

# Concept Note

Project Title: Enhancing Climate-Resilient and Sustainable Energy Access in Papua New Guinea through Ocean-based Renewable Energy Utilizing Salinity Gradient and Ocean Thermal Resources

Country(ies): Papua New Guinea

Accredited Entity(ies) (AE):

Date of submission Not yet submitted to the GCF. Prepared as a deliverable of CTCN TA 24-017; to be submitted once an Accredited Entity is identified.



## Notes

- The GCF's revised concept note template (*Concept note template V.3.0*) is being made available in Word format only for reference in the interim period in the first half of 2025.
- The latest template in the system prevails over the Word format document.
- Starting 1 April 2025, all new concept note submissions should be made through the GCF Partner Portal using the new digital template.



<sup>1</sup> Concept notes (or sections of) not marked as confidential may be published in accordance with the Information Disclosure Policy ([Decision B.12/35](#)) and the Review of the Initial Proposal Approval Process ([Decision B.17/18](#)).

|                                                              |                                                                                                                                                                                                                                                                                                                                                                               |                                               |                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                              | <input type="checkbox"/> T2. <u>DAEs</u> : Doubling the number of DAEs with approved GCF funding proposals through strengthened climate capacity and increasing the allocation of GCF resources through DAEs                                                                                                                                                                  |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input type="checkbox"/> T3. <u>CIEWS</u> : Countries particularly vulnerable to the adverse effects of climate change protected by new or improved early warning systems                                                                                                                                                                                                     |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input type="checkbox"/> T4. <u>Food</u> : Beneficiaries adopting low-emission climate-resilient agricultural and fisheries practices, securing livelihoods while reconfiguring food systems                                                                                                                                                                                  |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input type="checkbox"/> T5. <u>Ecosystems</u> : Hectares of terrestrial and marine areas conserved, restored or brought under sustainable management                                                                                                                                                                                                                         |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input checked="" type="checkbox"/> T6. <u>Infrastructure</u> : Countries supported by GCF to develop or secure low-emission climate resilient infrastructure, through systemic and/or country-driven resilience planning, funding and/or de-risking of investments, including those that draw on nature-based solutions or ecosystem based approaches                        |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input checked="" type="checkbox"/> T7. <u>Clean Energy</u> : Countries supported to expand access to sustainable, affordable, resilient, reliable renewable energy, particularly for hardest to reach, and/or to increase renewable energy sources in the energy mix                                                                                                         |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input type="checkbox"/> T8. <u>Transport, buildings, industry</u> : Countries supported to shift toward clean and efficient energy end-use for transport, building and industry sectors, including through electrification, decreasing energy consumption and novel solutions and emerging technologies for hard-to-abate sectors                                            |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input type="checkbox"/> T9. <u>Locally-led climate action</u> : Does the project have potential to support locally-led climate action by enabling local actors to decide over the use of GCF finance at project activity level or maintain a strong involvement across the project cycle? (If yes, please expound in sections C.2 and C.3.)                                  |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input type="checkbox"/> T10. <u>MSMEs</u> : Local private sector early-stage ventures and MSMEs provided with broad-based seed and early-stage capital for innovative climate solutions, business models and technologies, with a focus on adaptation, energy access and transport sectors, and removing barriers for home-grown innovation                                  |                                               |                                                                                                                                                                                                                                                                   |
|                                                              | <input type="checkbox"/> T11. <u>LFIs</u> : National and regional financial institutions supported to access GCF resources, and other green finance, particularly for MSMEs.                                                                                                                                                                                                  |                                               |                                                                                                                                                                                                                                                                   |
| <b>A.9. Indicative total project cost (GCF + co-finance)</b> | Amount: <b>≈ USD 20.96 million (indicative total project cost)</b> . Breakdown: Project Development ~USD 0.35 M (feasibility study, site survey & basic design, CEPA environmental permitting); Pilot construction & commissioning ~USD 20.5 M (SGE 100 kW ~4.0 M; e-OTEC 50–100 kW ~3.0–3.5 M; 800 kWh / 4 h Blue Battery storage ~2.5–3.0 M; Capacity Building ~USD 0.11 M. | <b>A.10. Indicative GCF funding requested</b> | ≈ USD 20.96 million (GCF grant, 100% of project cost). No financial co-financing has been secured at this stage. Indicative in-kind contributions are expected from the PNG Government / NEA (staff, site access, permitting) and from KIER as technology partner |

|                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                       | (technology, engineering support and training). A preceding technology demonstration in PNG (Stage 1, from 2027), funded through Korean R&D (NRF), will provide parallel financing and reduce technology risk. Co-financing for the scale-up phase, including possible loans or guarantees from multilateral development banks, will be sought during Funding Proposal preparation. |
| <b>A.11. Financial instrument requested from GCF</b> | <input checked="" type="checkbox"/> Grant <input type="checkbox"/> Reimbursable grant <input type="checkbox"/> Guarantees <input type="checkbox"/> Equity<br><input type="checkbox"/> Subordinated loan <input type="checkbox"/> Senior Loan <input type="checkbox"/> Other: _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>A.12. Estimated project implementation period</b> | 2029–2034                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>A.12. Estimated duration of investment</b>                                         | 2029–2034                                                                                                                                                                                                                                                                                                                                                                           |
| <b>A.12. Estimate project lifespan</b>               | 30 years                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>A.13. Will support from Project Preparation Facility be requested?<sup>2</sup></b> | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/><br><br>Preparation funding may be requested once an Accredited Entity is identified.                                                                                                                                                                                                                            |
| <b>A.14. ESS category<sup>3</sup></b>                | <input type="checkbox"/> A <input type="checkbox"/> I-1<br><input checked="" type="checkbox"/> B <input type="checkbox"/> I-2<br><input type="checkbox"/> C <input type="checkbox"/> I-3 (link to <a href="#">SAP ESS screening checklist</a> )<br>Category B is an indicative screening pending the ESIA. It denotes medium risk: adverse impacts that are limited in scale, largely site-specific and reversible, and manageable with standard safeguards. These include localized effects on marine ecosystems and fisheries, seabed and cable-route habitat disturbance, <b>entrainment at seawater intakes, thermal and salinity discharge plumes, and restricted access to customary fishing grounds</b> . The definitive category will be confirmed by the ESIA at the feasibility / Funding Proposal stage. It would be revised to Category A if the |                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>A.15. Has the CN been shared with the NDA(s)?</b>                                  | Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                 |

<sup>2</sup> See [here](#) for access to project preparation support request template and guidelines.

<sup>3</sup> Refer to the Fund's environmental and social safeguards ([Decision B.07/02](#)).



|                                          |                                                                                                                                        |  |  |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|--|--|
|                                          | ESIA identified significant or irreversible impacts, for example on critical coral-reef habitat in the Coral Triangle Initiative area. |  |  |
| A.16. Alignment with country NDCs & NAPs |                                                                                                                                        |  |  |
|                                          |                                                                                                                                        |  |  |
|                                          |                                                                                                                                        |  |  |



**A.17. Has this CN been developed with GCF Readiness support?**

Yes ☐ No ☒

If your answer is yes, please provide additional details including grant agreements and country(ies) involved:

\_\_\_\_\_

**B. Proposal Executive Summary (max. 500 words)**

Papua New Guinea (PNG) faces the dual challenge of high climate vulnerability and a power structure heavily dependent on fossil fuels. In particular, island and coastal regions are directly exposed to climate hazards, such as intensifying cyclones, sea-level rise, coastal erosion, and fluctuating sea temperatures, which threaten livelihoods (fisheries), housing, critical infrastructure, and the stability of energy supply. Concurrently, many remote and island areas still rely on high-cost diesel power generation, leading to continuous increases in greenhouse gas (GHG) emissions, high volatility in electricity tariffs, and structural weaknesses in energy access. Despite the energy sector being one of the fastest-growing sources of GHG emissions in PNG, access to clean and stable energy remains limited. Without a transition to low-carbon, climate-resilient energy systems suited to the marine environment, PNG risks long-term lock-in to carbon-intensive infrastructure, while the climate vulnerability of its most fragile communities will further intensify.

This project aims to supply clean electricity on the Central Province coast serving the Port Moresby demand area, as a model for later replication in coastal and island regions, by introducing innovative ocean-based renewable energy technologies, specifically Salinity Gradient Energy (SGE) and Electrochemical Ocean Thermal Energy Conversion (e-OTEC), with seawater-based Blue Battery storage. The executing entity is the National Energy Authority (NEA) of Papua New Guinea, which will implement the project in collaboration with provincial governments and technology providers particularly the Korea Institute of Energy Research (KIER). The scope of project preparation includes 1. an Environmental and Social Impact Assessment (ESIA) which is critical for issuance of environmental permit by the Conservation Environment and Protection Authority (CEPA). 2. Stakeholder Consultation and Free Prior and Informed Consent (FPIC) Study, including customary marine-tenure agreements, 3. Seismic Assessment/ Geotechnical Assessment Studies, 12-month in-situ oceanographic measurements, bathymetric and habitat surveys, Engineering and other power development studies that may be needed to secure permit from the National Energy Authority including power purchase agreement (PPA) from PNG Power Limited to derisk the project funding. This initiative aligns with PNG's Nationally Determined Contributions (NDC) and National Adaptation Plan (NAP), reducing fossil-fuel dependency and strengthening climate-resilient energy infrastructure. By demonstrating a marine-based renewable energy model applicable to Small Island Developing States (SIDS), the project will lower barriers to technology adoption and create a structural paradigm shift to catalyze future public and private investment. This also aligns with PNG's Climate-Compatible Development Management Policy, the National Energy Policy 2018–2028, Vision 2050, the Sustainable Development Plan (SDP), and the Medium-Term Development Plans (MTDPs).

