable.

Interviewee 5: My pleasure. I hope your research helps move these ideas forward. Floating solar has real potential here — but like the reefs, it needs careful stewardship to thrive.

Interviewee 5: Both, to be honest. Sustainability has been a marketing instrument, which is not necessarily bad, it induces pressure to do something. The actually hard part is whether it is not just the symbolic solar panel stage. In my case the resort management has been desiring renewable energy but they are afraid of technical failure and visual disturbance. The green aesthetic must remain invisible, which is ironic.

Interviewer: That is interesting. What role do you view donor/international actors playing in this image?

Interviewee 5: The role of the donors has been critical in the pilot of the renewables in the inhabited islands and less in the resort sector, as the resorts are privately owned and profitable. There is however an increasing urge towards blended finance models - private-public partnerships in which the donors will finance preliminary feasibility and surveillance and the resorts will install and maintain these systems. That would be a good idea with floating PV when placed as a demonstration with common data.

Interviewer: Would such resort based projects be beneficial to the local communities?

Interviewee 5: Yes, possibly. It would be wonderful to be able to share excess power with other inhabited islands using mini-grids or exchanging batteries. However, there is no infrastructure and legal system to enable that at this time. Nevertheless, there are indirect benefits of the kind capacity-building, local employment, improved awareness. The symbolic impact is also important: once a luxurious resort resort chooses something new, it becomes normalized in society.

Interviewer: What has been the average reaction of guests to sustainability programs such as coral restoration or energy efficiency programs?

Interviewee 5: They are usually very good, particularly European customers. Most people are shocked to get to know that the Maldives is powered by diesel. When they are told about renewable alternatives they are supportive. Others are even making contributions to our marine fund. I believe that evident activities, such as solar arrays, coral nurseries, bring about educational value. That could be the case with floating solar, provided that it is communicated in a proper way.

Interviewer: Communication and transparency, is that included in environmental acceptance?

Interviewee 5: Definitely. When new technology is perceived and the purpose of the technology known by guests or locals, trust is established. The converse, which is secrecy or hasty action, is a source of suspicion. This is the same case with government projects. A floating solar platform has the potential to be a scientific discovery, a teaching aid, rather than an energy producer.

Interviewer: Under scientific view, do you regard any long-term risks in floating solar deployment in lagoons?

Interviewee 5: The largest risks are technically structural degradation and anchoring. In case of corrosion of materials or failure of anchors, debris would destroy reefs. However, these are controllable through adequate design and control. Shading is the risk that was generated ecologically in excess. However, once more, when it is restricted to small spaces and combined with the restoration projects, it might be balanced.

Interviewer: Lastly, what, do you feel, would it require the Maldives to mainstream technologies such as floating solar?

Interviewee 5: Participation and policy clarity at the local level. Innovation is currently at pilot projects, one by a donor in this country, one by a resort in that country. It has no system to study together. In case the government designed an infrastructure to promote data sharing, technical standards, and training, the adoption would be expedited. The Maldives would be a pioneer of other small island states.

Interviewer: Thank you. So that was very useful.

Interviewee 5: My pleasure. I wish your study will be a step in the right direction. Floating solar can work here, in a real sense, however, similar to the reefs, it requires careful management in order to prosper.

Interview I6

Interviewee 6: Resort engineer, international private resort

Date: 25 July 2025

Location: Resort island, Maldives

Format: In-person interview (30 minutes)

Duration (edited transcript): ~25 minutes (non-relevant parts omitted)

Context note:

The interview was to be taken in the lobby of the resort in the late afternoon. The interviewee is a senior, South-Asia based engineer, who has fifteen years of experience in the infrastructure of the island and is in charge of power generation and desalination and any technical operations. The resort is known to have sustainability programs such as rooftop solar, in-house glass bottling, and waste reduction programs although it has geographic and technical limitations of installing floating solar because of the lagoon depth and exposure.

Interviewer: Thank you very much for taking your time to talk to me. Could you begin by explaining your current energy configuration and its role in the sustainability strategy of the resort?

Interviewee 6: Sure. Our system is a hybrid system of diesel generators and rooftop solar. The cumulative solar installed capacity is approximately 180 kilowatts which is primarily on staff quarters and service buildings. It produces approximately 10-12 percent of our day to day electricity needs during sunny days. The remaining is provided by three diesel gensets 500 kilowatts each operating in rotation. We also are very progressive with regard to sustainability in general. The resort has done away with single-use plastics, we bottle our own water using glass, compostable waste bags using paper, and a waste separation system. The energy efficiency belongs to the same philosophy, however, it is always the technically most complicated part.

