THE GOVERNMENT OF VANUATU

Technology Action Plan for Mitigation Technologies

July 2023

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USP
THE UNIVERSITY OF THE SOUTH PACIFIC

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PREFACE

Vanuatu prioritizes GHG emission reduction through renewable energy adoption, efficient transportation, and waste management. Limited resources pose challenges, but regional cooperation and targeted initiatives are crucial for sustainable development.

Vanuatu is committed to formulating strategies, national policies and best practices for addressing GHG emissions and making a practical contribution to the global mitigation efforts. While at the same time the country is also pursuing its national and regional development priorities and sustainable development objectives. This is planned to be achieved by integrating GHG abatement efforts with other social, environmental and economic priorities.

Energy is one of the crucial development indicators in any country and like the other Pacific Island Countries; Vanuatu's primary energy needs are mainly met by imported petroleum fuel. The majority of electricity is produced from Diesel (67%) followed by Copra oil (14.3%), Hydro Power (10.3%), Wind Power (8.1%) and Solar Power (0.2%). Vanuatu is exploring opportunities to further utilize the renewable energy sources such as hydro, solar, biomass, wind, and coconut bio-fuel and geothermal.

Transportation infrastructure development is one of the priority sectors for Vanuatu and with this view, the Government has initiated a long-term Vanuatu Transport Sector Support Program (VTSSP). Government of Vanuatu (GoV) is also focusing on mitigation options for emissions from land, sea and air transport sectors. Measures include public transportation awareness programme, vehicle emission standards, promoting fuel-efficient and alternative fuel vehicles, improving public transport services, introducing financial incentives to encourage energy efficiency and promoting non-motorized transport.

The GHG emissions from the agriculture and waste sectors make a significant contribution to GHG emissions from Vanuatu. However, the limited resources (financial and technical) pose a larger challenge in planning and implementation of GHG mitigation measures.

Vanuatu is an active participant in the Pacific island regional affairs and has signed on to a number of regional policies and initiatives that have implications for climate change mitigation.

However, specific measures are necessary in order to overcome barriers with introducing prioritized technologies in the energy and waste-to-energy sectors which can contribute to voluntary overall target goals to reduce 7% of greenhouse gas (GHG) emissions below 1990 level by 2020 and 15% reduction by 2025 compared with the 1992 GHG emissions level.

Implementation of pilot projects will reduce electricity shortages in the energy deficit regions, provide coverage of semi-peak loads, increase power quality, and reduce greenhouse gas emissions. In addition, during construction and operation, additional jobs will be created.

To conclude, the Ministry of Climate Change would like to thank all national officers and stakeholders from the line ministries, academia, NGOs and the private sector, as well as our partners from UNEP-CCC and the University of the South Pacific (USP) who led the execution of the TNA Project in Vanuatu and developed this crucial and enabling framework for progressing Vanuatu's climate change technology portfolio forward.

Ms. Esline Garaebiti
Director General
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The Government of the Republic of Vanuatu

ACKNOWLEDGEMENTS

The successful compilation of this report was attributed to divine wisdom from God, the everlasting Father, and the dedicated individuals involved in the process leading to its completion. Their assistance, support, and guidance were essential in enabling the TNA National Consultants to finalize and submit the TAP report. We would like to sincerely express our heartfelt appreciation to all these individuals.

We wish to thank the Director General to the Ministry of Climate Change, Mrs. Esline Garaebiti and the respective Directors for allowing the TNA National Consultants to participate in the Vanuatu Technology Needs Assessment Project. In addition, technical working group for mitigation that were nominated from the relevant line departments and the civil society. Your commitments and involvement have enabled us to complete the 3rd Phase of the TNA process.

Finally, we would like to express our sincere gratitude to the Global Environment Facility for funding this climate technology pathway for implementing the Paris Agreement and implemented by the UN Environment through the UNEP CCC Partnership.

LIST OF ACRONYMS

ADB	Asian Development Bank
ARTI	Appropriate Rural Technology Institute
BA&EF	Barrier Analysis & Enabling Framework
BEV	Battery Electric Vehicle
CBA	Cost Benefit Analysis
CBD	Compact Biogas Digester
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CTCN	Climate Technology Centre and Network
DoE	Department of Energy
EE	Energy Efficiency
ESCO	Energy Services Company
EWS	Efficient Wood Stove
GCF	Global Climate Facility
GGGI	Global Green Growth Institute
GHG	Greenhouse Gas
GIZ	German Agency for International Cooperation
GoV	Government of Vanuatu
HEV	Hybrid Electric Vehicle
IPP	Independent Power Producer
JICA	Japan International Corporation Agency
MBBD	Manure Based Biogas Digester
MCA	Multi criteria analysis
MoCC	Ministry of Climate Change
MoFEM	Ministry of Finance and Economic Management
MSW	Municipal Solid Waste
NAB	National Advisory Board
NC	National Communication

LIST OF ACRONYMS

NCCC	National Climate Change Committee
NDC	National Determine Contribution
NE	Not Estimated
NEDC	New European Driving Cycle
NERM	National Energy Road Map
NGEF	National Green Energy Fund
NGO	Non-Governmental Organization
NO_x	Nitrogen Peroxide
N_2O	Nitrous Oxide
NSDP	National Sustainable Development Plan
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PRISM	Promotional of Regional Initiative Solid Waste Management
R&D	Research and Development
RDF	Refuse Derive Fuel
SDG	Sustainable Development Goal
SNC	Second National Communication
TAP	Technical Action Plan
TNA	Technical Needs Assessment
TNC	Third National Communication
UDP	UNEP-DTU Partnership
UN	United Nation
UNDP	United Nations Development Programme
UNELCO	Union Electrique du Vanuatu Limited
UNEPCCC	United Nation Environmental Programme Copenhagen Climate Centre
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nation Industrial Development Organization
URA	Utilities Regulatory Authority
VAT	Value Added Tax
VCCDRRP	Vanuatu Climate Change Disaster Risk Reduction Plan
WB	World Bank

Physical Units

1 Gg = 1,000,000 g

1 Gg = 1,000 metric tonnes (mt)

1 kW = 1,000 W

1 MW = 1,000 Kw

1 GW = 1,000 MW

EXECUTIVE SUMMARY

This Report, the Technology Action Plan (TAP) Report, is the third and final report of the activities on which Vanuatu embarked under the Technology Needs Assessment (TNA) Project. The purpose of this TAP Report is to document the actions and activities needed in response to the outcomes of a systematic and long process of assessing the obstacles and limitations that are hindering the widespread diffusion and deployment of climate change technologies in Vanuatu. Such actions are presented in order to translate the measures (incentives) needed to overcome the barriers that have been identified. They are being put forward as ways of removing the obstacles that are hindering the enabling frameworks in maximizing and enhancing the dissemination of such technologies effectively and steadily in the long path to dealing with climate change in Vanuatu. The TAPs presented provide a comprehensive description of the action plans for mitigation and adaptation technologies, partly based on condensed and edited content from Report no. II, the Barrier Analysis and Enabling Framework (BA&EF) Report. It is expected that the audience (target group) for this report will consist of national policy-makers and stakeholders and national and international donor institutions, as well as investors and other individuals and groups interested in climate change issues.

This TAP Report is supplemented by specific project ideas, submitted in separate chapters after each TAP, outlining concrete actions that can contribute to meeting the identified ambitions identified in relation to the TAP.

A quick summary of main actions proposed in each sector and the prioritized technologies are provided below.

Energy Sector:

The TAP was proposed for the two priority technologies of Efficient Wood Stove and Battery Electric Vehicles in the energy sector. The main actions proposed are:

i. Remove/minimize financial and economic barriers;

ii. Strengthened institutional arrangements and cooperation between stakeholders;

iii. Effective awareness programs and;

iv. Establish Renewable Energy (RE) charging stations for our outer island and the urban centers.

Based on the barriers and measures analyzed, the TAP for the energy sector has been designed for mitigation of GHGs particularly. Thus, several activities have been articulated for the main actions listed above. To achieve the Energy Sector TAP's results and main goal, it is proposed to implement some projects in which the tied activities will be considered as a way of turning ideas into realities. As a result, the following three main project ideas are suggested:

i. Introduce duty exemption for imported stove materials and the BEVs

ii. Design financial support mechanisms and subsidies for the purchase of Efficient Wood Stove and BEVs and;

iii. Review and amend relevant policies to strengthened Efficient Wood Stove and BEV measures

Waste-to-Energy Sector

i. The TAP was also proposed for the two priority technologies of the Manure Based Biogas Digester and Compact Biogas Digester. The main actions proposed are:

ii. Set regulations that incentivize users and potential users of the biogas digesters;

iii. Create soft loans for the user's access from the National Green Energy Fund;

iv. Organize a capacity-building program for the users and operators;

v. Promoting and providing incentives to produce and assemble biogas digester units locally; and

vi. Organize a wide awareness campaign to incentivize users and potential users of biogas digesters.

Among the project ideas proposed in the Waste-to-Energy sector are:

i. Develop concept note and proposals to seek financial support;

ii. Conduct R&D for the technologies and;

iii. Implementation of pilot projects to demonstrate the advantages of the technology

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01 INTRODUCTION

1.1 SUMMARY OF OUTCOMES FROM THE TNA REPORT (REPORT I OF PHASE I OF THE TNA PROJECT IN VANUATU) AND BA&EF REPORT (REPORT II OF THE TNA PROJECT IN VANUATU)

The Technology Needs Assessment (TNA) process originated in the Poznan Strategic Programme on Technology Transfer established at the Fourteenth Conference of the Parties (COP 14) to the United Nations Framework Convention on Climate Change (UNFCCC). This had the aim of scaling up investment in technology transfer to enable developing countries to address their needs for environmentally sound technologies. The TNA can be defined as a set of country-driven, participatory activities leading to the identification, selection and implementation of environmentally sound technologies to decrease CO_2 emissions (mitigation) and/or decrease vulnerability to climate change (adaptation). Thus, as a country-driven process, it should not be conducted in isolation but rather integrated with other similar ongoing processes that aim to support national sustainable development.