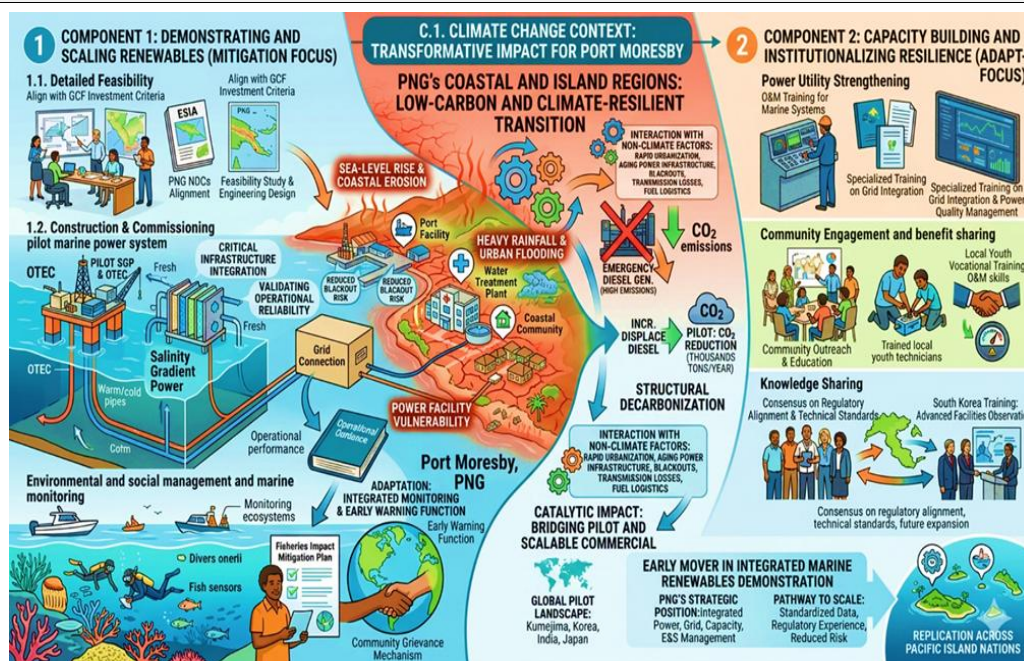
As a first-of-its-kind ocean energy project, it currently faces limited access to private finance due to high upfront investment costs, technological performance uncertainties, lack of local technical capacity, low creditworthiness of remote power utilities, and long payback periods. GCF grant funding will support project preparation, pilot demonstration, environmental and social management, and capacity building to de-risk the project and improve its bankability, thereby facilitating the mobilization of co-financing. This is consistent with the GCF Strategic Plan's priorities for low-emission development and climate-resilient infrastructure. Furthermore, the project will drive the scaling of finance in PNG's renewable energy sector by establishing a scalable financial model that can transition from grant-based pilots to blended finance and Public-Private Partnership (PPP) structures.

The target submission date for the full Funding Proposal is December 2028, subject to (i) identification of an Accredited Entity in 2027, (ii) completion of the feasibility study, including a 12-month in-situ oceanographic campaign, the ESIA and FPIC, in 2027–2028, and (iii) results from the Stage 1 technology demonstration in PNG funded through Korean

R&D (NRF) from 2027. Preparatory work completed under CTCN TA 24-017 includes the pre-feasibility study, stakeholder mapping, preliminary site screening and the *CCDA Technical Review of marine-energy data (April 2026)*. The next steps are the identification of an Accredited Entity (AE) and the preparation of the Funding Proposal over 2027–2028. This includes *a feasibility study with a 12-month in-situ oceanographic campaign*, the Environmental and Social Impact Assessment (ESIA), FPIC and stakeholder consultations. Preparation funding, including possible Project Preparation Facility support, will be sought once the AE is confirmed. In parallel, a Stage 1 technology demonstration in PNG, funded through Korean R&D (NRF), is planned from 2027.

## C. Proposal Information

### C.1. Climate change context (max. 500 words)



This proposal addresses climate issues directly applicable to the coastal and port areas of Port Moresby and the adjacent Central Province coast, employing a cross-cutting approach that simultaneously achieves greenhouse gas (GHG) mitigation and climate adaptation. The project design is structured to align with the Investment Criteria outlined in GCF Decision B.33/12 (Impact Potential: scale, sustainability, innovation, transformationality, and equity).

**Alignment with GCF investment criteria.** Impact Potential: combined mitigation (fossil-fuel displacement) and adaptation (resilient supply to critical loads). Paradigm Shift: first-of-its-kind ocean-energy model replicable across Pacific SIDS. Sustainable Development: co-benefits in jobs, gender, freshwater (desalination) and SDG 7. Needs of the Recipient: addresses high fossil-fuel generation cost and weak climate-finance access. Country Ownership: aligns with PNG's NDC 2.0, NAP, Climate-Compatible Development Management Policy, *National Energy Policy 2018–2028*, Vision 2050, STaRS and the MTDPs. Efficiency & Effectiveness: GCF concessional finance addresses the upfront CAPEX and O&M-capacity barriers.

**Mitigation:** Port Moresby accounts for a significant portion of PNG's total power demand, and its grid depends substantially on fossil fuels: *of 311 MW nominal capacity, about 40% is hydropower, 33% natural gas and 25% diesel/HFO (CCDA Technical Review)*. Critical infrastructure, including ports, cold storage/fishery processing plants, logistics hubs, hospitals, and water treatment facilities, relies heavily on emergency diesel generators during frequent



outages, resulting in high emissions per unit of power. This structure leads to rising emissions in the capital region and increasing energy costs. This project will establish a pilot for Salinity Gradient Energy (SGE) and Electrochemical Ocean Thermal Energy Conversion (e-OTEC) on the Central Province coast. By integrating these with the local grid, the project will incrementally displace fossil-fuel generation. The pilot phase is expected to avoid **about 550–1,020 tonnes of CO<sub>2</sub> per year** (A.6), while the scaling phase will catalyze the structural decarbonization of the capital's energy mix.

**Adaptation:** Port Moresby is increasingly vulnerable to climate hazards such as sea-level rise, coastal erosion, anomalous wave patterns, heavy rainfall, and urban flooding. These risks threaten port operations, coastal roads, power facilities, water treatment plants, and hospital accessibility, exacerbating the risks faced by vulnerable populations during power outages. This project will integrate marine environmental monitoring with early warning functions to manage coastal erosion and ecological changes, providing actionable data for urban adaptation planning and sustainable development in communities.

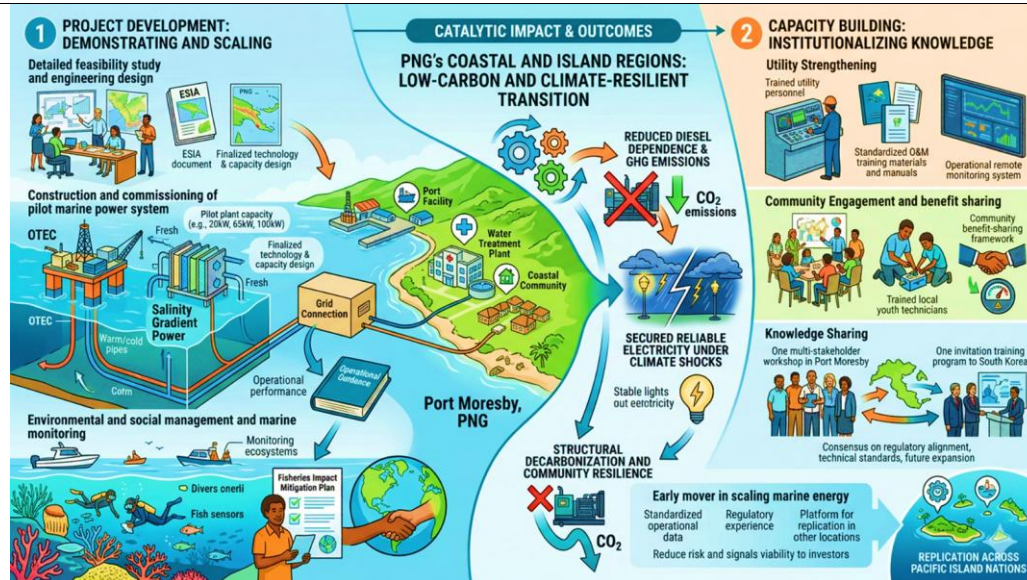
**Interaction with Non-Climate Factors**

Port Moresby faces overlapping challenges, including rapid urbanization, aging power infrastructure, irregular blackouts, high transmission losses (24–28%), and fuel logistics risks. These non-climate factors intensify overall climate vulnerability. The project will mitigate these structural weaknesses by improving grid stability through pilot demonstration and cultivating a local technical workforce.