Interviewer: What is so difficult about energy as opposed to other sustainability measures?

Interviewee 6: Since energy is invisible and needed. You can never afford to be unreliable. Tourists will demand air-conditioning, desalinated water, flawless lighting - 24/7. Diesel provides that reliability though at a cost. The amount of litres that we burn is between 8,000 and 9,000 litres per day. That is our largest single outlay other than staff salaries. We can save a lot of litre each time we save it, yet it is not simple to transition to diesel altogether.

Interviewer: Have you thought of going green, such as floating solar?

Interviewee 6: Yes, we have researched on it. It is a really good idea in theory, but not here. The shore is too close to the lagoon, and too open farther. Towards the bottom, there is a good deal of coral rubble, which is not a good anchoring material. The swell comes in directly during monsoon, one-and-a-half metre waves are easily attained. Strong moorings would be required to hold panels together and this would add to the cost and ecological disturbance.

Interviewer: Then the geography of the region makes it hard to install floating systems?

Interviewee 6: Exactly. Floating solar is most effective in closed lagoons or artificial ponds, still but having a small amount of waves. That is not possible here as the open reef does. Even our boats travel not like that in monsoon; what would become of a floating building. In case it escapes, it might destroy corals or even wash to the jetty. It simply does not belong to this island.

Interviewer: What of considering it as a common project between the adjacent islands?

Interviewee 6: That would be theoretically possible - a bigger, centralized floating platform off a more peaceful atoll. However we would require transmission line or battery changes, which we have no system to support as yet. Every resort is a grid which is legally and physically isolated.

Interviewer: What other energy enhancements do you think are the most sensible to your resort?

Interviewee 6: Productivity and marginal optimization. We have also installed all lighting with LEDs, optimized our chiller plant, and we have variable speed drives on our pumps. This alone cut down the amount of energy by approximately 15 percent. Rooftop solar is also gradually growing - we are looking at lightweight panels on the staff accommodation and maintenance roofing. And we check the efficiency of generators every week so as to detect performance regressions.

Interviewer: What do these efforts do to the expectations of the guests or corporate sustainability objectives?

Interviewee 6: Very closely. Visitors can tell when we tell them that there are no plastic bottles or no plastic straws. The actions that can be seen are important. But energy is less visible. Therefore, we are attempting to make it clearer, e.g., displaying solar monitoring gauges at the checkin desk and describing our desalination and waste systems when the guests are on a tour. The HQ of the corporation monitors our carbon footprint and promotes renewable growth where feasible. The concept of floating solar would be perfect on paper, but the location is not suitable.

Interviewer: Do you think floating solar could still have a role in the Maldives more broadly?

Interviewee 6: Absolutely. Not every island is like ours. Some have deep, calm lagoons that are perfect for it. It could transform the sector if deployed in the right conditions. But for us, we'll focus on maximizing rooftops and efficiency first. Sometimes the sustainable choice is knowing where not to build.

Interviewer: That's an interesting way to put it. What about maintenance and workforce — do you rely on local technicians?

Interviewee 6: Yes, mostly local staff. Our maintenance team includes Maldivians trained on both electrical and mechanical systems. They can handle the solar array and daily operations. When it comes to specialized equipment like hybrid controllers or desalination systems, we get external engineers once or twice a year. But the goal is always to increase local capacity.

Interviewer: If conditions were different — say, if you had a suitable lagoon — would you see floating solar as technically reliable?

Interviewee 6: With the right design, yes. I've seen data from Singapore and Thailand. The efficiency gains are real, and hybrid integration is not that complex. The main concern is durability in marine environments — you need UV-resistant floats, corrosion-proof connections, and redundant anchoring. But it's doable. It just has to be customized for island realities.

Interviewer: Thank you, that was very insightful.

Interview I7

Interviewee 7: Representative, Swimsol (Austria)

Date: 15 October 2025

Location: Online (Zoom)

Format: Semi-structured technical interview (45 minutes)

Duration (edited transcript): ~30 minutes (non-relevant parts omitted)

Context note:

This interview was conducted through Zoom with one of the project development managers of Swimsol, an Austrian firm dealing with solar energy buoys to power the islands in the tropics. Swimsol has pioneered the SolarSea, which is the first commercial scale floating solar system to operate in marine environments and was developed by Swimsol and has been operational in the Maldives since 2014. It was discussed in relation to technological development of the company, the engineering changes to the conditions of the ocean, the financing, and the perspectives of the use of renewables in small islands in the long run.