The first report produced from the activities of the Climate Change Technology Needs Assessment (TNA) Project in Vanuatu, which is being implemented through the UNEP-DTU Partnership (UDP), was submitted to Vanuatu's Ministry of Climate Change and Adaptation (MCCA) in July 2020. The TNA activity was systematically conducted through a country-driven process involving all relevant stakeholders taking national sustainable development priorities into consideration. The national stakeholders were involved in the first phase of the TNA Project through two rounds of consultation. In the first round, the launch of the TNA project in Vanuatu took place on 17 November 2018, where the assignment's approach and work plan were presented and discussed to obtain feedback from stakeholders, brainstorm perspectives and identify relevant pools of stakeholder groups to be involved in the activities and discussions of the project. In this workshop, three exercises were conducted involving all attendees. The first exercise was conducted to enable selection of priority mitigation and adaptation sectors for TNA activities in Vanuatu, based on some dedicated multi-criteria analysis (MCA) exercise tailored deliberately for this purpose by the TNA Team in Vanuatu. This MCA exercise, which was aimed at determining the priority sectors, was conducted in addition to the systematic MCA exercise that UDP had proposed for selecting priority technologies. The two MCA exercises revealed that the top two priority mitigation sectors for carrying out climate change technology needs assessments in Vanuatu are Energy and Waste-to-Energy, while the top two priority adaptation sectors were Water and Agriculture. This conclusion was not unexpected in light of the status of the energy and waste-to-energy sectors as the two largest emitters of GHGs in the country and their critical implications with regard to sustainable development (TNC, 2020). The same conclusion is valid for the water and agriculture sectors, as they are the two sectors that are most vulnerable to climate change in Vanuatu, as shown in the extensive assessments conducted in some national studies, mainly the TNC study (TNC, 2020).

In round two of the process of involving stakeholders in phase I of the project in Vanuatu, Mitigation and Adaptation Technical Working Groups were invited to a two-day workshop to discuss and prioritize an initial list of technologies for each priority sector based on the set criteria for each sector. Results of the four MCA exercises revealed the following top two technologies as priorities out of the long initial rosters of assessed technologies in each targeted sector. The top two mitigation technologies for the energy sector were (1) Efficient Wood Stove (EWS), and (2) Battery Electric Vehicles (BEV). The two top ranked priority technologies for the waste-to-energy sector were (1) Manure Based Biogas Digester

(MBBD), and (2) Compact Biogas Digester (CBD). The final results for the water sector's top three priority adaptation technologies were (1) Roof-top Rainwater Harvesting, (2) water safety plans and (3) Flood Hazard Mapping. Finally, the results for the agriculture sector's top three priority adaptation technologies were (1) Crop diversification and new varieties, (2) Agro-forestry, and (3) Farmer field schools.

For detailed results and outcomes of the first phase (TNA Report) of the TNA Project of Vanuatu, the reader may refer to the TNA Report for Vanuatu published on the TNA Project's Hub at: http://www.tech-action.org/participating-countries

Having obtained the above results from the first phase of the TNA Project in Vanuatu, the Project Team and national stakeholders involved in the first phase, along with the existing stakeholders from the activities of that phase, proceeded to the second phase, that of the barrier analysis and enabling framework (BA&EF phase). The second phase aimed at assessing the obstacles and limitations hindering the wide dissemination and deployment of such technologies in order to identify the measures (incentives) needed to overcome these limitations and barriers and also to outline the enabling frameworks to maximize and enhance the dissemination of these technologies effectively and systematically to deal with climate change in Vanuatu. The BA&EF Report documented the results of a systematic barrier analysis assessment for each priority technology and explored options (incentives or measures) for addressing the barriers. In addition, the process entailed diagnosing the optimal enabling framework for each technology, at the sector level. In the BA&EF Report, the barriers and enabling measures were thoroughly identified for each priority technology within each priority sector using a systematic process supported by tools selected from the literature and best industry practices for these types of assessment. The procedure was set so that the preliminary targets for each sector were first determined, before both the financial and non-financial barriers were diagnosed. Then measures and incentives to overcome these barriers were introduced accordingly, the preliminary targets being revisited and refined based on the results of the barrier analysis and the elaboration of an enabling framework.

In the BA&EF phase, the barrier analysis of the proposed technologies was conducted based initially on an extensive desk study and literature review. Then, deep analyses of policy papers and relevant studies were conducted to identify the primary reasons why each of the two top priority technologies in each selected priority sector is not currently in widespread use and why neither the private nor public sectors have invested significantly in it. In particular, economic assessments (economic and financial barriers) of the selected technologies were included in the desk study, as were other relevant assessments, for example, of the environmental and social impacts, as well as institutional capacity assessments. The summaries of the proper financial and other assessments of the selected technologies, which were made available by each sector's consultant before conducting the barrier identification process, were also of great value in decomposing the barriers. As an example, feasibility analyses illustrated the cost of capital, showing in particular why the cost might be considered too high for the public or potential investors. Thus decomposing the barrier's 'cost of capital' into its barrier elements and further into their dimensions was deduced from the feasibility summaries prepared by the consultants. Two specific tools proved useful in assisting the analysis of the decomposition of barriers: root cause analysis and logical problem analysis or LPA After conducting the barrier analyses, measures or incentives (solutions) were identified for each barrier (economic and financial measures and non-financial measures). All the described steps were aided by conducting dedicated stakeholder participation and engagement meetings in the format of focus group discussions and results-oriented group exercises. The representatives of stakeholders that were to be invited to the BA&EF consultation workshop were similar to those involved in the first TNA workshop. The main action was to identify relevant active stakeholders for the particular technology under assessment so that they could cover all aspects of the technology being evaluated. These representative stakeholders were from companies involved in the market and supply chain, key players from policy making and government, research, innovation and technology development (incubator) institutions, regulatory and governance parties, representatives of NGOs and farmers, water users associations, and competent and well-known economists in each particular sector. Parallel to this brainstorming process and preparation of the workshop's materials, it was decided that a two-day workshop involving consultations with stakeholders would provide the greatest benefit and added value feedback from participants. Thus, a focused three-day workshop was held in the Melanesian Hotel, Port Vila from 01-03 February 2021. A total of 10 stakeholders attended the workshop, representing all the stakeholder categories mentioned above.

A cost benefit analysis (CBA) of the transfer and diffusion of selected consumer technologies was also conducted prior to and during the workshop, and input and outputs values as well as sensitivity analyses of the model were also discussed, supported by feedback from distinguished economists involved in the sector who highlighted the aspects and implications of the estimates. However, the economic experts stressed that the UDP models being used were basic ones and that more in-depth CBA estimates using advanced models might be needed at the project's full proposal preparation phase to provide better estimates of the real costs and benefits of particular technologies.

1.2 OVERVIEW OF THIS REPORT

This current report is the third and final report from the Vanuatu TNA project. Its aim is to document the actions and activities needed in response to the outcomes of the systematic and extensive consultative process of assessing the barriers hindering the wide diffusion and deployment of the priority technologies. The set of actions being proposed are presented plainly in order to promote the measures (incentives) required to overcome the barriers that have been identified as hindering the deployment of proper enabling frameworks to maximize and enhance the dissemination of such technologies effectively and systematically along the long road to dealing with climate change in Vanuatu. The TAPs presented in this report provide a comprehensive description of the action plans for mitigation technologies, partly based on condensed and edited content from Report no. II, the BA&EF Report. The audience (target group) for this consists of is national policy-makers, national stakeholders and national and international donor institutions, as well as investors and other individuals and groups interested in climate change.

This TAP Report is supplemented by specific ideas for projects, submitted in separate chapters after each sector's TAP and outlining concrete actions that can contribute to meeting the identified aims of the TAP. It is expected that activists, stakeholders, and practitioners directly and indirectly involved in climate change and sustainable development will adopt and buy into the outcomes of this report, spontaneously embarking on proposal development and partnership identification activities by teaming up with each other to articulate concept notes and to approach potential donors and climate change funds in order to secure the funding needed to support a project of interest to their organizations.

02 TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR ENERGY SECTOR

2.1 TAP FOR ENERGY SECTOR

2.1.1 ENERGY SECTOR OVERVIEW

Vanuatu has a population of around 300,019 (Vanuatu National Statistics Office, 2021), which is geographically dispersed over more than 80 islands. Around 75.6% of the population reside in the rural areas and economic development is largely focused within the urban zones. Access to electricity nationwide is low (33%), however drops even further in rural areas. Low access to reliable, affordable electricity has negative impact on the livelihoods of households, particularly rural households. Where electricity is available in the provinces, it is largely diesel generated. Cost of electricity is high; however, quality of supply is high which is partially due to the electricity grids being operated by the private sector. High cost and limited access to electricity is having a negative impact on economic development, particularly in the provinces. Over-reliance on imported fossil fuels (diesel) also has a negative macro-economic impact.

Electricity is generated and supplied in Vanuatu under two separate private sector contracts and two government owned contracts, which operate standalone island grids. These consist of one concession in Efate (Port Vila) held by UNELCO EDF Suez (UNELCO) and one memorandum of agreement in Espiritu Santo (Luganville) held by Vanuatu Utilities and Infrastructure Limited (VUI) and the Tanna and Malekula concession operated and managed by the Government of Vanuatu through the Department of Energy.

The Utilities Regulatory Authority (URA) monitors the contract and sets tariffs under the Luganville agreement, while tariffs are set contractually for the other concessions. Outside the concession areas, provision of power services is relatively limited and is provided under a range of delivery schemes installed under various government and donor projects. While the cost of electricity under the concession is relatively high, the quality of supply is high compared to Pacific utility benchmark data (PPA, 2020). Power generation is predominantly diesel with some contribution from wind (Devils Point Wind Farm, Efate, approximately 3MW), and hydropower from the Sarakata Hydropower Plant (3x300kW units) on the Luganville grid.

