

Technical Assistance Closure Report

Objective of the technical assistance (TA) Closure Report:

- To communicate publicly in one document a summary of progress made and lessons learned during the TA towards the anticipated impact (sections 1-4).
- To document qualitative and quantitative data collected during TA, for use in donor and UN reporting (Annex 1).

Steps for completing the TA Closure report:

- The lead TA implementer submits the closure report at the end of the technical assistance as a final deliverable. The TA closure report will capture outputs, outcomes and impacts of all activities conducted under the TA. Please copy and summarise relevant material from previous TA outputs/deliverables and the Response Plan, as relevant.
- A CTCN Manager will review and revise the closure report before final approval by the CTCN Deputy Director.

Important note on public and internal use of the closure report:

Once approved by the CTCN Deputy Director, the TA closure report will be a public document available on the CTCN website www.ctcn-n.org. Selected content will be used for targeted communication activities. Annex 2 is for internal use only and will not be publicly available.

Closure Report for CTCN Technical Assistance

1. Basic information

Title of response plan	Pre-feasibility Study on Ocean Energy focusing on Salinity Gradient Energy Technology and Electrochemical Ocean Thermal Energy Conversion
Technical assistance reference number	2024000020 (PCA Reference: CTCN 24-017)
Country/countries	Papua New Guinea
NDE focal point and organization	Mr. Danny Nekitel — Manager, Mitigation and Low Carbon Growth Ms. Emily Pomoh — CCDA technical lead
Proponent focal point and organization	Name: Mr. Larsen Daboyan Organization: National Energy Authority (NEA), Manager, Research and Statistics Email: Larsen.Daboyan@nea.gov.pg
Designer of the response plan	Hanki Kim, Korea Institute of Energy Research, South Korea (KIER), hankikim@kier.re.kr
Implementer(s) of technical assistance	Korea Institute of Energy Research (KIER)-Distributed Energy Team, Jeju Global Research Center; project lead Dr. Hanki Kim; resource analysis Assoc. Prof. Changhyun Jun (Korea University)
Beneficiaries	Government of Papua New Guinea-National Energy Authority (NEA), Climate Change and Development Authority (CCDA), Department of Petroleum & Energy, Independent Consumer and Competition Commission

	(ICCC), Conservation and Environment Protection Authority (CEPA), PNG Power Limited (PPL), National Institute of Standards and Industrial Technology (NISIT), Water PNG; University of Papua New Guinea (UPNG); PNG University of Technology (Unitech); coastal communities of the candidate area on the Central Province coast
Sector(s) addressed	Energy-Renewable energy generation; Ocean / Marine renewable energy
Technologies supported	Salinity Gradient Energy (SGE)-Reverse Electrodialysis (RED); Electrochemical Ocean Thermal Energy Conversion (e-OTEC); Blue Battery Technology (seawater-based energy storage)
Implementation period and total duration in months	22 August 2024 – 31 May 2026 (≈21 months, including two no-cost extensions of an originally 12-month assistance)
Total budget for implementation	USD 246,500
Description of delivered outputs and products as well as the activities undertaken to achieve them. In doing so, review the log frame of the original response plan and refer to it as appropriate	Output numbering follows the Response Plan log-frame. • Output 1: Implementation planning and communication documents – detailed work plan; Monitoring & Evaluation Plan; CTCN Impact Description (initial and final); Closure and Data Collection Report; Gender Assessment and Action Plan. • Output 2: Preliminary Technical Preparation (including establishment of the Project Steering Committee) - Activity 2.1: Mapping stakeholders, background data analysis and site screening: inception mission to candidate sites near Lae (Basu and Markham rivers, November 2024), which were not retained; subsequent screening of the Central Province coast, including a site visit to Kalo (27 May 2025); PSC established (first meeting 19 February 2025) - Activity 2.2: Inception workshop and data collection: inception workshop (Port Moresby, 11–13 November 2024); single-day seawater/freshwater sampling and CTD measurements at Kalo; installation of lab-scale RED equipment at UPNG (May 2025). See Deviations. • Output 3: Pre-feasibility of the technologies-Salinity Gradient Energy and e-OTEC, including Blue Battery Technology - Activity 3.1: Technical pre-feasibility (commissioning and operational aspects) - Activity 3.2: Socio-economic and financial analysis - Activity 3.3: Pre-feasibility report and stakeholder consultations (communities and government) • Output 4: GCF Concept Note and in-person workshop - Activity 4.1: Development of one GCF Concept Note - Activity 4.2: In-person workshop and project wrap-up (Korea wrap-up program, 8–13 March 2026, including