Interviewer: Thank you for joining the call today! Not to take much of your time, maybe we straight away?

Interviewee 7: Sure, thank you for the invitation to talk, let’s start.

Interviewer: Perfect, could you please begin with a short introduction of Swimsol and its activities in the Maldives?

Interviewee 7: Of course. Swimsol was founded over a decade ago in Vienna and specialized in solar solutions at locations with a narrow area of land - particularly islands in the tropical areas. Our initial SolarSea prototype was in the year 2014 near Malé, and since that time we have installed most of the floating systems in the resort and industrial locations. We have a combined idea that involves rooftop solar on land systems and floating platforms on lagoons to open hybrid systems that are specific to the geography of the islands.

Interviewer: What is so significant about the Maldives market to you?

Interviewee 7: There is an ideal fit between need and potential. The Maldives relies nearly solely on imported diesel, timely and no longer economical logistically. Simultaneously, the solar irradiation and lagoon areas are quite good in the country. Therefore, it is not the resource itself that is a problem, it is that there is no space. And that is where floating solar comes in.

Interviewer: What is the difference between Swimsol technology and conventional inland floating?

Interviewee 7: That is the major difference. The majority of the floating PV systems are built for fresh waters in reservoirs - calm water, no waves, no salt. Our system is designed to be marine grade initially. The floats are constructed out of UV stabilized, salty resistant, polymers and the frames are made of aluminium and stainless steel and the whole structure of the construction is semi-flexible to move with the waves. Coulter moorings are used, not cast anchorages, thus the platform will not snap with the tides and swells.

Interviewer: What have the systems been doing so far in conditions of the Maldives?

Interviewee 7: Yes, taking into consideration the environment. We have a number of installations that have withstood monsoons. Performance data energy yield, mooring tension, 1/corrosion, etc. is continuously checked to improve the design. Among other things, one of the things that I have discovered is that a regular shelving, particularly cleaning, is necessary. Sea water and bird excreta lower production within a short period of time unless controlled. That is a big component of our strategy because we have trained domestically based technicians.

Interviewer: Local capacity-building is therefore part of your projects?

Interviewee 7: Always. We do not simply sell some system- we develop working expertise. Each installation has featured technical training of the staff of the resorts or islands. That is what will make it sustainable in the long run. We would wish the Maldivians to instigate and operate their own renewable facilities instead of having to employ foreign technical staff who come in every time something went awry.

Interviewer: Technically, what are the primary site selection criteria of floating solar of the Maldives?

Interviewee 7: Interviewee depth, exposure and seabed type. Preferably you must have a lagoon, which is enclosed by an external reef, with a depth of between two and six meters, sandy/muddy bottom on which it gets anchored and low current speed. Coral regions are not visited at all. There is no compromise over environmental compatibility. We always put our systems in place following some environmental checks and liaisons with marine biologists.

Interviewer: And where there is no floating solar such as shallow lagoons or exposed lagoons, is there an alternative you provide?

Interviewee 7: Yes, absolutely. Suitable lagoons are lacking in many islands. In such instances, we pay attention to making the most of the rooftop and integrating with the inverters that are highly efficient and intelligent hybrid control systems. Optimized rooftop installations can enable resorts to save 2030 percent of diesel even without floating arrays. Floating is also another possibility where it is a geographical possibility, rather than a substitute to other solutions.

Interviewer: Could we talk about financing? How are the systems financed normally?

Interviewee 7: We normally provide two of them: direct purchase (or turnkey) or long-term power purchase arrangements (PPAs). In the case of resorts, PPAs are an excellent option, since they do not require initial outlay and also because the tariff is lower than that of diesel generation. Swimsol retains the services and maintenance, thus guaranteeing performance of the system. Grants-loan hybrids are typical of projects under donors that were on inhabited islands. Aligning financial terms to the comparatively small system size is normally the challenge.

Interviewer: Have you been facing regulatory or administrative challenges in Maldives?

Interviewee 7: The allowing environment has been enhanced significantly, however, it remains disjointed. As an example, a project can be required to be approved by the Environment Ministry, the Tourism Ministry and in some cases by the island council. No one floating solar regulation exists. Every project is considered separately and this may delay things. With that said, the government has been accommodative and sensitization is increasing rapidly.

Interviewer: How do the resorts customarily view floating systems- as an asset, or rather a risk?

Interviewee 7: It is at first hesitating. The resorts are concerned about aesthetic appearance or technological breakdown. However, when they realize that it is functioning, quiet, no smell, no vibration, then the perception is transformed. It turns out that it is good marketing as many know. The sustainability story and the panels are questioned by guests and are valued by them. Floating solar will be very effective in terms of communication when properly incorporated within the resort setting.