Vanuatu does not have indigenous sources of fossil fuels, and the importation of diesel for power generation has a high cost to the economy. However, there are significant indigenous resources which are being increasingly utilized. Vanuatu has considerable technical potential for hydropower generation; however it is generally located near smaller urban areas, and there is limited scope for the main island of Efate. The Sarataka hydropower scheme provides power to the Luganville concession. A number of technically viable rural hydropower sites have been assessed, however there are significant barriers associated with

i. lack of long-term monitoring data to support feasibility analysis,

ii. intermittent nature of supply,

iii. high capital costs,

iv. absence of a sustainable institutional model for operation and maintenance, and

v. land access issues.

Progress on rural hydropower has been slow to date.

There are a number of potential geothermal sites which have been identified, including sites adjacent to Port Vila. However, due to high exploration and capital costs, these sites have not proceeded. UNELCO has constructed a 3MW wind farm at Devils Point, which is connected to the Port Vila grid, and wind monitoring is being undertaken for a second wind farm near Port Vila. Biomass is used as an energy source by a large percentage of the rural population for household cooking. Coconut oil is being used as a biofuel replacement for diesel generation for small power grids such as Port Olry, and up scaling is underway with European Union assistance. UNELCO is using a diesel coconut oil blend for power generation in Port Vila. Household solar power systems have been trailed extensively for schools and health facilities, however issues with high cost and maintenance have prevented widespread up scaling. The most promising future prospects for renewable energy include:

i. use of biofuel for power generation,

ii. development of small hydropower for provincial urban loads, and

iii. development of grid connected renewable energy (solar, wind, geothermal) for the major load of Port Vila, Efate.

The key challenges for the power sector include:

i. developing alternative power supplies to reduce the impact to the economy from diesel importation,

ii. increasing access to electricity, particularly in off-grid areas,

iii. delivering sustainable operation and maintenance models for rural electrification projects, and

iv. coordination of donor activities in the power sector.

Access to electricity is low. While the national electricity access rate is 33% of households, there is wide variation, from 82% access in urban areas to 17% access in rural areas. Of the 33% households who have access, 64% are connected to the grid, while the remainder rely on solar systems or diesel generators. Household access to grid-connected electricity is 21.5% in Espiritu Santo and 8.2% in Malekula. The main reasons for the low access rates are:

i. lack of government community service obligation funding for grid extensions,

ii. difficult geography and small, dispersed pockets of population,

iii. low capacity to pay in some areas, and

iv. the high cost of diesel power generation in the provincial centers due to difficult supply chains and small size of grids, which provides a disincentive to increase customers (where generation and supply costs exceed the tariff) particularly given the low lifeline tariff. Significant unmet demand means that people resort to self-generation but would connect to the grid if sufficient capacity were available. The limited reach of the distribution grid is slowing economic growth, particularly in the agriculture and tourism sectors. There is significant opportunity to increase the access rate through extensions of the existing distribution grid to peri-urban areas and establishing sustainable household solar system rollout models.

Provision of modern electricity services to communities through distribution extensions (as opposed to household based solar systems) has been demonstrated to support economic growth, particularly where supporting existing infrastructure is in place, such as:

i. access roads to markets,

ii. communication systems, and

iii. agricultural produce suitable for value adding.

Social benefits of grid extensions include:

i. replacing kerosene lighting with a cheaper form of energy, thereby freeing household expenditure,

ii. enabling household income generation,

iii. improving children's education, and

iv. reducing indoor health and safety issues associated with burning kerosene.

Over-reliance on imported diesel for power generation has a negative macro-economic impact. The cost of petroleum product imports typically exceeds 17% of total imports and 85% of the total value of Vanuatu's exports. On a macro-economic level, increasing renewable energy in the national energy mix will

i. improve balance of trade by reducing fossil fuel imports

ii. improve energy security, and

iii. reduce greenhouse gas emissions which contribute to global warming.

Electricity tariffs are high which is impeding economic growth. Over-reliance on diesel power generation has placed upward pressure on electricity tariffs. Diesel power generation is more expensive than renewable energy options such as hydropower. Renewable energy generation will benefit the economy by

i. placing downward pressure on tariffs,

ii. minimizing tariff volatility by partially converting the national grid to renewable energy,

iii. supporting growth of the private sector, and

iv. reducing household expenditure on electricity.

Governance of the sector policy is through the Department of Energy (DOE) within the Ministry of Climate Change, Adaptation, Meteorology & Geo-hazards, Energy, Environment and Natural Disaster Management (MOCC). Vanuatu is unique amongst ADB Pacific Island Member Countries (PIC's) as electricity is generated and supplied by mostly the private sector.

In collaboration with the World Bank, Global Green Growth Institute (GGGI) provided technical assistance to the Department of Energy for the revision of the National Energy Road Map (NERM), which identified five strategic areas for policy intervention in the energy sector: accessible energy, affordable energy, secure and reliable energy, sustainable energy, and green growth. In addition, a financing gap of at least $20 million was identified to achieve national energy targets.

The National Green Energy Fund (NGEF) is set up to facilitate capital investment opportunities to improve energy access. . The objective of the NGEF is to improve electricity access through renewable energy and to enhance energy efficiency throughout the country, in particular for rural households and business. The NGEF is part of the revised NERM and will be used as a tool to implement the objectives of the NERM to achieve 100% rural electrification and promote business and income generating activities in the rural areas through use of renewable energy. In addition, the DOE has prepared a study on rural electrification through solar mini-grids as a means to improve electricity access to households and business and is also conducting a nationwide hydropower resource assessment. GGGI has also assisted in identifying potential renewable energy projects by developing a pipeline of project ideas on solar mini-grids, renewables for tourism, rural water supply, and biomass for electricity.

Asian Development Bank (ADB) also provided support to various infrastructure-planning activities in Vanuatu, including energy sector planning in the 1980's. Recently, ADB has supported development of renewable energy through the regional technical assistance project TA 7329:REG Promoting Renewable Energy in the Pacific which supported

i. installation of 40kW solar power on the Luganville grid, and
ii. screening of priority renewable energy in the provinces, and
iii. preparation of pre-feasibility studies for small hydropower plants in the provinces.

ADB is also assisting to reduce the energy intensity of the economy through TA 6485:REG Promoting Energy Efficiency in the Pacific.

There has been considerable support for the power sector from various development partners, however the private sector concession holders have largely managed the concessions with minimal development partner support. The World Bank has provided considerable support for a range of activities such as support for the Utilities Regulatory Authority, development of the Vanuatu Energy Road Map, and technical assessments of proposed geothermal generation. World Bank is proposing projects to support increased energy access both on the main grids through output-based aid, and in off-grid rural areas. The Australian Government has also supported a range of initiatives in the power sector. The Japanese Government financed the Sarataka hydropower plant, which now provides the majority of power for the second largest grid (Luganville, Espiritu Santo). There has been considerable bilateral support for development of renewable energy for rural electrification including Japanese Government support for solar power, European Union support for coconut oil-diesel mini-grids, the UNDP supporting implementation of Efficient Wood Stoves and UNIDO supporting the feasibility study for low emission land transport sector in Vanuatu.

In the phase I of the TNA project in Vanuatu, two prioritized technologies have been determined as follows:

Efficient Wood Stove. Firewood or fuel wood is widely used as fuel by almost all social categories in the rural communities, even in urban areas of Vanuatu for several reasons, among others, lack of access to clean, affordable, and efficient energy. As a result, most of the communities more specifically those living in the rural areas depend on biomass sources however, the availability, cost and quality of wood varies with geographical locations. Since firewood has sometimes to be collected at significant distances from villages, in most cases women are seen as the main person responsible for collecting firewood and cooking exposing them more than men to health risk from severe pains and inhaling toxic smoke and burns from open fire.

In general, the Efficient Wood Stove can be classified into:

- Locally designed and fabricated stove
- Imported type cook stove
- Range of sizes depending on the size of family

Potential applications are as follows:

- Cooking family food
- Boiling Water for drinking, bathing and washing
- Cooking food for generating daily income
- Getting away from the use of LPG and open fire

Battery Electric Vehicle. The advantage of introducing BEVs is that Vanuatu is progressing well in terms of increasing the penetration of renewable energy (solar) systems on the Efate grid. Connecting BEVs to the grid would help with the storage problem and would support effective and efficient

grid management. The tariff for charging BEVs could also be reduced if vehicles are charged when there is an excess of solar availability and the vehicles could sell electricity back to the grid at times of shortage. The commercial viability of BEVs is increasing rapidly, and appropriate government policies and support can further enhance public and private sector interest in them. International experience also suggests that government policies and incentives can play an important role in accelerating both demand and supply of BEVs.

In general, the Battery Electric Vehicles can be classified into:

- Electric Vehicles (e-buses) for public transportation (10% of total Public Buses);
- Electric Cars (e-Cars) in Vanuatu (10% of government fleet); and
- Electric Two wheelers (e-bikes) /Three Wheelers (e-rickshaw)

Potential applications are as follows:

- Consumer Electronics.
- Public Transportation.
- Electricity Grid.
- Renewable Energy Storage.

2.1.2 TECHNOLOGY ACTION PLAN (TAP) FOR THE ENERGY SECTOR'S TWO TECHNOLOGIES: EFFICIENT WOOD STOVE AND BATTERY ELECTRIC VEHICLE

2.1.2.1. Introduction

The two technologies that have been selected are Efficient Wood Stove and Battery Electric Vehicle. They both share the concept of partial fuel consumption, and zero pollution respectively. Earlier, in the previous barrier analysis and enabling framework phase of the TNA project, it was found that the two technologies share common major barriers and measures. It was therefore decided to join their action plans into one comprehensive program entitled "Expanding the diffusion and penetration of the energy sector applications in Vanuatu".