	the CTCN TA cRD&D Marine Energy Specialist Workshop at GLAD Yeouido, Seoul, on 11 March 2026)
Methodologies applied to produce outputs and products	• Oceanographic analysis using the HYCOM ocean model (August 2024 – August 2025) and AI-based satellite interpretation; historical river-gauge records and GEBCO bathymetry compiled in the CCDA Technical Review (April 2026). • Single-day seawater and freshwater sampling and CTD measurements at Kalo (Central Province), 27 May 2025. • Multi-Criteria Decision Analysis (MCDA) for comparative assessment of candidate ocean energy technologies. • Socio-economic and financial analysis adapted to PNG coastal/island conditions. • Capacity-building seminars and KIER-UPNG young professionals workshop on marine energy. • Stakeholder consultations through PSC meetings (online and in-person), webinars, and the multi-stakeholder specialist workshop at the wrap-up program.
Deviations	The implementation timeline was extended through two no-cost extensions, with the final contractual end date set at 31 May 2026. The extensions were agreed with the CTCN Project Manager to accommodate previous budget administration delays and to allow sufficient time for the wrap-up workshop program and final reporting. Location of the final in-person workshop (Activity 4.2). The Response Plan foresaw the implementer traveling to PNG to present the findings. The final workshop and wrap-up were held in the Republic of Korea (8–13 March 2026) with an eight-member PNG delegation, to combine the final PSC meeting, technical tours of KIER’s operating pilots in Jeju and the specialist workshop in Seoul. Monitoring equipment and datasets (Activity 2.2). The Response Plan foresaw deployment of pressure sensors, current meters and CTD instruments at the site for a specified duration. Field data collection was limited to a single day of sampling and measurements at Kalo (27 May 2025); the resource assessment relied mainly on HYCOM ocean-model data and historical river-gauge records. A 12-month in-situ campaign is recommended for the feasibility stage. Site. The candidate sites visited at inception (Basu and Markham rivers, Morobe Province) were not retained

	because of access and sediment conditions; the assessment moved to the Central Province coast. The CCDA Technical Review (April 2026) identified the Kemabolo–Hula coastline as the optimal zone; final site selection is carried forward to the feasibility stage. Stakeholder webinar and online survey (Deliverable 3.2). <i>not carried out</i>
Anticipated follow-up activities and next steps	• PNG stakeholders (CCDA, NEA, UPNG, Unitech) showed strong interest in proceeding with follow-up projects with the implementer (KIER). Long-term cooperation arrangements were discussed at the wrap-up workshop program in Korea (8–13 March 2026) • A GCF Concept Note was prepared as a deliverable of the TA and reviewed with the Ecosian advisory partner at the final PSC meeting (9 March 2026). The joint visit to GCF headquarters planned for 13 March 2026 was canceled. The Concept Note is therefore delivered to CTCN as a TA deliverable and will be submitted to the GCF once an Accredited Entity has been identified, in coordination with CCDA as NDA. • KIER plans a two-stage follow-up: Stage 1, a technology demonstration in PNG funded by Korean R&D (NRF) from 2027, with a ~10 kW e-OTEC pilot and up to 100 kWh Blue Battery; Stage 2, scale-up to the hybrid pilot through the GCF or other financing. • Complementary funding pathways were articulated through the CTCN TA cRD&D Marine Energy Specialist Workshop (11 March 2026, GLAD Yeouido), which explicitly targeted funding alignment with the Ministry of Science and ICT (MSIT, Republic of Korea), the Green Climate Fund (GCF), the Asian Development Bank (ADB), and the Asian Infrastructure Investment Bank (AIIB). • Continued operation of the lab-scale Reverse Electrodialysis (RED) equipment installed at UPNG as a foundation for ongoing local research, capacity-building, and demonstration. • A 12-month in-situ oceanographic campaign (temperature and salinity to ~1,000 m, currents, suspended sediments), bathymetric and habitat surveys, and FPIC with customary owners at the selected site, as the first steps of the feasibility stage.