Interviewer: Do you pay attention to environmental impacts, such as shading or marine life interactions?

Interviewee 7: Yes, over and over again. We have carried out research with marine biologists in which there is little ecological impact when they are placed in non-coral zones. In other instances, fish do have shelter on the platforms. Location, and scale are crucial, small modular arrays are much superior to huge single platforms. We shape them so that they fit into the lagoon like they do not obstruct navigation or even influence reefs.

Interviewer: What is the next step in terms of scaling the floating PV in the Maldives based on your experience?

Interviewee 7: The second step is replication. We have already demonstrated the technology is good — the next thing is to scale it through alliances. Demonstration projects assist in the creation of confidence; further development in the next phase needs concise support resources in the technical policies, funding tools, and uniformity in technical instructions. Should those get on point, then it is easy to get the Maldives to 50 MW of floating PV to 100 MW in a couple of years.

Interviewer: And globally? What do you think floating solar will be 10 years down the line?

Interviewee 7: It is growing at a very rapid rate. The expenses have fallen almost by 70 percent since 2016. Storage is now being attached to floating systems producing 24-hour hybrid microgrids. In the case of islands and other coastal countries, it is the next logical step. The Maldives can be the leader of the pack; not only in using it, but in being a center of expertise in marine solar technology.

Interviewer: Thank you. This was very educational.

Interviewee 7: My pleasure. It is always pleasant when academic studies refer to practical projects. Floating solar is not merely technology: it provides the islands with an opportunity of becoming energy-independent, without damaging the environment that makes them survive.

Appendix F. Coded passages

#	Source title	Source type	Year	Geography	Coded passage (copy verbatim)	Code label	MLP level
1	Accelerating Maldives' Transition to Renewable Energy (UNDP Joint Programme)	Donor report	2024	Maldives	Technical assistance to strengthen governance and enable blended finance for the transition	Donor influence and agendas	Landscape
2	Accelerating Maldives' Transition to Renewable Energy (UNDP Joint Programme)	Donor report	2024	Maldives	Strengthening institutional environment and resource mobilization for energy projects	Institutional capacity & maintenance follow-through	Regime
3	ADB News Release: Expand Renewable Energy in Maldives	Donor report	2023	Maldives	ADB approved a $505 million package to expand renewable energy in Maldives	Financing instruments (PPA/capex/blended)	Regime
4	ADB News Release: Expand Renewable Energy in Maldives	Donor report	2023	Maldives	Support for scaling island hybrid systems built under previous programs	Replicability & scaling logic	Cross-cutting
5	ADB Partnership Report 2024: Empowering Maldives' Sustainable Energy Future	Donor report	2024	Maldives	Partnerships enabled renewable investments and policy actions across atolls	Donor influence and agendas	Landscape
6	ADB Partnership Report 2024: Empowering Maldives' Sustainable Energy Future	Donor report	2024	Maldives	Lessons from earlier phases inform expansion to additional islands	Replicability & scaling logic	Cross-cutting

7	AIIB: Solar Power Development and Energy Storage Project – Maldives	Donor report	2021	Maldives	36 MW solar and ~50–106 MWh battery storage across multiple islands to modernize the grid	Hybrid integration (PV + diesel + storage)	Niche
8	AIIB: Solar Power Development and Energy Storage Project – Maldives	Donor report	2021	Maldives	Grid modernization to integrate variable renewable energy into island systems	Grid/legal isolation of islands	Regime
9	An assessment of floating photovoltaic systems and energy storage	Academic / Technical / Review	2024	Global	Coupling FPV with BESS smooths intermittency and supports microgrid stability	Hybrid integration (PV + diesel + storage)	Niche
10	An assessment of floating photovoltaic systems and energy storage	Academic / Technical / Review	2024	Global	Biofouling and soiling on floats/panels require scheduled cleaning	Maintenance burden & lifecycle costs	Cross-cutting
11	An assessment of floating photovoltaic systems and energy storage	Academic / Technical / Review	2024	Global	Design optimization targets corrosion, UV exposure, and mooring fatigue	Technical reliability (marine grade)	Niche
12	Anhenunfushi Solar Roof Hybrid Installation	Private sector / Resort	2023	Maldives	Resort adopts rooftop PV to cut diesel and meet sustainability targets	Corporate strategy & KPIs (resorts)	Regime
13	Anhenunfushi Solar Roof Hybrid Installation	Private sector / Resort	2023	Maldives	Visible solar assets reinforce the resort's sustainability narrative	Social acceptance & trust-building	Cross-cutting
14	ASSURE – Main Report	Donor report	2023	Maldives	Program includes O&M planning, training, and spare parts strategies	Institutional capacity & maintenance follow-through	Regime