The above-named technologies use the heat energy from the RE source and from battery storage rather than fossil fuels to generate low-cost, environmentally friendly thermal or electrical energy. This energy is used to generate heat for thermal applications and generate electricity for the vehicle applications. The main advantages of these technologies include on-site clean, modular, safe and rapid installation of the equipment. They provide an immediate and measurable reduction in fuel bills, together with reductions in carbon dioxide emissions. Although it needs a high, initial investment cost, feasibility studies show clear advantages over the other conventional resources due to the partial fuel costs needed during the lifetime of the systems. One more advantage in Vanuatu is the high potential of solar radiation levels, which lead to higher system outputs and better feasibility compared to other regions.

2.1.2.2 Ambition for the TAP

The target set for "Expanding the diffusion and penetration of the energy sector applications in Vanuatu" is ambitious. By 2030, 10% improvement in transport (land and marine) energy efficiency and includes (a) Introduce e-buses for public transportation (10% of total public buses); (b) Introduce e-cars in Vanuatu (10% of government fleet); and (c) 1000 electric two wheelers (e-bikes)/three wheelers (e-rickshaw); 100% electricity access by public institutions (on- and off-grid); 14% improve biomass end use (improved cook stoves and drying) efficiency.

2.1.2.3 Actions and activities selected for inclusion in the TAP for the energy sector

Such energy technologies face several challenges in economic, financial and market conditions, regulations, human skills, and the social and awareness fields. These barriers are hindering its widespread deployment around the globe. Strong markets are needed to stimulate the required investments in technological development and deployment, yet further technological advances are needed to increase market demand. The lack of sufficient market pulls for BEV, due to its comparatively higher costs, creates the need for policy-driven support to bridge this cost disadvantage. Training and awareness programs are key to increasing the penetration of their applications among users.

Barriers and measures were discussed earlier for the two technologies in the BA&EF Report. Table 2.1 below shows the main barriers and corresponding measures needed to facilitate the up scaling of the two priority technologies: Efficient Wood Stove and Battery Electric Vehicle.

Table 2.1 Overview of main barriers and measures of Efficient Wood Stove and Battery Electric Vehicles

Categories	Identified Barriers	Measures to overcome barriers
Economic and Financial	High capital cost	Facilitate tax reduction or tax removing scheme on importation
Market conditions	Lack of Sufficient financial support and subsidy	Engage with international funding agencies and Create subsidy program for energy efficiency in residential sector
Legal and regulatory	Lack of /insufficient policy, legal and regulatory framework	Develop appropriate policy and regulation framework to promote mitigation technologies
Information and awareness	Limited market information	Create awareness campaign through various media platform

As the three technologies are included in one general program, all the measures listed in Table 1 were found necessary for the following actions:

i. Action 1: Remove or mitigate financial and economic barriers;

ii. Action 2: Engage with international funding agencies and create subsidy program for EE;

iii. Action 3: Develop appropriate policy and regulation framework; and

iv. Action 4: Create awareness campaigns

Table 2 below describes the actions and their specific activities needed to expand the diffusion and penetration of the energy sector applications in Vanuatu.

Table 2.2 Actions and their specific activities needed to expand the diffusion and penetration of the energy sector applications in Vanuatu.

Action 1	Remove or mitigate financial and economic barriers
Activity 1.1	Establish a working agreement with the Custom's Department to introduce tax reduction on the EE imports
Activity I.2	Introduce a tax removing scheme on the importation of technologies in respect of EE Projects
Action 2	**Engage with international funding agencies and create subsidy program for EE**
Activity 2.1	Preparation and implementation of a comprehensive program of incentives for users and manufacturers.
Activity 2.2	Introduce concessional loans to support the deployment of EE Projects
Action 3	**Develop appropriate policy and regulation framework**
Activity 3.1	Develop BEV regulation
Activity 3.2	Establish regulatory mechanism for EE Projects to promote mitigation technologies for household-level EE improvements
Action 4	**Create awareness campaigns**
Activity 4.1	Establish demonstration facilities for the public and users
Activity 4.2	Design and implement an effective awareness program that can reach prospective and potential users.

2.1.2.4 Stakeholders and timeline for implementation of TAP

The technology action plan and program suggested to achieve this TAP mainly relate to EE projects. The main stakeholder is the Department of Energy, which is responsible for all the laws and regulations in the energy sector. Other departments, like the Department of Climate Change, also has some major roles in the TAP since most energy projects aim to mitigate GHG emissions. The private sector has a major role in establishing projects that will lead eventually to achieving the TAP targets.

The results of the analysis are shown in the overview in Table 3 below.

2.1.2.5 Estimate of resources needed for action and activities

Resources are varied, based on the actions suggested. The results of the analysis are shown in the overview table below (Table 3).

2.1.2.6 Management planning

Articulation of risks and contingency planning are shown in the overview in Table 3 below.

2.1.2.7 TAP overview table for energy sector

Table 3 below elaborates and overviews the action plan put forward by Vanuatu to diffuse and accelerate the deployment and wide dissemination of prioritized energy technologies in the country.

Table 2.3 TAP summary overview of the action plan put forward in Vanuatu to diffuse and accelerate the deployment and wide dissemination of Efficient Wood Stove and Battery Electric Vehicle technologies in Vanuatu

Sector	Energy
Technology	Efficient Wood Stove and Battery Electric Vehicles
Ambition	By 2030, 10% improvement in transport (land and marine) energy efficiency and includes (a) Introduce e-buses for public transportation (10% of total public buses); (b) Introduce e-cars in Vanuatu (10% of government fleet); and (c) 1000 electric two wheelers (e-bikes)/three wheelers (e-rickshaw); 100% electricity access by public institutions (on- and off-grid); 14% improve biomass end use (improved cook stoves and drying) efficiency
Benefits	Climate Change mitigation: 1,182 $mTCO_2$/year Social Development: 500 jobs Environmental Protection: Local health improvement and protecting the earth Economic Development: improve balance of payment, political and social stability

Activities	Responsible body and focal point implementation	Start preparation	Complete implementation	Preparation	implementation	Cost summary	Source of funding	Risks	Success criteria	Indicators for monitoring implementation
Action 1 Remove/mitigate financial and economic barriers										
Establishe a working agreement with the Custom's Department to introduce tax reduction on the EE imports	MoFEM MoCC	2023	2026	Existed	Existed	VT2M	WB, International fund with in kind contribution from local ministries	Government revenue may be affected on the long run and competition of price	After 10-15years ni-vans use the technologies	Number of people using the technologies
Introduce a tax removing scheme on the importation of technologies in respect of EE Projects	MoFEM MoCC	2023	2026	Existed	Existed	VT2M	WB, International fund with in kind contribution from the Government of Vanuatu	Government revenue may be affected	After 10-15 years investors may increase their imports on EE products	Number of EE product imported into the country
Action 2 Engage with international funding agencies and create subsidy program for EE										
Preparation and implementation of a comprehensive program of incentives for users and manufacturers	MoFEM MoCC MoIPU Private Companies	2023	2033	training	Technical support	VT300M	GCF, International fund with in kind contribution from the Government	Demands becomes depended on subsidy therefore needs to slowly phase out	(a) Tangible experience of incentive programs; (b) Availability of highly trained personals	(a) No. of incentive program options; (b) % increase in users due to the economic viability of the systems; (c) Number of beneficiary; (d) sectors benefited; (e) Number of new beneficiaries / users added within certain time after implementing the program ; (f) Number of new direct and indirect jobs related to diffusion of the technology

Activities	Responsible body and focal point implementation	Start preparation	Complete implemen-tation	Prepara-tion	implementa-tion	Cost summary	Source of funding	Risks	Success criteria	Indicators for monitoring implementation
Introduce concessional loans to support the deployment of EE Projects	Government Utilities ESCOs Bank	2023	2033	training	Technical support	VT600M	WB	The borrower may not repay the loan in full in accordance to the terms and conditions of the loan	Having access to financial access to afford the purchase of EWS and BEV	Number of EWS and BEV in Vanuatu
Action 3 Develop appropriate policy and regulation framework										
Develop BEV regulation	MoCC MIPU	2023	2026	training	Capacity building	VT1M	UNDP	Competition high on market	Policy and landscape of Vanuatu allow for BEV in Vanuatu	Relevant policies/laws reviewed and gazette
Establish regulatory mechanism for EE Projects to promote mitigation technologies for household-level EE improvements	MoCC	2023	2026	training	Capacity building	VT10M	UNDP	(a) Companies not willing to participate in the busines; (b) Political interference	A good measures for EE across all sector	Relevant regulation reviewed and gazette by parliament
Action 4 Create awareness campaigns										
Establish demonstration facilities for the public and users	Local experts, universities and concerned ministries	June 2023	Dec 2024	existed	Know -how and technology transfer	VT5M	International fund with in-kind contribution from local ministries	(a) Delay in securing funding; (b) Delay in licensing and approvals form government. Contingency plans: Consider local funding sources	(a) User friendly and efficient facilities; (b) Wide base of Target groups and beneficiaries; (c) How efficient the message is reached	(a) Number of facilities / technologies considered; (b) Number of users and beneficiaries used the demonstration facility in certain time; (c) Number of experts and local engineers involved
Design and implement an effective advertising program that can reach prospective and potential users	Media agencies in cooperation with ministries	Jan 2024	Dec 2026	Existed	Existed	VT4M	International fund with in-kind contribution from local ministries	(a) Delay in securing funding; (b) Delay in stakeholders response; (c) Delay in securing approvals from relevant governmental bodies Contingency plans; (d) Consider local funding sources; (e) Keep continuous coordination with relevant stakeholders and governmental bodies	(a) professionalism of the programs; (b) Level of dissemination among target groups	(a) Number of programs; (b) No. of technologies considered; (c) No. of target groups reached stakeholder involved

2.2 PROJECT IDEAS FOR ENERGY SECTOR

2.2.1 BRIEF SUMMARY OF PROJECT IDEAS FOR THE ENERGY SECTOR

Based on the analyses of barriers and measures conducted in Phase II of the project, the technology action plan has been designed to mitigate GHGs and obtain other socioeconomic benefits. Several actions and activities have been determined accordingly. In achieving TAP's results and goal, certain projects need to be implemented in which activities are considered to turn ideas into realities. As a result, the following three main projects are suggested:

- Introduce duty exemption for imported stove materials and the BEVs
- Design financial support mechanisms and subsidies for the purchase of Efficient Wood Stove and BEVs and;
- Review and amend relevant policies to strengthened Efficient Wood Stove and BEV measures

The following section briefly describes these projects.