2. Lessons learned

	Lessons learned	Recommendations
Lessons learned from the CTCN TA process	- Coordinating stakeholder engagement across PNG's PSC member institutions required substantial time and persistent follow-up, particularly for online PSC meetings spanning a 1-hour time difference between Korea and PNG. - Budget administration delays during the early stages of the project affected the timing of in-country missions and required two no-cost extensions to deliver the full scope of work. - In-country logistics for marine site visits and equipment deployment to remote coastal areas require advance planning and reliable local partners; the May 2025 mission to Kalo benefited from coordination with UPNG and CEPA. - Working with frontier marine renewable energy technologies (SGE, e-OTEC, Blue Battery) required substantial knowledge-transfer effort to bring PNG counterparts to a working understanding of the technical concepts, ahead of meaningful technical decision-making. - The wrap-up workshop program (8–13 March 2026, Korea) demonstrated the value of an integrated multi-day program combining	- Plan for an extended inception phase when working with a multi-institution PSC in a Pacific SIDS context. - Ensure budget administration is finalized before the official start date, to avoid early implementation delays and the need for no-cost extensions. - Establish a single in-country logistics partner early in the project to support equipment deployment, mission logistics, and stakeholder coordination. - Front-load technical knowledge-transfer activities so that PSC members can engage substantively in technical decisions from early-stage meetings onward. - Hold marine fieldwork during the dry season (May–October) to minimize weather-related risks. - Agree at inception how the NDE's and proponent's own technical analyses will feed into site selection and the pre-feasibility study. Budget and schedule moored in-situ instruments from the start when the Response Plan foresees them. - For wrap-up programs, sequence the days to build cumulatively from governance > technical exposure > multi-institution specialist workshop > financing pathway, maximizing strategic impact.

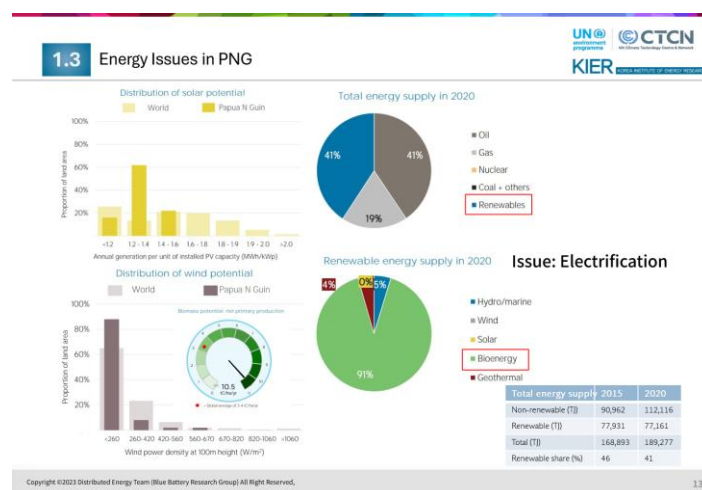
	governance (Day 2 PSC), technical exposure (Day 3 KIER/CFI/Jeju Technopark), multi-institution specialist workshop (Day 4 CTCN TA cRD&D Workshop at GLAD Yeouido), cultural engagement (Day 5), and financing pathway (the GCF visit planned for Day 6 was canceled). • The NDE's own technical review of marine-energy data (April 2026) provided site-selection and regulatory insight: navigation safety, Coral Triangle areas, and customary tenure, which was not available from the implementer's desk analysis. Integrating such national analysis earlier would have avoided divergence between deliverables on site selection. • Field data collection planned in the Response Plan (moored instruments over a specified period) could not be carried out within the TA budget and timeline; single-day sampling is not sufficient to validate model-based resource estimates.	
Lessons learned related to climate technology transfer	Lessons from the project include: • Salinity Gradient Energy (SGE) is suited to PNG's geography: four Central Province rivers with a combined mean flow of $\approx 455 \text{ m}^3/\text{s}$ (historical gauge records) offer a gross potential of $\approx 1.2 \text{ GW}$, of which $\approx 360\text{--}368 \text{ MW}$ is technically feasible at $\sim 30\%$ membrane efficiency. Performance with turbid tropical river water remains to be demonstrated.	• For Pacific SIDS contexts, evaluate SGE and e-OTEC alongside more established renewables (solar, wind): they offer stable baseload and small land footprint, but remain at pilot (SGE) and laboratory (e-OTEC) maturity. • Specify $\geq 10 \text{ m}$ intake depth for SGE installations in PNG coastal waters to ensure salinity and temperature stability across seasons. • Combine ocean-model data with sustained in-situ measurement to bridge data gaps cost-effectively.