15	ASSURE – Main Report	Donor report	2023	Maldives	Donor-supported program aligns with national planning objectives	Donor influence and agendas	Landscape
16	Ciel & Terre Company Profile (2025)	Vendor / Global reference	2025	Global reference (Tech/Vendor)	Portfolio shows multi-MW FPV across climates with standardized floats	Global FPV technology maturation	Landscape
17	Ciel & Terre Company Profile (2025)	Vendor / Global reference	2025	Global reference (Tech/Vendor)	Modular platforms and bankable references accelerate deployment	Replicability & scaling logic	Cross-cutting
18	Ciel & Terre Îlots Blandin Floating Solar Project (France)	Vendor / Global reference	2024	Global reference (Tech/Vendor)	Project placed on sheltered quarry water to minimize wave stress	Site suitability (lagoon/reef)	Niche
19	Ciel & Terre Îlots Blandin Floating Solar Project (France)	Vendor / Global reference	2024	Global reference (Tech/Vendor)	Project documents water quality and ecological monitoring baselines	Environmental safeguards & monitoring	Cross-cutting
20	Comparative assessment of offshore floating photovoltaic systems using thin-film and pontoon systems	Academic / Technical study	2022	Global / Maldives	Model considers wave height and wind loading for technology choice	Site suitability (lagoon/reef)	Niche
21	Comparative assessment of offshore floating photovoltaic systems using thin-film and pontoon systems	Academic / Technical study	2022	Global / Maldives	Pontoon structures show differing fatigue and survivability profiles	Technical reliability (marine grade)	Niche

22	Developing reliable floating solar systems on seas: A review	Academic / Technical study	2025	Global	Redundancy in mooring lines and anti-corrosion strategies are critical	Technical reliability (marine grade)	Niche
23	Developing reliable floating solar systems on seas: A review	Academic / Technical study	2025	Global	Guidelines call for baseline ecology surveys and post-install monitoring	Environmental safeguards & monitoring	Cross-cutting
24	Energy Policy and Strategy 2024–2029	Governmental report	2024	Maldives	Policy 2024–2029 sets strategies to diversify energy mix and reduce diesel dependence	Policy clarity and stability	Regime
25	Floating Solar Expands in Maldives (1 MW Swimsol Project)	Private sector / Resort	2025	Maldives	Swimsol completed a 1,037 kWp SolarSea floating system at Fari Campus	Pilot/demonstration projects	Niche
26	Floating Solar Expands in Maldives (1 MW Swimsol Project)	Private sector / Resort	2025	Maldives	Resort-based FPV projects visibly demonstrate benefits to communities and guests	Social acceptance & trust-building	Cross-cutting
27	Implementing Sustainable Tourism Practices in Luxury Resorts of Maldives	Academic / Technical study	2023	Maldives	Luxury resorts integrate solar to meet sustainability KPIs and guest expectations	Corporate strategy & KPIs (resorts)	Regime
28	Implementing Sustainable Tourism Practices in Luxury Resorts of Maldives	Academic / Technical study	2023	Maldives	Resorts communicate sustainability actions to guests via programming	Communications & education	Cross-cutting
29	Interview I1	Interview	2025	Maldives	Interviewee 1: We have our mini generator, which is linked to the island grid. The island runs on diesel. The boat comes once every few weeks with the	Diesel dependence and price volatility	Landscape

					fuel and when there is bad weather it may come later.		
30	Interview I1	Interview	2025	Maldives	Interviewee 1: Yes, particularly during monsoon season. There might be higher risks of power cuts. The machines are non-modern and repairs are slow. Diesel prices are also expensive and they continue to fluctuate.	Diesel dependence and price volatility	Landscape
31	Interview I1	Interview	2025	Maldives	Interviewee 1: But here the sea is by no means always smooth. When you put it in the lagoon, it must survive storms, salt and fishing or swimming people. You must select the appropriate location.	Site suitability (lagoon/reef)	Niche
32	Interview I2	Interview	2025	Maldives	Interviewee 2: Oh, well... when it is proven that it is safe and we actually see that it is. Here people believe in what they see.	Social acceptance & trust-building	Cross-cutting
33	Interview I2	Interview	2025	Maldives	Interviewee 2: Once or twice a month, occasionally during the rainy season. The engine stops, or diesel fails to get in time. You see, when the sea is rough the supply boat cannot arrive in days	Diesel dependence and price volatility	Landscape
34	Interview I3	Interview	2025	Maldives	Interviewee 3: Involve us. Those familiar with the sea ought to make the selection of a location. There are cases when foreign projects are brought in and locals are not consulted. Then they fail.	Social acceptance & trust-building	Cross-cutting
35	Interview I3	Interview	2025	Maldives	Interviewee 3: Yes, big changes. The coral bleaching - that we had seen many times now. After 2016, it was really bad. The fish also moved away.	Climate impacts and reef stress	Landscape