2.2.2 SPECIFIC PROJECT IDEAS

Introduce duty exemption for imported stove materials and the BEVs

Introduction/background: One of the main barriers that still hinders the widespread applications of energy systems in Vanuatu is the relatively high initial cost. Although several actions in policy, regulations and financing have been taken, many actions still need to be undertaken to incentivize these clean and attractive applications. This should include the two technologies: Efficient Wood Stove and Battery Electric Vehicles

Objectives: To improve affordability, reduce the cost of the systems and thus increase the penetration of energy systems across the country.

Outputs: Efficient incentives programs.

Relationship to the country's sustainable development priorities: Energy oriented systems such as EWS and BEV are clean applications and conform to the economic development orientation of cleaner production and environment. They play a considerable role in GHG mitigation, one of the country's current priorities, as set out in the country's 2021 to 2030 revised and enhanced NDC and the Vanuatu's NERM Vision 2030. Moreover, dependence on energy imports is reduced, thus contributing to energy security.

Project deliverables:

- Creating an active EWS and BEV energy market;
- Encouraging the development of EWS and BEV projects;
- Bringing important economic, social, and environmental benefits.

Project scope and possible implementation: Feasibility studies and market surveys have already proved the viability of the EWS and BEV technologies. The existence of incentives and seeking to reform import duties, tariffs, and VAT to encourage imports of EE and RE equipment will lessen the high initial cost effect and encourage users to import these systems and the core materials. This in its turn may encourage internal and external investors to participate actively in business transactions in the country. Eventually, this will contribute to mitigating GHG emissions.

Project activities:

- Review current import regulations and incentives programs;
- Review international success stories;
- Determine relevant stakeholders and experts and invite them to share ideas; and
- Design the program in close collaboration with the ministries concerned and the relevant private sector.

Timelines: Two years during 2024 to 2026

Budget/resource requirements: Estimated budget: VT4M to be funded from global funds such GCF and other international donors with in-kind local contribution.

Measurement/evaluation: The main indicator for evaluation can be measured by comparing the increase in the penetration rate over a year after implementing the project, in comparison to the year before.

Possible complications/challenges: Funding is the main challenge facing this project, since without funding it will be difficult to implement projects and achieve goals.

Responsibilities and coordination: Department of Energy, Department of Customs, and local experts.

Design financial support mechanisms and subsidies for the purchase of Efficient Wood Stove and BEVs

Introduction/background: One of the main barriers that still hinders the widespread applications of the EE systems in Vanuatu is the relatively high initial cost. Although several actions in policy, regulations and financing have been taken, many actions still need to be undertaken to incentivize towards the purchase of EE systems. This should include the two technologies: Efficient Wood Stove and Battery Electric Vehicles.

Objectives: To identify and recommend appropriate financial mechanism that can be implemented under the existing regulatory and appliance market environment in Vanuatu. It is envisaged that the proposed financials will serve as additional market-based instruments to promote the uptake of EE systems in Vanuatu and thus increase the penetration of EE systems across the country.

Outputs: Efficient financial mechanism framework and subsidy programs.

Relationship to the country's sustainable development priorities: EE systems are clean applications and conform to the economic development orientation of cleaner production and environment. They play a considerable role in GHG mitigation, one of the country's current priorities, as set out in the country is the revised and enhanced NDC of 2021 to 2030 and the NERM 2016.

Project deliverables:

- Identification of options for national financial mechanisms
- Financial mechanisms consultation workshops
- Design a selected financial mechanism and related implementation plan

Project scope and possible implementation: Feasibility studies and market survey have already proved the viability of EE systems. The existence of incentives and subsidies programs will lessen the high initial cost effect and encourage users to purchase these systems. This in its turn may encourage internal and external investors to participate actively in business transactions in the country. Eventually, this will contribute to mitigating GHG emissions.

Project activities:

- Review current regulations and incentives programs,
- Review international success stories,
- Determine relevant stakeholders and experts and invite them to share ideas, and
- Design the program in close collaboration with the ministries concerned and the relevant private sector.

Timelines: Ten years beginning 2023

Budget/resource requirements: Estimated budget: VT900M, to be funded from global funds such GCF and other international donors with in-kind local contribution.

Measurement/evaluation: The main indicator for evaluation can be measured by comparing the increase in the penetration rate over a year after implementing the project, in comparison to the year before.

Possible complications/challenges: Funding is the main challenge facing this project, since without funding it will be difficult to implement projects and achieve goals.

Responsibilities and coordination: Department of Energy, Ministry of Finance, Distributors/retailers, and local experts.

Review and amend relevant policies to strengthened Efficient Wood Stove and BEV uptakes

Introduction/background: This is another common barrier for all technologies although the nature of the policy framework is varying from one another. Since the country does not have sufficient GHG Emission Policy and long-term planning goals, the pathway of more diffusion of these technologies are in the bottleneck. For example, investors are generally reluctant to invest more in EE system due to lack of legislation, geared toward the provision of a sufficient number of related infrastructures, government procurement strategies, environmental awareness, subsidized purchasing, among other policies, should be included in long-term plans and goals for accelerated EE system uptake.

Objectives: To identify and recommend appropriate policies that can be implemented under the existing regulatory framework in Vanuatu. It is envisaged that the proposed policies will serve as additional market-based instruments to promote the uptake of EE systems in Vanuatu and thus increase the penetration of EE systems across the country.

Outputs:

Efficient policy framework.

Relationship to the country's sustainable development priorities:

Develop an effective policy and risk-sharing framework for PPP transactions to accelerate major investments (to include legislation and regulations to facilitate IPPs and PPAs)

Project deliverables:

- Identification of options for national policy framework
- Policy framework consultation workshops
- Draft a selected policy and related implementation plan

Project scope and possible implementation: Existed policies have already proved the viability of EE appliance uptake. The existence of relevant policies that are relevant to EE system will encourage users to purchase these systems. This in its turn may encourage internal and external investors to participate actively in business transactions in the country. Eventually, this will contribute to mitigating GHG emissions.

Project activities:

- Review current regulations and policy frameworks,
- Review international and regional related policies, and
- Submit a drafting instruction to the state law office

Timelines: Three years beginning 2023

Budget/resource requirements: Estimated budget: VT11M, to be funded from global funds such GCF and other international donors with in-kind local contribution.

Measurement/evaluation: The main indicator for evaluation can be measured by comparing the establishment of the new EE policies over a year after implementing the project, in comparison to the year before.

Possible complications/challenges: The policy paper that is submitted to the Council of Ministers for their endorsement was not accepted or recommendation was not appealing.

Responsibilities and coordination: Department of Energy, State Law Office, and other local and international experts.

03

TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR WASTE-TO-ENERGY SECTOR

3.1 TAP FOR WASTE-TO-ENERGY SECTOR

3.1.1 WASTE-TO-ENERGY SECTOR OVERVIEW

Domestic, agriculture, livestock and industry waste generated from consumption of natural capital, or production of manufacturing capital by units of production and consumption, often have potential effects on the environment and human health. Under particular circumstances, a fraction of specific waste might be reused for some purpose, but the generality of waste debris and matters are eventually disposed of. The fate of waste either being disposed or stored depends on the receiving/repository medium's capacity to break down and disperse waste into more environmentally benign concentrations or components through natural or biological means and transformation processes. For pragmatic reasons, the focus of the analysis that follows is on municipal solid waste (MSW) in the urban centers in Vanuatu, where management challenges linked to this waste disposal has reached epic proportions. Compared to homogenous waste from industrial and agricultural activities, it is noted that MSW comprises a complex assortment of wastes. Vanuatu is currently strengthening the local authorities and municipal planning authorities to enact and enforce land use planning laws and regulations (NSDP 2016 - 2030, 2016).

In Vanuatu, air quality protection is constrained by the absence of emission standards, inadequate technical assets, a weak workforce of scientific and engineering professionals, and economic agents' disengaged commitments to environmental education (SNC, 2014).

It is worth noting that emissions of carbon dioxide (CO_2), carbon monoxide (CO), and nitrous oxides (NOx) from waste burning, a low intensity form of incineration, is not included in the Vanuatu Second National Communication due to the lack of pertinent data (SNC, 2014).

GHG emissions from the waste sector in Vanuatu are estimated for the following sub sectors;

- Solid Waste Management and Disposal
- Domestic and Commercial Wastewater Handling

Waste management sector emissions have been estimated using data for two major cities Port Vila and Luganville, which are the main population centres of the country and respectively contain 20% and 6%of the total Vanuatu population. The remaining islands in Vanuatu are sparsely populated and are not included in the estimation due to lack of reliable data on waste generation. Data for waste sector has been largely sourced from published literature on MSW management, study on Port Vila urban development projects for Promotion of Regional Initiative Solid Waste Management (J-PRISM PROJECT REPORT, 2011) Department of Environmental Protection and Conservation data, and results from the population census (SNC, 2014).