**Key Barriers:** The primary barriers to investment include performance uncertainties of emerging marine technologies, high upfront capital costs (CAPEX), grid integration risks in urban settings, long payback periods, and a lack of local Operations and Maintenance (O&M) capacity. GCF support will address these barriers by financing the pilot demonstration, grid integration studies, environmental and social management, and capacity building.

**Alignment with National Policies:** The project is fully aligned with PNG's Nationally Determined Contributions (NDC), Including, the Climate-Compatible Development Management Policy, the National Energy Policy, the Vision 2050, SDP, MTDP, etc., which prioritize low-emission transitions in the power sector and the expansion of renewable energy, as well as national directions for strengthening infrastructure resilience in the capital. Furthermore, it integrates with Port Moresby's urban adaptation strategies. In the short term, the project will reduce blackout risks for critical facilities; in the long term, it will drive a paradigm shift toward transforming the capital into a marine-based, low-carbon, and climate-resilient city.

**C.2. Proposed project / programme (max. 1000 words)**



If marine salinity-gradient and ocean thermal energy-based power systems are progressively demonstrated and deployed in conjunction with a local capacity-building programme, then Papua New Guinea (PNG)'s coastal and island regions will reduce fossil-fuel dependence and GHG emissions while securing reliable electricity under climate shocks, because dependable marine-based clean power combined with strengthened local operational capacity enables structural decarbonization and enhances community resilience to climate hazards.

**Recommended demonstration technology and site (responding to PSC/CCDA review).** Of the three technologies presented to the PSC at its final meeting in Jeju (9 March 2026): Salinity Gradient Energy (SGE), electrochemical OTEC (e-OTEC) and the Blue Battery; the recommended configuration is a hybrid system combining all three, which ranks first in the multi-criteria analysis of the pre-feasibility study. The technologies are at different maturity levels: SGE at TRL 5–6 (KIER's 5 kW pilot in operation since 2018) and e-OTEC at TRL 4 (laboratory scale). The output of e-OTEC depends on the depth of the cold-water intake: the thermal gradient is  $\approx 23\text{--}26\text{ K}$  with water from  $\sim 1,000\text{ m}$ , but only  $\approx 10\text{--}13\text{ K}$  with water from  $\sim 200\text{ m}$ . SGE provides stable, dispatchable output from the four Central Province rivers ( $\sim 455\text{ m}^3/\text{s}$  combined;  $\sim 360\text{--}368\text{ MW}$  technically feasible).

**Recommended site.** The Central Province coast is the recommended area: it lies away from the high-turbidity plumes of the Fly and Sepik–Ramu rivers and is close to PNG's largest demand centre. The CCDA Technical Review (April 2026) classes the Port Moresby harbor and the sectors extending west as non-viable because of NMSA shipping lanes, and identifies an optimal zone between Kemabolo and Hula (Annex G.1), with a cold-water pipe of about 6–8 km to the 1,000 m depth contour, a marine cable of about 14 km to a substation near Kemabolo and a connection to Port Moresby via the existing PPL grid network. A 10 MW-class plant requires about 5 ha of land near electricity consumers, which also favours the Port Moresby coast outside the harbour and shipping lanes. Both candidate areas lie within the Coral Triangle Initiative area, so habitat surveys are required at either site. The final footprint will be confirmed with the PSC, NMSA and CEPA during Funding Proposal preparation.

**Implementation strategy.** The project follows a two-stage approach. In Stage 1 (from 2027, Korean R&D funding through NRF), an e-OTEC pilot of about 10 kW with a shallow intake and a Blue Battery of up to 100 kWh will be demonstrated in PNG to validate the technologies under local conditions. Stage 2, proposed in this Concept Note, scales up to the hybrid pilot and prepares a 10 MW-class integrated plant, which would require about 5 ha of land close to an electricity demand center. A deep cold-water intake for high-efficiency e-OTEC will be included if it can be provided by a PNG partner.

The detailed activities for each component are provided below.

**Component 1: Project Development (USD 0.35 M)**

The objective is to confirm the site, technology configuration and design basis, and to obtain the permits required for construction.

This will be achieved through the following activities.

**1.1 Detailed feasibility study, site survey and basic design**

Technology selection and pilot capacity will be finalised on the basis of a 12-month in-situ oceanographic campaign (temperature and salinity profiles to ~1,000 m, currents, suspended sediments), river gauging, multibeam bathymetry and side-scan habitat survey, and seismic/geotechnical investigation. The basic design will specify the intake and discharge systems, marine structures and grid connection. A comprehensive environmental and social impact assessment (ESIA) will be conducted under the Environment Act 2000 and GCF safeguards, leading to the CEPA environmental permit, together with FPIC and customary marine-tenure agreements with the communities concerned.

Expected outputs include: (i) confirmed site, technology and capacity design; (ii) basic design of intake, discharge and grid connection; (iii) a completed ESIA and environmental permit; (iv) FPIC and customary marine-tenure agreements; and (v) an implementation roadmap.

**Component 2: Construction and Commissioning of the Pilot Plant (USD 20.5 M)**

The objective is to construct and operate a hybrid pilot (~100 kW SGE, 50–100 kW e-OTEC, 800 kWh Blue Battery) under real service conditions, reducing technological uncertainty and establishing operational experience and technical standards for scale-up.

**2.1 Detailed engineering, construction and commissioning of the pilot marine power system**

Based on the finalized designs, ocean thermal and salinity-gradient generation equipment will be installed, including reverse-electrodialysis and electrochemical OTEC stacks, seawater and freshwater intakes with pre-treatment, pumps, heat exchangers, the cold-water pipe, Blue Battery storage and power-conversion equipment, and electrical connections will be established with nearby facilities (e.g., port facilities, public utilities, hospitals, or coastal communities). The pilot system will operate under real service conditions to generate operational data and validate reliability and maintenance requirements.

Expected outputs include: (i) an installed pilot marine power system; (ii) completed electrical connections to priority facilities; (iii) operational performance data; and (iv) operational guidance.

**2.2 Environmental and social management and marine monitoring**

Coastal ecosystems, fish populations, and seawater temperature changes will be monitored continuously, including intake entrainment/impingement and the discharge plume. A fisheries impact mitigation plan will be developed and implemented in consultation with local stakeholders. Coastal erosion dynamics will be tracked, and a community grievance redress mechanism will operate to address local concerns.

Expected outputs include: (i) periodic marine environmental monitoring reports; (ii) an implemented fisheries impact mitigation plan; (iii) coastal impact monitoring results; and (iv) an operational community grievance mechanism.

**Component 3: Capacity Building (USD 0.11 M)**

The third outcome is that government institutions, utilities, and communities acquire sustained capacity to independently plan, operate, regulate, and expand marine renewable energy systems.

The objective is to systematically strengthen the technical, institutional, and community capacity of Port Moresby to independently plan, operate, regulate, and expand marine-based renewable energy. This component ensures that infrastructure investments translate into sustainable long-term capability within government institutions, utilities, and local communities.

This will be achieved through the following activities.

**3.1 Strengthening power utility capacity**

Targeted training programmes will be delivered to power utility engineers and technicians on operation and maintenance (O&M) of marine energy systems, including safety procedures, troubleshooting, and lifecycle asset

management. Specialized training on grid integration and power quality management will support stable incorporation of marine energy into existing networks. A remote monitoring and diagnostics system will be introduced to enable real-time performance tracking and predictive maintenance, with hands-on training provided to local operators.

Expected outputs include: (i) trained utility personnel; (ii) standardized O&M training materials and manuals; (iii) an operational remote monitoring system.

### 3.2 Community engagement and benefit sharing

Public outreach and education programmes will increase community awareness of renewable energy and climate change benefits. Workshops will be conducted for residents in project-adjacent communities. Technical vocational training will be provided to local youth in maintenance and monitoring skills related to marine energy systems, creating employment opportunities and fostering local ownership.

Expected outputs include: (i) completed community education programmes; (ii) trained local youth technicians; (iii) a community benefit-sharing framework linked to project operations.

### 3.3 Knowledge sharing

One multi-stakeholder workshop in Port Moresby will be conducted to build consensus among government agencies, utilities, research institutions, and civil society on regulatory alignment, technical standards, and future expansion strategies. One invitation training programme to South Korea will allow PNG officials and engineers to directly observe advanced marine renewable energy facilities and offshore utilities.