36	Interview I4	Interview	2025	Maldives	Interviewee 4: We have. As a matter of fact, the corporation head office has been urging us to have more renewables.	Corporate strategy & KPIs (resorts)	Regime
37	Interview I4	Interview	2025	Maldives	Interviewee 4: However, we have issues, such as visual impression, perception of guests, and operation in a salty environment.	Guest/consumer perception	Niche
38	Interview I4	Interview	2025	Maldives	Interviewee 4: It is contingent upon the payback. In case you can demonstrate a 5-7 year payback, we will take it into consideration.	Financing instruments (PPA/capex/blended)	Regime
39	Interview I5	Interview	2025	Maldives	Interviewee 5: Local warming is also an indirect result of the use of diesel due to the heat of the generators and leaks of oil.	Climate impacts and reef stress	Landscape
40	Interview I5	Interview	2025	Maldives	Interviewee 5: The sustainability department is exploring on how to cut down on emissions. There is already a small rooftop solar array, primarily symbolic.	Corporate strategy & KPIs (resorts)	Regime
41	Interview I5	Interview	2025	Maldives	Interviewee 5: Donors have been crucial in piloting renewables on inhabited islands, but less so in the resort sector, because resorts are private and profitable.	Donor influence and agendas	Landscape
42	Interview I5	Interview	2025	Maldives	Interviewee 5: However, there’s a growing push for blended finance models — public–private partnerships where donors fund initial feasibility and monitoring, and resorts handle installation and maintenance.	Financing instruments (PPA/capex/blended)	Regime

43	Interview I6	Interview	2025	Maldives	Interviewee 6: That would be theoretically possible - a bigger, centralized floating platform off a more peaceful atoll. However we would require transmission line or battery changes, which we have no system to support as yet.	Technical reliability (marine grade)	Niche
44	Interview I6	Interview	2025	Maldives	Interviewee 6: Our maintenance team includes Maldivians trained on both electrical and mechanical systems. They can handle the solar array and daily operations.	O&M capability and local training	Niche
45	Interview I6	Interview	2025	Maldives	Interviewee 6: The main concern is durability in marine environments — you need UV-resistant floats, corrosion-proof connections, and redundant anchoring. But it's doable. It just has to be customized for island realities.	Technical reliability (marine grade)	Niche
46	Interview I7	Interview	2025	Maldives	Interviewee 7: That is the major difference. The majority of the floating PV systems are built with fresh waters in reservoirs - calm water, no waves, no salt. Our system is designed to be marine grade initially.	Technical reliability (marine grade)	Niche
47	Interview I7	Interview	2025	Maldives	Interviewee 7: Always. We do not simply sell some system- we develop working expertise. Each installation has featured technical training of the staff of the resorts or islands.	O&M capability and local training	Niche
48	Interview I8	Interview	2025	Maldives	Interviewee 7: In the case of resorts, PPAs are an excellent option, since they do not require initial outlay and also because the tariff is lower than that of	Financing instruments (PPA/capex/blended)	Regime

					diesel generation. Swimsol retains the services and maintenance.		
49	Interview I7	Interview	2025	Maldives	Interviewee 7: It is growing at a very rapid rate. The expenses have fallen almost by 70 percent since 2016.	Replicability & scaling logic	Cross-cutting
50	Interview I8	Interview	2025	Maldives	Interviewee 7: Storage is now being attached to floating systems producing 24-hour hybrid microgrids.	Hybrid integration (PV + diesel + storage)	Niche
51	ListSolar: Ciel & Terre 11 MW Project Announcement	Vendor / Global reference	2025	Global reference (Tech/Vendor)	11 MW FPV announced, adding to global large-scale references	Global FPV technology maturation	Landscape
52	ListSolar: Ciel & Terre 11 MW Project Announcement	Vendor / Global reference	2025	Global reference (Tech/Vendor)	Supplier cites standardized design enabling rapid deployment	Replicability & scaling logic	Cross-cutting
53	Maldives Energy Act (Law No 18/2021)	Governmental report	2021	Maldives	Document provides guidance shaping renewable deployment pathways	Policy clarity and stability	Regime
54	Maldives Gazette: Presidential Declaration on Renewables	Governmental report	2024	Maldives	Presidential declaration commits to increase the share of renewables within five years	Policy clarity and stability	Regime
55	Maldives Investment Framework for Net Zero Clean 2023 (ARISE)	Policy / Investment plan	2023	Maldives	Outlines investment pathways and blended finance options for renewables	Financing instruments (PPA/capex/blended)	Regime