Table 3.1 presents GHG emissions from waste disposal in Vanuatu for the years between 2007 and 2015 The emissions from waste sector were not estimated in 1994 under the first national communication. Emissions from this sector in 2000 are a total of 12.21Gg CO_2, that is 2.1% of Vanuatu's total GHG emission. Solid waste disposal on land accounted for 80% of total waste related GHG emissions followed by domestic wastewater handling that accounts for the remaining 20%.

Table 3.1 CO_2 emissions from waste sector in Vanuatu ($GgCO_2e$) (TNC, 2020)

Source	2007 CO_2 emissions ($GgCO_2e$)	2015 CO_2 emissions ($GgCO_2e$)
Solid Waste Management and Disposal	22.44	29.62
Domestic and Commercial Wastewater Handling	7.11	7.65
Total GHG Emission	29.55	37.28

Table 3.2 presents emissions of different gases in the waste sector in Vanuatu for the year 2015. Methane is the most prominent gas emitted from the waste sector. Unmanaged solid waste and wastewater sites, lead to methane emissions. The methane emitted is estimated using the quantity of waste generated by the management of the waste, the proportion of carbon that may be transformed into methane, etc.

Table 3.2 GHG Emissions from Waste Sector in Vanuatu (Gg) (TNC, 2020)

Source	CO_2	CH_4	N_2O	Total CO_2e
Solid Waste Management and Disposal	-	1.058	-	29.62
Domestic and Commercial Wastewater handling	-	0.157	0.012	7.65
Total GHG Emissions	-	1.215	0.012	37.27

The transfer and diffusion of technologies to mitigate climate change in Vanuatu will be guided by the objectives enshrined in the Vanuatu climate change and disaster risk reduction policy (VCCDRRP) and the Nationally Determined Contributions (NDCs). The overarching relevant objectives from the Climate Change policy are:

- Facilitate climate smart (low carbon, climate resilient) infrastructure location, planning, design and maintenance, and sustainable land management and reduce greenhouse gas (GHGs) the electricity, transport, waste, and forestry sectors.
- Access climate technologies for mitigation and adaptation along with capacity building and increase external climate fiancé support to Vanuatu's adaptation and mitigation.

The NDCs specifically "... commits to reducing Greenhouse gas emission by 30% of 2010 by 2025, with an indicative reduction of 40% of 2010 by 2030".

Additionally, the GoV also recognizes the important role the Sustainable Development Agenda 2030 and the Sustainable Development Goals (SDGs) that guide the agenda play in mitigating climate change. As a result, the SDG 7-ensure access to affordable, reliable, sustainable, and modern energy for all, and SDG 13-take urgent action to combat climate change and its impacts, are relevant. The key SDG targets for technology transfer and diffusion are shown in table 3.3.

Table 3.3 SDG targets relevant technology transfer and diffusion in Vanuatu

SDG #	Relevant targets to technology transfer and diffusion
7	(a) By 2030, increase substantially the share of renewable energy in the global (Vanuatu) energy mix (b) By 2030, double the global (Vanuatu) rate or improvement in energy efficiency (c) By 2030, access to affordable, reliable and modern energy services
13	Improve education, awareness-raising and human and institutional capacity on climate mitigation

The TNA therefore will seek to address these goals and objectives in part. In this regard, by reducing barriers and proposing an enabling framework for the further diffusion of renewable energy and energy efficiency technologies, this process seeks to increase the share of biogas systems and thus reduce greenhouse gas emissions.

In the phase I of the TNA project in Vanuatu, two prioritized technologies have been determined as follows:

Manure Based Biogas Digester

Manure-based biogas digesters are animal manure treatment and fermentation system, which includes fermentation tanks, manure input and fermentation via anaerobic environment. The methane concentration of biogas is around 60%, so the recovery and utilization of biogas from digested slurry in a biogas digester will reduce CH_4 emissions from the manure. In addition, the biogas can be used to provide electricity, energy and reduce CO_2 emissions from fossil fuel (diesel\) displaced by biogas.

In general, the Manure Based Biogas Digester can be classified into:

- Locally design and fabricated digester

i. Imported type digester

- Range of sizes depending on the size of family and the usage

Potential applications are as follows:

- Cooking family food
- Boiling Water for drinking, bathing and washing
- Cooking food for generating daily income
- Getting away from the use of LPG and open fire
- Power generation

Compact Biogas Digester

Appropriate Rural Technology Institute (ARTI) of Pune, Maharashtra, India (www.arti-india.org) has developed a "Compact Bio-Gas Digester" to resolve technical as well as operational challenges of the conventional biogas digester." The volume of this digester is 0.75 m^3. It essentially consists of two plastic tanks. Through this technology, an average household could generate adequate biogas to meet the household requirements for cooking. The ARTI compact biogas system is made from two cut-down standard high-density polyethylene water tanks and standard plumber piping. The larger tank acts as the container containing the waste material while the smaller one is inverted and telescoped into this larger one. This smaller inverted tank is the floating gas chamber, whose rise is proportional to the produced gas and acts as a storage space for the gas. The gas can then be used directly for cooking on an adjustable gas stove and the liquid effluent from the digester can be applied as fertilizer in gardens or agriculture. By specification of ARTI, the CBS of approximate 1 m^3 capacity is designed for treating 1-2 Kg (dry weight) of kitchen waste per day (www.howtopedia.org). The usable gas volume of the 750 L-gasholder is 400 L.

The Hydraulic Retention Time (HRT) suggested by ARTI-TZ, which is the ratio of the reactor volume (0.85 m^3) to the flow rate of the inflow substrate (0.02 m^3/day), is 42.5 days. The rather long HRT is designed to compensate for incomplete mixing.

In general, the Compact Biogas Digester can be classified into:

- Locally design and fabricated digester
- Imported type digester
- Range of sizes depending on the size of family and the usage

Potential applications are as follows:

- Cooking family food
- Boiling Water for drinking, bathing and washing
- Cooking food for generating daily income
- Getting away from the use of LPG and open fire
- Lighting
- The slurry (liquid effluent from the digester) used as fertilizer

2.1.2 TECHNOLOGY ACTION PLAN (TAP) FOR THE WASTE-TO-ENERGY SECTOR'S TWO TECHNOLOGIES: MANURE BASED BIOGAS DIGESTER AND COMPACT BIOGAS DIGESTER FOR HOUSEHOLDS

3.1.2.1. Introduction

The two prioritized technologies that have been selected are Manure Based Biogas Digester and Compact Biogas Digester. They both share the same concept of nil fuel consumption, andthe reduction of greenhouse gas into the environment. Earlier, in the previous barrier analysis and enabling framework phase of the TNA project, it was found that almost all the two technologies share common major barriers and measures. It was therefore decided to join their action plans into one comprehensive program entitled "Expanding the diffusion and penetration of the waste-to-energy sector applications in Vanuatu".

The above-named technologies utilize anaerobic digester technology to replicate waste decomposition processes under anaerobic conditions. Thus, the technology is able to reduce landfill spatial requirements, reduce methane ordinarily emitted from primitive dumpsites and produce recyclable products. Moreover, anaerobic digesters can be deployed on a variety of scales and significantly reduce transportation costs. Diverting compostable material from landfill to composting operations, as a way of avoiding CH_4 emissions, could potentially deliver GHG emission reductions of about 83% (Brown et al. 2008). Aerated static pile composting is particularly suited for facilities processing wet organic materials and large feedstock volumes.

3.1.2.2 Ambition for the TAP

The target set for "Expanding the diffusion and penetration of the waste-to-energy sector applications in Vanuatu" is ambitious. By 2030, installation of 1000 Biogas Plants for Commercial and Residential Use and 14% improvement for biomass end use (cooking and drying) efficiency.

3.1.2.3 Actions and activities selected for inclusion in the TAP for the waste-to-energy sector

Such energy technologies face several challenges in economic, financial and market conditions, regulations, human skills, and the social and awareness fields. These barriers are hindering its widespread deployment around the globe. Strong markets are needed to stimulate the required investments in technological development and deployment, yet further technological advances are needed to increase market demand. The lack of sufficient market pulls for the two technologies, due to its comparatively higher costs, creates the need for R&D to bridge this cost disadvantage. Pilot projects and live demonstrations are key to increasing the penetration of their applications among users.

Barriers and measures were discussed earlier for the two technologies in the BA&EF Report. Table 3.4 below shows the main barriers and corresponding measures needed to facilitate the up scaling of the two priority technologies: Manure Based Biogas Digester and Compact Biogas Digester.

Table 3.4 Overview of main barriers and measures of Manure Based Biogas Digester and Compact Biogas Digester

Categories	Identified Barriers	Measures to overcome barriers
Economic and Financial	High capital cost	Develop concept note and proposals to seek financial support;
Market conditions	Lack of Sufficient knowledge on the technologies	Conduct R&D for the technologies
Information and awareness	Limited market information	Implementation of pilot projects to demonstrate the advantages of the technology

As the two technologies are included in one general program, all the measures listed in Table 3.4 were found necessary for the following actions:

i. Action 1: Engage with funding agencies to seek financial support;

ii. Action 2: Conduct R&D programs to enlighten on the technologies; and

iii. Action 3: Implement pilot projects to demonstrate the feasibility of the technologies

Table 3.5 below describes the actions and their specific activities needed to expand the diffusion and penetration of the waste-to-energy sector applications in Vanuatu.

Table 3.5 Actions and their specific activities needed to expand the diffusion and penetration of the waste-to-energy sector applications in Vanuatu.