Expected outputs include: (i) workshop proceedings and policy recommendations; (ii) technical exchange reports from the invitation training program; and (iii) a roadmap for scaling marine energy deployment.

### Catalytic Impact and Competitive Landscape

The proposed project is a strategic demonstration that bridges the gap between small pilot experiments and scalable commercial deployment of marine thermal and salinity-gradient energy. Globally, comparable initiatives remain largely at pilot scale. The Kumejima model in Okinawa, Japan links a 100 kW land-based OTEC plant with desalination, aquaculture, and local industries and has stimulated replication studies in other island contexts, including Palau.

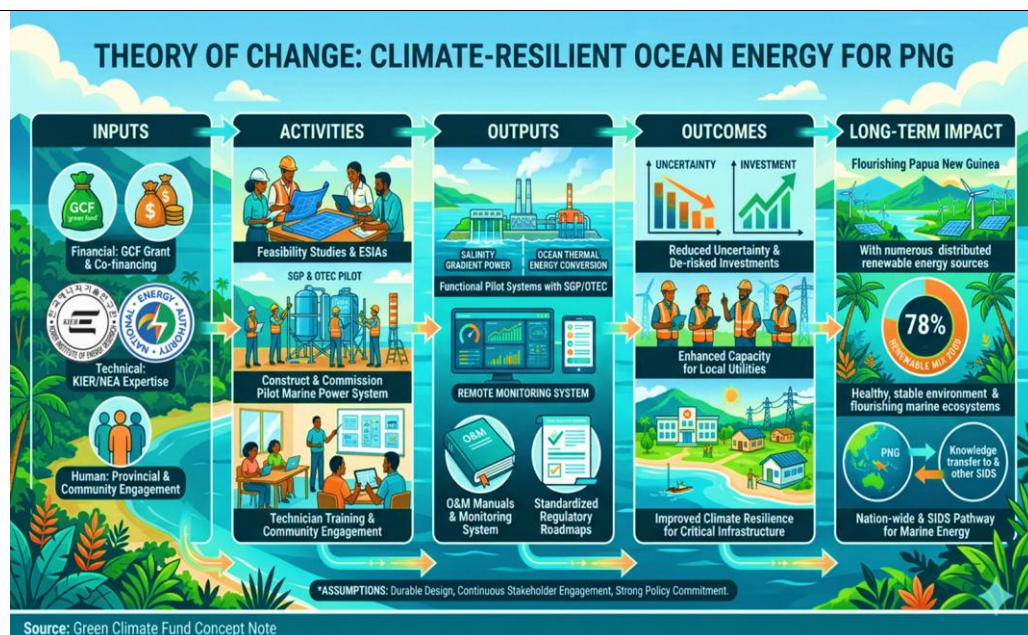
Existing OTEC demonstrations, including those in Japan, Korea and India, use conventional turbine cycles; no field demonstration of electrochemical OTEC has been reported, and salinity-gradient power has been demonstrated only at pilot scale (e.g. KIER's 5 kW RED plant in Jeju).

Against this backdrop, the project positions PNG as an early mover toward an integrated pilot-to-early-commercial demonstration in an urban coastal setting. Unlike stand-alone technology pilots, it combines power generation with grid integration to critical infrastructure, environmental management, and institutional capacity building, aligning international lessons with PNG's coastal energy needs.

No comparable marine energy demonstration of this scale exists in PNG. By generating standardized operational data, regulatory experience, and local technical capacity, the project creates a platform for replication in other coastal and island locations. The demonstration reduces first-of-a-kind risk, signals viability to investors, and complements other renewables by providing stable baseload power, catalysing a pathway in which marine energy becomes a credible component of PNG's long-term low-carbon and climate-resilient transition.

### Project Theory of Change

The project aims to overcome challenges by soft and hard methodologies to support and enhance renewable energy development in Papua New Guinea. The measures in the project aim particularly to increase penetration of renewable energy grid integration and transition for low emissions electricity generation and climate resilient society from high fossil fuel energy consumption in PNG.



The Theory of Change for the "Climate-Resilient Ocean Energy for PNG" project outlines a pathway from foundational inputs to long-term national impact. The table below details out the theory of change for the climate-resilient ocean energy project:

**Theory of Change: Climate-Resilient Ocean Energy for PNG**

| Phase                   | Key Components                                                                                                                                                                                                                                                                                                                                        |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>INPUTS</b>           | <ul style="list-style-type: none"> <li>Financial: GCF Grant &amp; Co-financing</li> <li>Technical: Korea Institute of Energy Research and PNG National Energy Authority Expertise</li> <li>Human: National, Provincial &amp; Community Engagement</li> </ul>                                                                                          |
| <b>ACTIVITIES</b>       | <ul style="list-style-type: none"> <li>Feasibility Studies &amp; Environment Social Impact Assessments (ESIs)</li> <li>Construct &amp; Commission Pilot Marine Power Systems (SGE &amp; e-OTEC)</li> <li>Technician Training &amp; Community Engagement, including women's participation in training and consultations</li> </ul>                     |
| <b>OUTPUTS</b>          | <ul style="list-style-type: none"> <li>Functional Pilot Systems (SGE &amp; e-OTEC with Blue Battery storage)</li> <li>Remote Monitoring System</li> <li>O&amp;M Manuals &amp; Standardized Regulatory Roadmaps</li> </ul>                                                                                                                             |
| <b>OUTCOMES</b>         | <ul style="list-style-type: none"> <li>De-risked Investments: Reduced uncertainty for future projects</li> <li>Enhanced Capacity: Local utilities trained for operations</li> <li>Improved Resilience: Climate-resilient critical infrastructure</li> <li>Gender: Women's participation in the marine-energy workforce and decision-making</li> </ul> |
| <b>LONG-TERM IMPACT</b> | <ul style="list-style-type: none"> <li>Distributed Energy: Flourishing PNG with numerous renewable sources</li> <li>Renewable Mix: Contributing to a 78% renewable energy mix by 2030</li> <li>Environmental Health: Stable marine ecosystems</li> </ul>                                                                                              |



- Knowledge Transfer: Establishing a pathway for other SIDS (Small Island Developing States)• Human resources and capacity building in vulnerable states/island

The success of this model relies on durable design, continuous stakeholder engagement, and strong policy commitment.

### C.3. Country ownership and engagement with stakeholders (max. 250 words)

During the Concept Note development phase, the project proponents conducted initial consultations with various key stakeholders in PNG, including the Climate Change & Development Authority (CCDA), the National Energy Authority (NEA), the Independent Consumer Competition Commission (ICCC), the University of Papua New Guinea (UPNG), the PNG University of Technology (Unitech), the National Institute of Standards and Industrial Technology (NISIT), Water PNG, Conservation and Environment Protection Authority (CEPA), and PNG Power Limited, through the Project Steering Committee of the CTCN technical assistance (five meetings, February 2025 – March 2026). **CCDA, as NDE and NDA, also prepared a Technical Review of marine-energy data (April 2026) and commented on the draft pre-feasibility study and safeguards screening.**

In the upcoming Funding Proposal preparation stage, further engagement, including stakeholder workshops, public hearings, **FPIC with customary owners of the reefs and fishing grounds at the selected site, consultation with NMSA and PNG Ports**, and technical consultations, will be carried out. These efforts aim to incorporate community concerns into the project design and to formalize the regulatory approval and permitting processes.

### C.4. Indicative safeguards profile (max. 500 words)

The project is expected to be classified as Environmental and Social (E&S) Category B (indicative, pending ESIA; see Annex G.3). Key identified risks include disturbances to marine ecosystems **in and near Coral Triangle Initiative areas**, impacts on local fishing activities **and access to customary fishing grounds**, and habitat degradation resulting from the installation of offshore facilities, **entrainment and impingement of marine organisms at the intakes, the thermal and salinity discharge plume, and the use of anti-fouling agents and electrolytes**. These risks will be mitigated through a comprehensive Environmental and Social Impact Assessment (ESIA), continuous marine ecological monitoring, **low-velocity screened intakes, discharge below the photic zone, low-toxicity fouling control**, and ongoing stakeholder consultations.

This project holds significant potential to contribute to gender equality by improving energy access for women and generating local employment opportunities. While the risk of Sexual Exploitation, Abuse, and Harassment (SEAH) is assessed as low, a formal Code of Conduct and grievance redress mechanisms (reporting procedures) will be established. **Coastal communities in PNG hold customary ownership of reefs and fishing grounds; the project will apply Free, Prior and Informed Consent (FPIC) and conclude customary marine-tenure agreements before any marine installation, and will implement measures to minimize negative impacts on traditional livelihoods.**

### C.5. Exit strategy and sustainability of impacts (max. 250 words)

This project is not merely the construction of a single power generation facility; it will create a lasting paradigm shift by presenting a new development pathway that establishes marine-based renewable energy as a core power source for Papua New Guinea's coastal and island regions. By transitioning power systems, that rely on fossil fuels into low-carbon systems powered by Salinity Gradient and Ocean Thermal Energy, the project will establish a standardized model scalable to other island regions. The impact of this paradigm shift is expected to persist for at least 20 to 30 years beyond project completion.