56	Maldives Investment Framework for Net Zero Clean 2023 (ARISE)	Policy / Investment plan	2023	Maldives	Framework targets pipeline scale-up via standardized procurement and risk tools	Replicability & scaling logic	Cross-cutting
57	Maldives Signs Investment Agreement for 100 MW Floating Solar	Policy / News release	2025	Maldives	SEZ framework used to anchor a 100 MW FPV 'Solar City' project	Replicability & scaling logic	Cross-cutting
58	Maldives Signs Investment Agreement for 100 MW Floating Solar	Policy / News release	2025	Maldives	Government-level agreement formalizes FPV expansion plan	Policy clarity and stability	Regime
59	Maldives: Accelerating Sustainable System Development Using Renewable Energy (project document)	Donor / Project document	2021	Maldives	Design integrates PV, BESS and control upgrades for island microgrids	Hybrid integration (PV + diesel + storage)	Niche
60	Maldives: Accelerating Sustainable System Development Using Renewable Energy (project document)	Donor / Project document	2021	Maldives	Project sets procurement packages and evaluation criteria for suppliers	Procurement and tendering practice	Regime
61	Offshore floating photovoltaics system assessment in worldwide perspective	Academic / Technical / Review	2023	Global	Comparative review catalogs offshore FPV concepts and deployments	Global FPV technology maturation	Landscape
62	Offshore floating photovoltaics system assessment in worldwide perspective	Academic / Technical / Review	2023	Global	Assesses mooring, survivability and materials under marine conditions	Technical reliability (marine grade)	Niche

63	Offshore Wind and Floating Solar PV – Support & Financing in SIDS	Donor / Policy / Technical report	2021	SIDS / Global	Development partners provide concessional finance and risk mitigation for SIDS FPV	Donor influence and agendas	Landscape
64	Offshore Wind and Floating Solar PV – Support & Financing in SIDS	Donor / Policy / Technical report	2021	SIDS / Global	Highlights guarantees and blended structures tailored to island utilities	Financing instruments (PPA/capex/blended)	Regime
65	Patina Maldives USD 3M Solar Project	Private sector / Resort	2024	Maldives	Resort invests to reduce diesel bills and enhance sustainability branding	Corporate strategy & KPIs (resorts)	Regime
66	Patina Maldives USD 3M Solar Project	Private sector / Resort	2024	Maldives	Project positioned as a guest-facing sustainability milestone	Communications & education	Cross-cutting
67	Paving the Way for a Just Energy Transition in the Maldives	Governmental report	2024	Maldives	Emphasizes equitable access, affordability, and job creation in the transition	Equity/benefit-sharing	Cross-cutting
68	Paving the Way for a Just Energy Transition in the Maldives	Governmental report	2024	Maldives	Calls for participation and transparent communication with communities	Social acceptance & trust-building	Cross-cutting
69	Powering an Island Energy System by Offshore Floating Technologies	Academic / Technical study	2021	Regional (SIDS)	Simulation indicates offshore FPV with storage can meet island load profiles	Hybrid integration (PV + diesel + storage)	Niche
70	Powering an Island Energy System by Offshore Floating Technologies	Academic / Technical study	2021	Regional (SIDS)	Model performance sensitive to wave climate and distance to shore	Site suitability (lagoon/reef)	Niche