Action 1	**Engage with funding agencies to seek financial support**
Activity 1.1	Develop concept notes to seek financial support from international funding agencies
Activity I.2	Create soft loan for users from the NGEF
Action 2	**Conduct R&D programs to enlighten on the technologies**
Activity 2.1	Conduct productive studies to analyze labor intensive is reduced
Activity 2.2	Strengthened institutional arrangements and cooperation between stakeholders
Action 3	**Implement pilot projects to demonstrate the feasibility of the technologies**
Activity 3.1	Conduct urban households evaluation on acceptability of the technologies
Activity 3.2	Identify selected sites for the pilot project

3.1.2.4 Stakeholders and timeline for implementation of TAP

The technology action plan and program suggested to achieve this TAP mainly relate to Waste-to-Energy projects. The main stakeholder is the Department of Energy, which is responsible for all the laws and regulations in the energy sector. Other departments, like the Department of Climate Change, also has some major roles in the TAP since most energy projects aim to mitigate GHG emissions. The private sector has a major role in establishing projects that will lead eventually to achieving the TAP targets.

The results of the analysis are shown in the overview in Table 3.6 below.

3.1.2.5 Estimate of resources needed for action and activities

Resources are varied, based on the actions suggested. The results of the analysis are shown in the overview table below (Table 3.6).

3.1.2.6 Management planning

Articulation of risks and contingency planning are shown in the overview in Table 3.6 below.

3.1.2.7 TAP overview table for waste-to-energy sector

Table 3.6 below elaborates and overviews the action plan put forward by Vanuatu to diffuse and accelerate the deployment and wide dissemination of prioritized waste-to-energy technologies in the country.

Table 3.6 TAP summary overview of the action plan put forward in Vanuatu to diffuse and accelerate the deployment and wide dissemination of Manure Based Biogas Digester and Compact Biogas Digester technologies in Vanuatu

Sector	Waste-to-Energy
Technology	Manure Based Biogas Digester and Compact Biogas Digester
Ambition	By 2030, installation of 1000 Biogas Plants for Commercial and Residential Use and 14% improvement for biomass end use (cooking and drying) efficiency
Benefits	Climate Change mitigation: 530 tCO_2/year Social Development: 1000 jobs Environmental Protection: Local health improvement, protecting the earth and help vegetables grow well Economic Development: improve balance of payment, political and social stability

Activities	Responsible body and focal point implementation	Start preparation	Complete implementation	Preparation	implementation	Cost summary	Source of funding	Risks	Success criteria	Indicators for monitoring implementation
Action 1 Engage with funding agencies to seek financial support										
Develop concept notes to seek financial support from international funding agencies	MoCC	2023	2026	Training	Existed	VT3M	GCF, International fund with in kind contribution from local ministries	Prolonged process for accessing funds	Seeking funds to implement	CN/proposal developed and funds secured
Create soft loan for users from the NGEF	MoCC MoFEM	2023	2033	Existed	Existed	VT100M	WB, International fund with in kind contribution from the Government of Vanuatu	(a) Hard to pay back loan; (b) Malfunction of the system; (c) Not at the interest of many	Avenue to allow installment to communities	Soft loans created with commercial banks.NGEF
Action 2 Conduct R&D programs to enlighten on the technologies										
Conduct productivity studies to analyze labor intensive is reduced	MoCC Private Companies Training Schools	2023	2028	training	Technical support	VT15M	Vanuatu Government, Development partners Donors	Staff turnover	Labor productivity	Study conducted and documented with recommendation
Strengthened institutional arrangements and cooperation between stakeholders	MoCC Relevant stakeholders	2023	2028	Existed	Existed	VT15M	WB ADB	Inactive participation through the process of implementation	A complete engagement of all sectors	Stakeholders shows high level of active participation
Action 3 Implement pilot projects to demonstrate the feasibility of the technologies										
Conduct urban households evaluation on acceptability of the technologies	MoCC	MoCC	2026	training	Capacity building	VT2M	UNDP Vanuatu Government	(a) HH refused to participate (b) No supplied data requested	Urban HHs offer views on use of technology in their homes	Evaluation report produced
Identify selected sites for the pilot project	MoCC Relevant stakeholders	2023	2026	training	Capacity building	VT10M	UNDP	(a) Travelling to site; (b) Agreement by the Village council	Most villages agree for the pilot projects to be located at their sites	Number of project sites

3.2 PROJECT IDEAS FOR ENERGY SECTOR

3.2.1 BRIEF SUMMARY OF PROJECT IDEAS FOR THE WASTE-TO-ENERGY SECTOR

3.1.2.1. Introduction

Based on the analyses of barriers and measures conducted in Phase II of the project, the technology action plan has been designed to mitigate GHGs and obtain other socioeconomic benefits. Several actions and activities have been determined accordingly. In achieving TAP's results and goal, certain projects need to be implemented in which activities are considered to turn ideas into realities. As a result, the following three main projects are suggested:

- Engage with funding agencies to seek financial support;
- Conduct R&D programs to enlighten on the technologies; and
- Implement pilot projects to demonstrate the feasibility of the technologies

The following section briefly describes these projects.

3.2.2 SPECIFIC PROJECT IDEAS

Engage with funding agencies to seek financial support

One of the main barriers that still hinders the widespread applications of waste-to-energy systems in Vanuatu is the relatively high initial cost. Although several actions and policy, regulations and financing have been taken, many actions still need to be undertaken to incentivize these clean and attractive applications. This should include the two technologies: Manure Based Biogas Digester and Compact Biogas Digester.

Objectives: To improve affordability and introducing financial mechanisms and thus increase the penetration of waste-to-energy systems across the country.

Outputs: Effective financial support programs.

Relationship to the country's sustainable development priorities: Waste-to-Energy oriented systems such as MBBD and CBD are clean applications and conform to the economic development orientation of cleaner production and environment friendly. They play a considerable role in GHG mitigation, one of the country's current priorities, as set out in the country's 2021 to 2030 revised and enhanced NDC and the Vanuatu's NERM Vision 2030.

Project deliverables:

- Report on national financial mechanism options;
- Workshop report including three (3) financial schemes for implementation and;
- Recommendations on the design of and implementation for three (3) selected financial schemes.

Project scope and possible implementation: Feasibility studies have already proved the viability of the biogas digester systems. The existence of incentives and financial support programs will allow the users and encourage users to purchase these systems. This in its turn may encourage internal and external investors to participate actively in business transactions in the country. Eventually, this will contribute to mitigating GHG emissions.

Project activities:

- Identification of options for national financial mechanism;
- Financing mechanisms consultation workshop and;
- Design of selected financial mechanism(s) and related implementation plans

Timelines: Ten years during 2023 to 2033

Budget/resource requirements: Estimated budget: VT10M to be funded from global funds such GCF and other international donors with in-kind local contribution.

Measurement/evaluation: The main indicator for evaluation can be measured by comparing the increase in the penetration rate over a year after implementing the project, in comparison to the year before.

Possible complications/challenges: Funding is the main challenge facing this project, since without funding it will be difficult to implement projects and achieve goals.

Responsibilities and coordination: Department of Energy, financial institutions such as the commercial banks, NGEF and the VNPF

Conduct R&D programs to enlighten on the technologies

One of the barriers that will hinders the widespread applications of waste-to-energy systems in Vanuatu is the High operational and maintenance cost due to the labour-intensive nature of operations. Workers on the farm see the process of feeding a biogas system with waste as extra work that needs extra compensation. This can be addressed through effective productivity surveys to see where savings in time and effort by workers can be reduced. In other words, the gathering of waste feedstock and the eventual feeding can be done more efficiently and effectively. On small farms where the feedstock is minimal, then this work will not significantly increase costs. In many cases it is now about changing what is done with the waste after pens and plots are cleaned.

Objectives: Conduct productivity study to analyze how labor intensity can be reduced.

Outputs: Effective R&D programs.

Relationship to the country's sustainable development priorities: Waste-to-Energy oriented systems such as MBBD and CBD are clean applications and conform to the economic development orientation of cleaner production and environment friendly. They play a considerable role in GHG mitigation, one of the country's current priorities, as set out in the country's 2021 to 2030 revised and enhanced NDC and the Vanuatu's NERM Vision 2030.

Project deliverables:

- Report on surveys conducted and findings;
- Workshop report for options to implement and;
- Recommendations on the design of and implementation plan.

Project scope and possible implementation: The technology to generate biogas from easily biodegradable biomass is a new technology for Vanuatu. Biogas digesters comes in various sizes and shapes. It is proposed to introduce MBBD and CBD to be used in rural and urban households with suitable feed material to generate adequate biogas to enable meeting the daily energy demand of an average family for cooking and other purposes. Few digesters have already been tested at Ardhi University (India) and found that it is a viable for using food leftover in households. But the amount of food left over in an average household is inadequate to generate the required amount of gas. Research is required to identify additional raw materials to supplement the household leftovers.

Project activities:

- Identification of options for the system upgrade;
- Conduct consultation workshop with relevant stakeholders and;
- Design of a digester to meet the Vanuatu context.

Timelines: Five years during 2023 to 2028

Budget/resource requirements: Estimated budget: VT15M to be funded from global funds such UNDP and other international donors with in-kind local contribution.

Measurement/evaluation: The main indicator for evaluation can be measured by comparing the improvement of the system in terms of feed materials to reduce the labor intensity.

Possible complications/challenges: Funding is the main challenge facing this project, since without funding it will be difficult to implement projects and achieve goals.

Responsibilities and coordination: Department of Energy, training institutions and local experts.

Implement pilot projects to demonstrate the feasibility of the technologies

One of the barriers that still hinders the widespread applications of waste-to-energy systems in Vanuatu is the acceptance and willingness of using the system in our communities. Although several actions and financing have been taken, many actions still need to be undertaken to incentivize these clean and attractive applications. This should include the two technologies: Manure Based Biogas Digester and Compact Biogas Digester.

Objectives: Relevant government institutions should develop communication strategy, awareness materials and promotional strategies to ensure public acceptance of the biogas digesters

Outputs: Demonstration of the digester in the selected densely populated sites.