Ownership and operational rights of the installed facilities (including intake/discharge infrastructure, **electrochemical stacks**, heat exchangers, storage, and onshore substations) will be transferred to a designated state-owned energy

enterprise. Furthermore, a joint management framework for marine intake structures and subsea cables will be established in coordination with the Climate Change & Development Authority (CCDA), the Conservation and Environment Protection Authority (CEPA), the National Maritime Safety Authority (NMSA), the National Energy Authority (NEA), and PNG Power Limited (PPL).

To ensure long-term sustainability after project closure, regular performance monitoring, marine ecosystem impact assessments, and social impact evaluations will be conducted. The resulting data will serve as an evidence base for scaling up the project to other local coastal provincial centres and island communities in PNG. Additionally, the project is designed to reduce long-term dependence on external technology by building local capacity for operation and maintenance (O&M), ensuring the facilities are managed by a domestic professional workforce. Through these efforts, the project will move beyond a one-off intervention to establish a sustainable, nation-wide pathway for marine renewable energy transition.

#### D. Indicative Financing Information

##### D.1. Total financing (max. 500 words)

Please provide a tabular presentation of the estimated sources and uses of funds in the proposal and disaggregate by source of financing (i.e., GCF financing and co-financing) and financial instrument.

| Sources of Funds          |                                                     |                | Uses of Funds                                                                        |                |
|---------------------------|-----------------------------------------------------|----------------|--------------------------------------------------------------------------------------|----------------|
| Name of Institutions      | Financial Instrument                                | Amount (USD)   | Use of Funds                                                                         | Amount (USD)   |
| GCF                       | Grant                                               | 20.96 M        | Pilot construction & commissioning                                                   | 20.50 M        |
| PNG Government / NEA      | In-kind (staff, site access, permitting)            | Not quantified | Project development (feasibility study, site survey & basic design, CEPA permitting) | 0.35 M         |
| KIER (technology partner) | In-kind (technology, engineering support, training) | Not quantified | Capacity building                                                                    | 0.11 M         |
| <b>Total Sources:</b>     |                                                     | <b>20.96 M</b> | <b>Total Uses:</b>                                                                   | <b>20.96 M</b> |

Please provide an indicative timeline of fundraising, project execution, and repayment / exit. Describe the status of co-financing arrangements (i.e., status of commitment and the certainty / timing). Consider also adding a capitalisation table, as necessary.

**Indicative sources and uses (to be finalised at Funding Proposal stage).** The uses of funds are taken from the project budget and total ~USD 20.96 M: project development USD 0.35 M; pilot construction and commissioning USD 20.5 M; capacity building USD 0.11 M. Within the pilot, the SGE unit (100 kW) is estimated at ~USD 4.0 M, the e-OTEC unit (50–100 kW) at ~USD 3.0–3.5 M and the 800 kWh Blue Battery at ~USD 2.5–3.0 M; the remaining ~USD 10–11 M (detailed engineering, marine works, grid connection, E&S management, contingency) will be itemised in the feasibility study. The GCF grant is requested for the full project cost and acts as catalytic finance for project preparation, pilot demonstration, E&S management and capacity building. NEA and KIER will contribute in kind (staff, site access and permitting; technology, engineering support and training); these contributions will be quantified during Funding Proposal preparation. A Stage 1 technology demonstration funded through Korean R&D (NRF) from 2027 provides parallel financing. For the scale-up toward a **10 MW-class plant**, blended finance will be sought, including loans or guarantees from development partners (e.g. ADB, World Bank) and private investment under a PPP/PPA structure.

**메모 포함[1]:** Need to develop Portfolio of marine energy system in PNG. On the given budget, how to comprise marine energy technology in PNG is key of Portfolio. (Capacity of e-OTEC, Blue-Battery, Salinity gradient energy etc.)

**메모 포함[2R1]:**

**메모 포함[3]:**  
Should be revised according to the budget.

D.2. Indicative terms – non-grants only (max. 500 words)

For projects involving instruments other than grants, please attach a table of indicative key terms. Below is an example for illustrative purposes only (for a fund-type investment). Please adapt as needed for the financing instrument being proposed. Where available, a simplified financial model should be provided as an annex to this document.

| Summary of terms  |  |
|-------------------|--|
| Capitalisation    |  |
| Fund domicile     |  |
| Legal form        |  |
| Regulatory status |  |
| Fund Type         |  |
| Fund term         |  |
| Target return     |  |
| Instruments       |  |
| ...               |  |

D.3. Financial structure (max. 500 words)

The project uses a GCF grant as catalytic finance, with in-kind contributions from NEA and KIER. GCF funds are mainly used for project development, pilot facility construction, environmental and social management, and capacity building. Blended finance, including a public-private partnership (PPP) structure, will be sought for the scale-up phase.

The Accredited Entity (AE) will be identified in consultation with CCDA as NDA; it will entrust and manage GCF funds and oversee procurement, financial controls, and compliance with environmental and social safeguards. The Executing Entity (EE) is the National Energy Authority (NEA) of Papua New Guinea, which oversees the project management unit, stakeholder coordination, regulatory licensing, coordination of environmental monitoring with CEPA, and overall performance management. KIER acts as a technology partner, providing the SGE, e-OTEC, and Blue Battery technologies, engineering support, and training.

Ocean thermal and salinity-gradient power generation is a first-of-its-kind technology in PNG, and it is difficult to access commercial finance due to performance uncertainty, high initial cost, and long payback period. Therefore, the GCF Grant is a minimal concessionary means to absorb risks and enable technology demonstration. If other means (loans, equity investment) are used, there is a high possibility that electricity prices will rise excessively or business will be suspended.

Senior Loan (and associated impact) : Can be reviewed during the expansion phase  
 Subordinated Loan (and associated impact): Can be reviewed during the expansion phase

**메모 포함[4]:**  
 Should be confirmed. (discussion should be followed after sharing concept note with CCDA)

*Equity (and associated impact): Not required*  
*Guarantees (and associated impact: MDB warranty can be reviewed during the expansion phase*  
*Reimbursable Grant (and associated impact): Not required*  
*Grant (and associated impact)*

- Establishment of pilot facilities and capacity building
- Improve business bankability by mitigating technology risks and initial capital costs
- Minimizing the increase in electricity tariffs for end beneficiaries

*Have other structures been considered? : No*

#### **D.4. Justification of GCF funding request (max. 500 words)**

*In Papua New Guinea, ocean-based power generation projects using salinity-gradient and ocean thermal technologies combine high initial investment costs, new technology characteristics, and high national risks, and access to existing public and private finance is structurally limited, so GCF grant support is necessary. PNG's island and coastal areas have small and dispersed electricity demand, limited financial creditworthiness of power utilities, weak domestic capital market, and low ability of end users to pay electricity bills. In this context, commercial banks or private investors are reluctant to participate in this project due to the long payback period, uncertainty in the performance of marine renewable technology, and risks in the construction and operation of offshore and coastal infrastructure. As a result, alternative financial instruments such as pure commercial loans and private project financing are currently difficult to use in reality.*

*GCF grants serve as key catalyst funds to absorb early-stage risks that are difficult for the market to afford, particularly high capital costs, technology demonstration risks, and uncertainty in the project development phase. GCF support enables the transition from concept to actual implementation by lowering capital costs, shortening the actual payback period, and improving the financial viability of the business. GCF support will facilitate structural transformation by introducing a new low-carbon pathway to PNG's island power system, demonstrating the technical feasibility of ocean-based renewable energy in Pacific Island countries, and creating a model that can be spread to other regions.*

*Without GCF support, the project is likely to be drastically scaled back, delayed, or cancelled, leading to continued dependence on fossil-fuel power generation, increased energy insecurity, and loss of greenhouse gas reduction opportunities. In addition, if only non-concessional finance is used, electricity prices may increase excessively, or long-term dependence on government subsidies may be unavoidable, hindering political and social sustainability. On the other hand, if there is support from the GCF, this project will be promoted on a full-scale scale to optimize resource efficiency, promote joint financial resources with multilateral development banks, etc., and build sustainable climate infrastructure with a lifespan of about 30 years.*

*The project is designed to facilitate the expansion of public and private finance in the PNG renewable energy sector. Successfully demonstrating the reliability of ocean-based power generation will reduce market awareness of technology risks and attract subsequent investment from development partners such as ADB and the World Bank. In the long term, it is possible to build a mixed finance ecosystem that combines government budgets, electricity bill revenues, and private capital, gradually transforming into a sustainable financial structure that reduces dependence on GCF.*

*The final beneficiaries, island households, regions, companies, and local governments, have difficulty accessing finance directly due to low incomes and poor access to financial institutions. If the entire cost of the project is transferred to electricity bills, there is a risk that energy poverty will intensify. Therefore, GCF subsidies are essential to absorb a significant portion of the initial investment, minimizing electricity tariff increases and ensuring energy access for vulnerable populations.*

*In conclusion, GCF grants are essential as a strategic investment not only to make this project feasible but also to accelerate the long-term low-carbon electricity transition in the island region of Papua New Guinea.*

#### E. Accredited Entity / Executing Entity Information (max. 500 words)

The Accredited Entity (AE) for this project will be confirmed at a later date, and the Executing Entity is the National Energy Authority (NEA) in partnership with the Climate Change and Development Authority (CCDA) and the Korea Institute of Energy Research (KIER). The AE will assume ultimate responsibility for GCF financial management, fiduciary responsibility, financial control, procurement oversight, and environmental and social risk management, and will work closely with NEA to ensure quality assurance, performance management, and compliance with GCF policies across the business.