71	Preparing Outer Islands for Sustainable Energy Development (POISED)	Donor report	2019	Maldives	Hybridization reduces diesel usage and transport exposure on outer islands	Diesel dependence and price volatility	Landscape
72	Preparing Outer Islands for Sustainable Energy Development (POISED)	Donor report	2019	Maldives	Program includes training local operators and standard O&M procedures	Institutional capacity & maintenance follow-through	Regime
73	Procurement Notice: Solar Program (Gazette)	Governmental report	2024	Maldives	Notice specifies eligibility, timelines, and evaluation criteria for solar suppliers	Procurement and tendering practice	Regime
74	Procurement Notice: Solar Program (Gazette)	Governmental report	2024	Maldives	Public notice operationalizes policy through procurement steps	Policy clarity and stability	Regime
75	Project Solar City – Abraxas Power (100 MW Floating Solar City)	Vendor / Project plan	2024	Maldives	Document outlines steps that support moving from pilots to programmatic deployment	Replicability & scaling logic	Cross-cutting
76	Renewable Energy Roadmap: The Republic of Maldives (IRENA)	Donor report	2015	Maldives	Roadmap highlights exposure to fuel imports and volatility risks	Diesel dependence and price volatility	Landscape
77	Renewable Energy Roadmap: The Republic of Maldives (IRENA)	Donor report	2015	Maldives	Early guidance for renewable pathways and islanded systems	Policy clarity and stability	Regime
78	Review of Recent Offshore Floating Photovoltaic Systems	Academic / Technical / Review	2024	Global	Catalog of recent pilots and design evolutions in offshore FPV	Global FPV technology maturation	Landscape

79	Review of Recent Offshore Floating Photovoltaic Systems	Academic / Technical / Review	2024	Global	Reviews EIA practices and mitigation strategies for marine settings	Environmental safeguards & monitoring	Cross-cutting
80	RWE & SolarDuck Merganser Offshore FPV Pilot	Vendor / Global reference	2024	Global reference (Tech/Vendor)	Offshore pilot tests structural, mooring and electrical designs ahead of scale-up	Global FPV technology maturation	Landscape
81	RWE & SolarDuck Merganser Offshore FPV Pilot	Vendor / Global reference	2024	Global reference (Tech/Vendor)	Pilot gathers knowledge on offshore installation and maintenance	Technical reliability (marine grade)	Niche
82	Scaling Up Renewables in Maldives (REGlobal Report)	Academic / Technical study	2024	Maldives	Document outlines measures that support programmatic deployment across islands	Replicability & scaling logic	Cross-cutting
83	SolarDuck Official News: Merganser Offshore Pilot	Vendor / Global reference	2024	Global reference (Tech/Vendor)	Pilot demonstrates modular triangular platforms for offshore survivability	Global FPV technology maturation	Landscape
84	SolarDuck Official News: Merganser Offshore Pilot	Vendor / Global reference	2024	Global reference (Tech/Vendor)	Engineering focuses on structural integrity and safe offshore operations	Technical reliability (marine grade)	Niche
85	SolarDuck Prototype Certification Announcement	Vendor / Global reference	2024	Global reference (Tech/Vendor)	World’s first prototype certification claimed for floating solar technology	Global FPV technology maturation	Landscape
86	SolarDuck Prototype Certification Announcement	Vendor / Global reference	2024	Global reference (Tech/Vendor)	Certification expected to accelerate commercial deployment pipelines	Replicability & scaling logic	Cross-cutting

87	Swimsol SolarSea FPV – LUX* South Ari Atoll	Private sector / Resort	2023	Maldives	Project is visible yet designed to minimize visual intrusion on key vistas	Guest/consumer perception	Niche
88	Swimsol SolarSea FPV – LUX* South Ari Atoll	Private sector / Resort	2023	Maldives	FPV complements rooftop PV and diesel in resort microgrid	Hybrid integration (PV + diesel + storage)	Niche
89	Swimsol SolarSea FPV – OZEN LIFE Maadhoo	Private sector / Resort	2023	Maldives	SolarSea array deployed near resort infrastructure for on-island use	Pilot/demonstration projects	Niche
90	Swimsol SolarSea FPV – OZEN LIFE Maadhoo	Private sector / Resort	2023	Maldives	Site selection avoids sensitive coral/seagrass and considers mooring impact	Environmental safeguards & monitoring	Cross-cutting
91	W Maldives RoofSolar System	Private sector / Resort	2025	Maldives	Rooftop PV adopted to cut diesel reliance and showcase sustainability	Corporate strategy & KPIs (resorts)	Regime
92	W Maldives RoofSolar System	Private sector / Resort	2025	Maldives	Resort publicizes solar output as part of guest sustainability messaging	Communications & education	Cross-cutting
93	World Bank ASPIRE and ARISE Project Overview	Donor report	2020	Maldives	PPP structures de-risk private investments in island solar programs	Financing instruments (PPA/capex/blended)	Regime
94	World Bank ASPIRE and ARISE Project Overview	Donor report	2020	Maldives	Framework enables replication of standardized projects across islands	Replicability & scaling logic	Cross-cutting