Relationship to the country's sustainable development priorities: Waste-to-Energy oriented systems such as MBBD and CBD are clean applications and conform to the economic development orientation of cleaner production and environment friendly. Public institution has promoted biogas digester technology. The success of it will be limited as there are still work to fix large designs targeting institutions. For this technology to succeed, involvement of private sector is essential. The digesters play a considerable role in GHG mitigation, one of the country's current priorities, as set out in the country's 2021 to 2030 revised and enhanced NDC and the Vanuatu's NERM Vision 2030.

Project deliverables:

- Inception Report
- Feasibility Studies
- Installation of Biogas Systems
- Consultations & Training Report
- Operation & Maintenance Manuals

Project scope and possible implementation:

Not only is Vanuatu encouraging grid-connected renewable energy projects, but it has also initiated some off-grid projects which have proven very useful for some of their rural communities. One of these initiatives is the utilization of organic waste (green waste and food scraps) to generate biogas via anaerobic digestion. Vanuatu has already seen the multitude of benefits from the biogas systems already installed at two of their rural educational institutions – Onesua Presbyterian College in North Efate and Vanuatu Agriculture College. Biogas systems offer an excellent waste management option, especially for green waste, animal waste and food scraps where methanogenic bacteria break down the waste to yield methane which can be used as cooking gas or electricity-generation. The overflow from the system can be diluted and used as fertilizer which is completely organic and has the ability to revitalize the soil with rich nutrients for better crop yields. By encouraging the use of biogas technology, the reliance on biomass (fuelwood and firewood) for cooking can be reduced along with GHG emissions from burning biomass. Furthermore, this will mean less exposure of traditional biomass users, mainly women and children, to the harmful effects of smoke inhalation once they switch to biogas for cooking. In terms of positive social impacts, women and children will have more time for other productive activities when they are not out collecting firewood for cooking.

Project activities:

- Work closely with the Department of Climate Change under the Vanuatu Ministry of Climate Change to collect the relevant data for the selected sites, in order to determine their feasibility and sustainability;
- Attend the pre-bid site assessment visit so that more information can be obtained to assist with designing suitable systems for each of the sites;
- Perform a final site assessment, once they are awarded with this contract, and present detailed biogas system designs for each of the "feasible" sites and all the related costs (feasibility studies);
- Prepare a work plan and procurement plan;
- Procure all the materials for the biogas systems;
- Carry out the installation works for the selected biogas systems;
- Perform trainings for the selected sites so they can maintain and sustain the systems effectively;
- Commission and trial run the biogas systems and;
- Prepare and submit Operational and Maintenance Manuals for each of the biogas systems;

Timelines: Three years during 2023 to 2026

Budget/resource requirements: Estimated budget: VT10M to be funded from global funds such GCF and other international donors with in-kind local contribution.

Measurement/evaluation: The main indicator for evaluation can be measured by the number of projects that has been implemented.

Possible complications/challenges: Funding is the main challenge facing this project, since without funding it will be difficult to implement the projects and achieve goals.

Responsibilities and coordination: Department of Energy, Department of Climate Change, and the local experts.

04
CROSS-CUTTING ISSUES

Bearing in mind that the top two sectors that have been prioritized and assessed with regard to TNA in Vanuatu were energy and waste-to-energy, the obvious crosscutting issues are the great need for regulatory reforms and the promotion of a robust incentive system to help improve the diffusion of such technologies as national priorities. Most importantly, coordinated action is greatly needed so that implementation takes place in harmony in all sectors and in line with the national development strategies.

With a focus on the most highly interlinked are the two sectors of energy and waste-to-energy, the prospect of identifying cross-cutting issues and benchmarking common enabling policies, measures, and actions in the two sectors in respect of climate change mitigation technologies becomes more challenging if tackled from the perspective of the energy and waste-to-energy sectors. Globally, but also particularly in a country like Vanuatu, accelerated trends in population growth, amplified by waves of natural disasters, and coupled with increased demands for energy – despite their deterioration because of climate change, which will have huge impacts on energy availability – all pose barriers to technologies from multiple sectors that utilize the Energy and Climate Nexus. As Dodds and Bartram have stated (Dodds & Bartram, 2016), it is increasingly clear that there is no place in an interlinked world for isolated solutions aimed at just one sector. In recent years the idea of a "nexus" has emerged as a powerful concept to capture these inter-linkages between resources, and it is now a key feature of policymaking.

Thus, we believe that the idea of the Energy and Climate Nexus represents a unique approach whereby both the global and Vanuatu situations can address these technologies and the policy barriers in the two sectors, thus encouraging holistic thinking and providing a platform for action. For example, integrating the measures and solutions that emerge from assessing the barriers to the technologies in the two interlinked sectors (particularly efficient wood stove and battery electric vehicles in the energy sector; and manure-based biogas digester and compact biogas digester in the waste-to-energy sector) will have a powerful effect, instead of addressing each set of barriers and solutions separately. Thus, adopting an efficient wood stove and battery electric vehicles for efficient (fuel) consumption would represent a very influential and viable approach. Thus, it is evident that the nexus perspective is primarily about seeking opportunities and achieving multiple benefits through the better and more efficient management of resources. This demands new approaches that take us beyond the predominant, traditional silo thinking (or sector thinking) and management approaches.

This perspective offers innovative practical approaches and solutions to the management of these key resources from a wider systems perspective.

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Legal and Policy Instruments

National Laws:

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20. Electricity Supply Act (2006)
21. Companies Act (2012)
22. Public Health Act (2006)
23. Municipality Act (1980)
24. Physical Planning and Development Control Act (1986)
25. Land Acquisition and Compensation Act (2006)
26. Local Government Act (2002)
27. Environmental Management and Conservation Act (2002)
28. Waste Management Act (2014)

National Regulations:

29. EIA Regulation (2002)
30. Public Health Regulations (1975)
31. National Policies
32. Vanuatu National Energy Framework Policy (2015)
33. Vanuatu Climate Change and Disaster Risk Reduction Policy (2015)

International Treaties and Conventions:

34. United Nations Framework Convention on Climate Change, UNFCCC (2018)

ANNEX I: LIST OF STAKEHOLDERS

Table I.1 Contact

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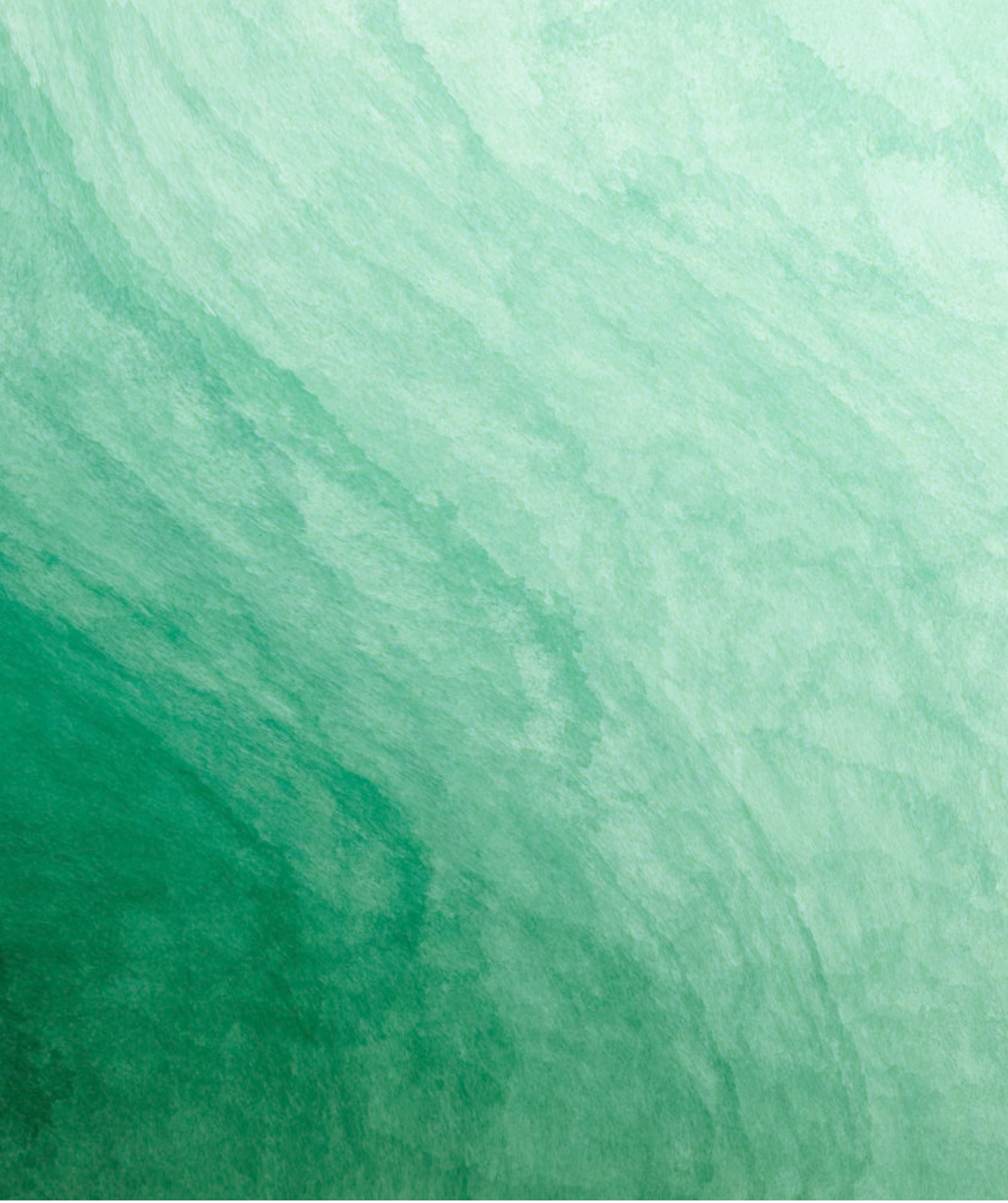

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