The [NEA of Papua New Guinea](#), established by the NEA Act 2021, is the independent regulator for the electricity, gas, and downstream petroleum industries. It drives the National Energy Policy 2018–2028, supporting the national targets of 70% electricity access by 2030 and 100% renewable generation by 2050.

Key functions of the NEA include:

- **Regulation:** Acting as the primary technical and economic regulator for PNG's energy sector, ensuring safety, compliance with standards, and managing licenses for electricity and gas operators.
- **Policy Implementation:** Implementing the [National Energy Policy 2018–2028](#) and the National Electrification Rollout Plan (NEROP), which aims to increase rural and urban electrification.
- **Renewable Energy Promotion:** Developing policies for and driving projects in hydro, geothermal, solar, wind, and bioenergy to reduce reliance on fossil fuels.
- **Sector Oversight:** Facilitating private sector investment, issuing independent power producer (IPP) licenses, and monitoring energy sector development projects.
- **Rural Electrification:** Coordinating the implementation of off-grid and small power systems to increase rural electricity access.

The NEA works to enhance national energy security and aligns its goals with the United Nations Sustainable Development Goal 7 (affordable and clean energy), and PNG Vision 2050.

The [Climate Change and Development Authority \(CCDA\)](#) in Papua New Guinea acts as the lead agency for managing, coordinating, and implementing national efforts on climate change, mitigation, and sustainable, low-carbon development. Key functions include developing national climate policies, managing greenhouse gas reporting, facilitating international climate agreements (e.g., Paris Agreement, UNFCCC), and overseeing REDD+ initiatives to conserve forest resources.

Key functions of the CCDA include:

- **Policy Development and Implementation:** The CCDA is responsible for creating and enforcing national policies and strategies for climate change adaptation and mitigation.
- **Coordination and Monitoring:** The authority coordinates climate-related projects across various government agencies and stakeholders, ensuring sustainable, low-carbon growth.
- **International Compliance & Reporting:** As the national focal point for the UNFCCC and the Green Climate Fund (GCF), the CCDA manages national greenhouse gas inventories and compliance with international climate agreements.
- **REDD+ and Sustainable Forestry:** The authority leads in reducing emissions from deforestation and forest degradation (REDD+), promoting sustainable forest management.
- **Climate Finance and Partnerships:** It manages climate finance and facilitates partnerships to ensure effective implementation of climate action and environmental protection.
- **Institutional Strengthening:** The CCDA focuses on improving accountability and efficiency through automated systems and capacity building to foster climate-resilient development.

The CCDA is designed to ensure that Papua New Guinea's economic development is compatible with the need to mitigate climate change. It is the key government agency responsible for Papua New Guinea's climate change response, NDC implementation, and international climate finance projects. In particular, CCDA serves as PNG's



National Designated Authority (NDA) to the GCF and as National Designated Entity (NDE) to the CTCN and has experience in implementing many GCF Readiness projects, GEF projects, and UNDP and ADB support projects. This experience provides an important institutional foundation for managing innovative and complex climate infrastructure projects such as this one.

In terms of funding flow structure, GCF funds will be transferred to NEA and its project partners through AE, which will allocate them to feasibility studies, build pilot power generation facilities, and strengthen community capacity.

In terms of sustainability standards, NEA and its project partners will formally commit to full compliance with the Papua New Guinea Environmental Permit requirements, GCF Environmental and Social Policies, SEAH requirements, and Indigenous Peoples' Policies. In addition, this project will be designed and implemented to reflect internationally recognized sustainable finance principles. This will ensure that this project goes beyond simple infrastructure construction and establishes itself as a responsible climate finance project that meets international standards.

In conclusion, NEA has the legal authority and policy mandate over the energy sector, including licensing and PPAs, and working with CEPA (environmental permitting) and CCDA (climate finance and NDA functions) it is the best implementing agency to successfully implement this project. NEA's involvement is a key factor in ensuring the project's institutional legitimacy, environmental sustainability, and long-term operational stability.

#### F. Key Risks / Mitigation measures (max. 500 words)

This project is a project to build low-carbon power generation using salinity-gradient and ocean thermal resources in coastal and island areas of Papua New Guinea, and has great potential to contribute to mitigating climate change and improving energy access, but there is a combination of external environmental risks and risks arising from the project itself. To systematically manage these risks, the project adopts a risk management strategy that combines a phased approach, climate-resilient design, strong stakeholder engagement, and GCF support.

In terms of external environmental risks, first, there are policy and regulatory risks. Changes in marine permits, electricity tariff regulations, and protected area designations can affect project timelines and costs. To alleviate this, a joint coordination committee involving the National Energy Authority, the Climate Change & Development Authority, the National Maritime and Safety Authority, the Conservation Environment Protection Authority and PNG Power Limited will be established to review regulatory consistency and conduct regular policy monitoring. The GCF grant assistance will mitigate regulatory risks by supporting regulatory analysis, legal and institutional advice, and stakeholder reconciliation costs.

**Applicable PNG marine permits and approvals (to be secured at feasibility stage).** Marine Pollution / Sea-Dumping Permit (NMSA) for any discharge; **navigation-safety approval (NMSA) for moored structures**; Marine Scientific Research Permit for marine surveys; Port permits (PNG Ports Corporation Ltd) for works in port areas; Fishing licences / access considerations (National Fisheries Authority); and, for any foreign vessels involved in installation, Customs cruise and coasting-trade permits. An Environmental Permit from CEPA (**following the ESIA under the Environment Act 2000**) and an energy licence/PPA pathway via NEA and PNG Power Ltd are also required.

Second, there is a risk of climate and natural disasters. Anomalous waves, cyclones, and seawater temperature fluctuations can hinder the stability of marine facilities. This project introduces the design of durable marine structures, the application of climate-resilient standards, real-time marine environmental monitoring, and early warning systems. GCF funding supports additional costs for climate-resilient design and the construction of monitoring infrastructure to reduce physical risks.

Third, there is the risk of community acceptance. Conflicts with fishing activities, concerns about livelihood impacts, and lack of information can lead to social conflicts. To mitigate this, free and prior informed consent **and customary marine-tenure agreements**, a shared benefit sharing mechanism, and a platform for continuous participation will be established.

In terms of business-related risks, first, there is technical performance risk. Salinity-gradient power has been demonstrated only at pilot scale and electrochemical OTEC only in the laboratory, so performance uncertainty is high. This project adopts a phased approach of expansion after pilot demonstration, and applies internationally verified

technology partner selection and independent technology verification. GCF absorbs technology risk by subsidizing initial pilot demonstration costs.

**Technology-specific risks and mitigation.** SGE / RED: principal risk is membrane fouling from high suspended solids (TSS) and organic load in tropical river inflows, which reduces power density and raises O&M cost; mitigated by siting away from major-river plumes, a  $\geq 10$  m seawater intake (stable  $\geq 34.4$  PSU), pre-treatment, and a membrane-replacement schedule. e-OTEC: the principal risk is the available thermal gradient:  $\approx 23\text{--}26$  K with a  $\sim 1,000$  m intake but only  $\approx 10\text{--}13$  K with a  $\sim 200$  m intake, which lowers power density about three-fold; mitigated by 12-month temperature profiling, a net-output calculation including pumping loads, and a deeper-intake option. Further risks are cold-water-pipe integrity, biofouling/scaling of heat-exchange surfaces and seismic exposure, mitigated by corrosion-resistant materials, real-time monitoring and a seismic/geotechnical study. Both: marine-ecosystem and fisheries effects, entrainment/impingement and discharges managed via ESIA, monitoring and the fisheries mitigation plan.

**Waste management and decommissioning.** Because the technology is at demonstration stage, a decommissioning and waste-management plan, including responsibility for removal costs, will be agreed among NEA, CCDA and KIER before installation. Should the technology be assessed as unsuitable after the demonstration, the equipment will be removed in line with this plan. Membranes, electrodes and electrolytes (including the  $\text{Fe}(\text{CN})_6$  redox electrolyte) will be handled and disposed of in line with PNG environmental regulations and the ESMP.

Second, financial risk. High initial investment costs and long payback periods limit private sector access to finance. To mitigate this, GCF Grants are used to lower capital costs and secure stable revenue streams through long-term power purchase agreements. The GCF will improve the bankability of the business and facilitate the subsequent attraction of joint funding.

Third, there is operation and maintenance (O&M) risk. Lack of local capacity may reduce the utilization rate. To alleviate this, long-term training and remote monitoring will be introduced for local technical personnel. The GCF will support capacity building and technology transfer costs.

Collectively, the project can maintain manageable risk levels through systematic risk mitigation strategies and GCF's catalytic support, achieving climate mitigation, energy access, and community benefits.

| Risk                                                          | Mitigation                                                                             |
|---------------------------------------------------------------|----------------------------------------------------------------------------------------|
| 1. Licensing delays                                           | Joint Coordination Committee, Fast-Track Consultation, Regulatory Monitoring           |
| 2. Changes in electricity tariff regulations                  | Signing of long-term PPA, MOU with government                                          |
| 3. Anomalous waves and cyclones                               | Climate-resilient design, early warning                                                |
| 4. Community opposition                                       | Profit sharing, job creation, FPIC and customary marine-tenure agreements              |
| 5. Uncertainty in technical performance                       | Pilot demonstration, independent verification                                          |
| 6. Insufficient e-OTEC thermal gradient at shallow intake     | 12-month temperature profiling; net-output calculation; deeper-intake option           |
| 7. Navigation conflict and Coral Triangle proximity           | Site outside NMSA shipping lanes and CTI-sensitive reefs; early NMSA/CEPA consultation |
| 8. Marine pollution from anti-fouling agents and electrolytes | Low-toxicity fouling control; closed electrolyte loops; discharge limits in the ESMP   |
| 9. High initial investment cost                               | GCF Grant, PPA                                                                         |
| 10. Current lack of O&M capabilities                          | Capacity building training and co-operation                                            |



#### G. Supporting documents to be uploaded

- ☒ G.1. Map indicating the location of the project, if available
- ☒ G.2. Pre-feasibility study, if available
- ☒ G.3. Results of environmental and social risk screening
- ☒ G.4. Theory of change diagram (public sector only)
- ☐ G.5. Simplified economic and financial model with key assumptions and potential stressed scenarios, if available (private sector only)
- ☐ G.6. Evidence of NDA support, if available

## ANNEX G.3

### Results of Environmental and Social Risk Screening

*Indicative screening (Concept Note stage) –pending full ESIA at feasibility / Funding Proposal stage*

| Item                  | Entry                                                                                                                                                                                                                                                                               |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Project title         | Enhancing Climate-Resilient and Sustainable Energy Access in Papua New Guinea through Ocean-based Renewable Energy Utilizing Salinity Gradient and Ocean Thermal Resources                                                                                                          |
| Country               | Papua New Guinea                                                                                                                                                                                                                                                                    |
| Target site           | Central Province coast: Port Moresby coast outside the harbor, NMSA shipping lanes and CTI-sensitive areas, or the Kemabolo–Hula coastline; subject to PSC/CCDA confirmation.                                                                                                       |
| Executing Entities    | National Energy Authority (NEA), with CCDA as NDA and the Korea Institute of Energy Research (KIER) as technology partner.                                                                                                                                                          |
| Technologies screened | Electrochemical Ocean Thermal Energy Conversion (e-OTEC), Salinity Gradient Energy (SGE/RED), and Blue Battery storage – hybrid pilot                                                                                                                                               |
| Screening basis       | GCF environmental and social safeguards (Decision B.07/02); GCF revised ESS screening guidance. Desktop screening based on the Concept Note KIER workshop analysis, the CCDA Technical Review (April 2026), and the NDE comments on the draft screening; no field survey conducted. |

#### 1. Purpose and how to read this screening

This annex documents the indicative environmental and social (E&S) risk screening for the proposed ocean-based renewable energy project. Its purpose is to support the No-Objection Letter process and the GCF concept review by setting out, at a preliminary level, the project's likely risk category, the principal risks identified to date, and the safeguard instruments that will manage them.

**This is a screening, not an assessment.** It is based on a desktop review of available information (the Concept Note, KIER's oceanographic analysis of the Port Moresby coast, the CCDA Technical Review, and published literature). No primary field survey, baseline data collection, or stakeholder verification has yet been undertaken. The screening conclusions are therefore indicative and will be confirmed or revised by the full Environmental and Social Impact Assessment (ESIA) to be conducted at the feasibility / Funding Proposal stage. This screening addresses environmental and social risks only; the project's greenhouse-gas emission-reduction rationale and indicative abatement estimates are presented in the Concept Note and will be confirmed through the feasibility-stage MRV design.

#### 2. Indicative risk category

| Item             | Determination                                                                         |
|------------------|---------------------------------------------------------------------------------------|
| GCF E&S category | <b>Category B</b> (I-1/I-2/I-3 applies only to intermediation and are not applicable) |

| Item                    | Determination                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Definition applied      | Medium risk – potential adverse E&S impacts that are limited in scale, largely site-specific, few or no irreversible impacts, and readily manageable through established mitigation measures and standard safeguards.                                                                                                                                                                                                                                                                                                                                                                                                   |
| Rationale               | Identified impacts (marine-ecosystem disturbance, localized fisheries effects, seabed and sub-sea cable habitat disturbance, <b>intake entrainment/impingement, discharge plume</b> ) are localized to the installation footprint and intake/discharge zone and are expected to be reversible with standard mitigation. The pilot is small-scale (100 kW-class hybrid; e-OTEC 50–100 kW; SGE 100 kW; 800 kWh storage) and sited on the southern (Coral Sea) coast away from the high-turbidity Fly and Sepik–Ramu river plumes. No impacts are anticipated of a scale or irreversibility that would warrant Category A. |
| Status of this category | <b>Indicative, pending ESIA.</b> The definitive category will be confirmed once the ESIA is completed at the feasibility / Funding Proposal stage. Should the ESIA reveal significant or irreversible impacts, <b>for example on critical coral-reef habitat within the Coral Triangle Initiative area</b> , the category will be revised accordingly.                                                                                                                                                                                                                                                                  |

### 3. Screening questions by safeguard area

The table below applies standard GCF E&S screening questions across the safeguard performance areas. “Answer” reflects the desktop screening; “Possible” indicates a risk that cannot be ruled out without field data and must be confirmed by the ESIA.

#### Assessment of E&S risks and impacts

| # | Screening question                                                                              | Answer | Basis / notes                                                                                                                                                                                                                                                                                                                                                                                |
|---|-------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Could the project cause adverse impacts to marine or coastal ecosystems and habitats?           | Yes    | Installation of offshore facilities, intake/discharge, and seabed cabling. Localized and site-specific; managed through the ESIA and continuous marine ecological monitoring. <b>The coast lies within or near the Coral Triangle Initiative (CTI) area; multibeam bathymetry and side-scan sonar habitat mapping will be used to keep structures, moorings and outfalls clear of reefs.</b> |
| 2 | Could the project affect local fishing activities or livelihoods dependent on marine resources? | Yes    | Fisheries effects identified in C.4. A fisheries impact mitigation plan to be developed and implemented with local stakeholders.                                                                                                                                                                                                                                                             |

### Concept note template V.3.0

For reference during the interim period (H1 of 2025)  
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| # | Screening question                                                                                   | Answer   | Basis / notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---|------------------------------------------------------------------------------------------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3 | Does the project involve discharge of effluent or thermal/salinity plumes to the marine environment? | Yes      | e-OTEC/SGE involves seawater intake and discharge. <b>SGE discharge is brackish (river water mixed with seawater); the e-OTEC cold-water discharge is ~16–19 °C with a ~200 m intake or ~4–5 °C with a ~1,000 m intake. Anti-fouling agents (e.g., chlorine, copper-based biocides) and the Fe (CN)<sub>6</sub> electrolyte are potential pollutants. Marine Pollution / Sea-Dumping Permit (NMSA) required for any discharge; thermal/salinity plume to be modeled in ESIA, with discharge below the photic zone.</b> |
| 4 | Is the project located in or near a seismically active or geologically hazardous area?               | Yes      | PNG lies on the Pacific “Ring of Fire.” Port Moresby has comparatively lower exposure, but a seismic/geotechnical study is required at the feasibility stage.                                                                                                                                                                                                                                                                                                                                                          |
| 5 | Could sediment, turbidity or suspended solids affect operations or the receiving environment?        | Possible | High TSS/turbidity is a key risk for membrane fouling (SGE). The site was selected to avoid major-river plumes; pre-treatment and intake siting mitigate this risk.                                                                                                                                                                                                                                                                                                                                                    |
| 6 | Could the project generate hazardous waste or require decommissioning of specialized equipment?      | Possible | Membranes, electrodes, electrolytes <b>(including ferricyanide solutions)</b> . Decommissioning and waste-management plan, including responsibility for removal costs, to be agreed among NEA, CCDA and KIER before installation; disposal per PNG regulations and ESMP.                                                                                                                                                                                                                                               |
| 7 | <b>Could intakes cause entrainment or impingement of marine organisms?</b>                           | Yes      | <b>Seawater intakes (≥10 m for SGE; deep intake for e-OTEC) can entrain plankton and fish larvae. Low intake velocities, screening, and intake siting to be specified in the ESIA and ESMP.</b>                                                                                                                                                                                                                                                                                                                        |
| 8 | <b>Could the project affect navigation safety?</b>                                                   | Yes      | <b>The Port Moresby Harbor approaches and western sectors are NMSA shipping lanes (including LNG traffic); the CCDA Technical Review classes them as non-viable. Barge and pipeline siting outside marked lanes; NMSA navigation-safety approval required.</b>                                                                                                                                                                                                                                                         |

#### Community, labor and vulnerable groups

| #  | Screening question                                                                                   | Answer         | Basis / notes                                                                                                                                                                                                                                                                                                                                                                   |
|----|------------------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9  | Are Indigenous Peoples present in or near the project area?                                          | Yes            | Coastal villages in the candidate area hold customary ownership of land, reefs and fishing grounds. Free, Prior and Informed Consent (FPIC) will be applied, customary marine-tenure agreements will be concluded before any installation and impacts on traditional livelihoods will be minimized. The ESIA will confirm the application of the GCF Indigenous Peoples Policy. |
| 10 | Does the project carry risk of involuntary resettlement or physical/economic displacement?           | Yes (economic) | Offshore/coastal siting limits land take, but access to customary fishing grounds may be affected, which constitutes potential economic displacement. To be assessed in ESIA; managed via livelihood/fisheries mitigation and benefit-sharing.                                                                                                                                  |
| 11 | Is there a risk of Sexual Exploitation, Abuse and Harassment (SEAH) or labor-influx impacts?         | Low            | Assessed as low. A formal Code of Conduct and grievance redress (reporting) mechanism will nonetheless be established.                                                                                                                                                                                                                                                          |
| 12 | Could the project have differentiated impacts on women, or opportunities to advance gender equality? | Yes            | Positive potential: improved energy access for women and local employment. Gender considerations to be built into design and benefit-sharing.                                                                                                                                                                                                                                   |
| 13 | Are occupational health & safety risks associated with marine/offshore works and electrical systems? | Yes            | Standard offshore construction and electrical hazards, and handling of process chemicals. Managed via O&M training, safety procedures, and lifecycle asset management (Component 3).                                                                                                                                                                                            |
| 14 | Are there cultural heritage or physical/archaeological resources that could be affected?             | Possible       | Seabed disturbance from cabling/foundations; sites of customary significance. Chance-find procedures and survey to be addressed in ESIA.                                                                                                                                                                                                                                        |

#### 4. Summary of key risks and indicative mitigation

The following consolidates the principal risks carried forward from the screening, with the safeguard instruments and design measures that will manage them. Technology-specific risks reflect the project's hybrid e-OTEC + SGE configuration.

| Key risk                                                                                   | Indicative mitigation                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Marine ecosystem &amp; fisheries disturbance</b>                                        | Comprehensive ESIA; continuous marine ecological monitoring; fisheries impact mitigation plan developed with local stakeholders; community grievance redress mechanism.                                                                                                                                         |
| <b>Seabed &amp; sub-sea cable habitat disturbance (Coral Triangle)</b>                     | Careful intake/discharge and cable-route siting; pre-construction seabed survey ( <b>multibeam bathymetry and side-scan sonar habitat mapping</b> ); joint management framework for marine intake structures and subsea cables with CCDA, CEPA, NMSA, NEA and PNG Power Ltd.                                    |
| <b>Entrainment/impingement at intakes</b>                                                  | Low intake velocities; screening; intake siting away from spawning and nursery areas; monitoring during operation.                                                                                                                                                                                              |
| <b>Discharge plume and chemical releases</b>                                               | Plume modeling; discharge below the photic zone; low-toxicity or non-chemical fouling control; closed electrolyte loops with leak detection; discharge limits in the ESMP.                                                                                                                                      |
| <b>Navigation safety</b>                                                                   | Siting outside NMSA shipping lanes; early NMSA consultation; <b>marking and lighting of moored structures.</b>                                                                                                                                                                                                  |
| <b>Seismic/geological exposure (Ring of Fire)</b>                                          | Site selected for comparatively lower seismic exposure; seismic hazard and geotechnical study at feasibility stage; climate- and hazard-resilient structural design.                                                                                                                                            |
| <b>SGE membrane fouling (high TSS/turbidity)</b>                                           | Siting away from Fly and Sepik–Ramu high-turbidity plumes; seawater intake at $\geq 10$ m (stable, high-salinity $\geq 34.4$ PSU); pre-treatment; membrane-replacement schedule.                                                                                                                                |
| <b>e-OTEC cold-water-pipe integrity &amp; biofouling</b>                                   | <b>Cold-water intake depth to be confirmed (~200 m gives <math>\Delta T \approx 10\text{--}13</math> K; ~1,000 m gives <math>\approx 23\text{--}26</math> K)</b> ; geotechnical and slope-stability survey of the pipe corridor; corrosion-resistant materials; real-time monitoring of heat-exchange surfaces. |
| <b>Climate &amp; natural disaster hazards (cyclones, anomalous waves, SST fluctuation)</b> | Durable marine-structure design; climate-resilient standards; real-time marine monitoring and early-warning functions.                                                                                                                                                                                          |
| <b>SEAH/labor &amp; community/customary tenure</b>                                         | Code of Conduct; grievance redress and reporting procedures; community engagement, benefit-sharing and <b>FPIC with customary owners; customary marine-tenure agreements.</b>                                                                                                                                   |
| <b>Hazardous materials &amp; decommissioning</b>                                           | Decommissioning and waste-management plan, including responsibility for removal costs, agreed among NEA, CCDA and KIER before installation;                                                                                                                                                                     |

| Key risk | Indicative mitigation                                                       |
|----------|-----------------------------------------------------------------------------|
|          | membranes/electrodes/electrolytes handled per PNG regulations and the ESMP. |

## 5. Applicable PNG permits and approvals

The following permits and approvals have been identified as applicable and will be secured at the feasibility / Funding Proposal stage:

- **Environmental Permit** – following the ESIA **under the Environment Act 2000**, issued by the Conservation and Environment Protection Authority (CEPA).
- **Marine Pollution / Sea-Dumping Permit** – for any discharge to the marine environment (National Maritime Safety Authority, NMSA).
- **Navigation-safety approval** – for moored barges, pipelines and cables (NMSA).
- **Marine Scientific Research Permit** – for marine surveys and baseline data collection.
- **Port permits** – for any works within port areas (PNG Ports Corporation Ltd).
- **Fishing licenses** – and access considerations (National Fisheries Authority).
- **Cruise and coasting-trade permits** – for any foreign vessels involved in installation (Customs).
- **Energy license / PPA** – an energy license and Power Purchase Agreement (PPA) pathway via NEA and PNG Power Ltd.
- **Customary landowner and marine-tenure agreements** – with the clans and villages holding customary rights at the selected site.

## 6. Safeguard instruments and next steps

The following instruments will be prepared to manage the risks identified above:

- **ESIA** – full Environmental and Social Impact Assessment, confirming the category and quantifying impacts (feasibility stage).
- **ESMP** – Environmental and Social Management Plan, including monitoring, mitigation and reporting, **fouling-control and chemical-management procedures**.
- **Fisheries Impact Mitigation Plan** – developed and implemented with affected fishing communities.
- **FPIC process** – applied **with customary owners at the selected site, leading to customary marine-tenure agreements**.
- **Stakeholder & grievance instruments** – Stakeholder Engagement Plan, Code of Conduct, and community grievance redress mechanism.
- **Decommissioning plan** – decommissioning and waste-management plan agreed before installation.

### Recommended next steps

- Initiate the desktop environmental baseline review and confirm the screening category through the ESIA scoping study.
- Conduct stakeholder mapping and initial consultations **with customary owners and fishing communities, and begin FPIC**.
- Commission the seismic/geotechnical and water-quality (TSS/turbidity) studies that underpin both safeguards and engineering design.
- **Deploy moored buoys for 12 months to profile temperature and salinity to ~1,000 m, tidal currents and TSS; carry out multibeam bathymetry and side-scan sonar habitat mapping of the candidate footprint.**
- **Consult NMSA and the Marine Environment Division of CEPA on siting before the footprint is fixed.**



**Concept note template V.3.0**  
**For reference during the interim period (H1 of 2025)**  
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**Disclaimer.** *This indicative screening is prepared at Concept Note stage from desktop sources and reflects the project's preliminary design. It does not constitute a completed environmental and social assessment. All risk determinations are subject to confirmation by the full ESIA at the feasibility / Funding Proposal stage, in accordance with GCF environmental and social safeguards (Decision B.07/02) and PNG national requirements*