	• Electrochemical OTEC (e-OTEC) converts the ocean thermal gradient without turbines or working fluids. In laboratory tests it reaches ~13–18% of the Carnot limit, i.e. an absolute efficiency of ~1%, lower than conventional OTEC (2–3%). Its potential advantage lies in modularity and cost. A shallower cold-water intake (~200 m instead of ~1,000 m) would cut pipe cost but reduces the thermal gradient from ~23–26 K to ~10–13 K; the optimum depth must be established with in-situ temperature data. • Vertical stability at 10 m depth in the Port Moresby coastal waters provides a favourable vertical profile for SGE: surface salinity is highly variable in the wet season (Dec- Mar) but the 10 m depth remains stable (≥ 34.4 PSU) thanks to a strong halocline (model result, to be verified in situ). Seawater intake should be installed at ≥ 10 m depth. • Ocean-model and satellite analysis can bridge data scarcity in PNG at screening level, but must be complemented by in-situ measurements before investment decisions. • Local capacity for operation of frontier marine energy technologies needs to be built progressively; lab-scale RED installation at UPNG provides a hands-on platform for ongoing PNG research and training. • Multi-institution capacity-building-bringing PNG	• Establish lab-scale demonstration / training facilities at host country universities early, to support local capacity-building beyond the TA period. • Pursue Korea-PNG (or wider Pacific) bilateral cooperation to accelerate knowledge transfer in marine renewable energy, leveraging Korea's experience with its first 5 kW RED plant in Jeju. • Engage funding partners across multiple channels (MSIT, GCF, ADB, AIIB) to maximise pathways to follow-on financing.
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counterparts into direct contact with the broader Korean marine renewable energy ecosystem (13 invited experts from 10 Korean institutions, together with KIER at the Day 4 specialist workshop)-substantially exceeds the value of a bilateral implementer-only engagement.

3. Illustration of the TA and photos

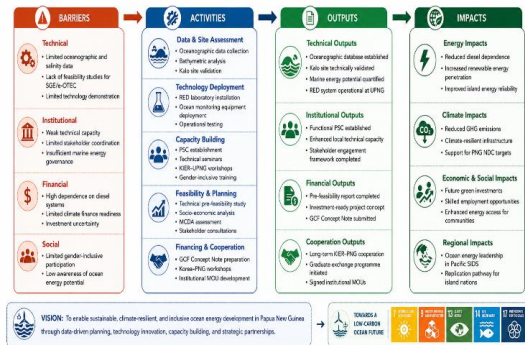
For communication purposes, please provide 2-4 Power Point slides, including illustrations or charts, describing barriers, opportunities, methodology, activities, outputs and achieved results. The illustrations must be copied into the TA Closure report but must also be delivered as power point files. Also, please provide at least five high-resolution pictures in jpg format, capturing technical assistance. The pictures should illustrate how the TA has impacted the lives of the beneficiaries in particular and the communities in general.



	Salinity Gradient Power (in particular, Reverse Electrodialysis)	Electrochemical Ocean Thermal Energy Conversion (e-OTEC)
Gross potential	The total average flow rate of the four target rivers reaches approximately 455 m ³ /s (0.75 kWh/m ³)	Very high
Theoretical Potential	Analysis: The total average flow rate of the four target rivers reaches approximately 455 m ³ /s. Theoretically, this equates to 1.2 GW, representing an immense energy reserve comparable to a nuclear power plant.	Revolutionary Increase Conventional: (dT=19°C) Carnot efficiency 6% → Practical system efficiency: 3% e-OTEC: (dT=20°C) ~20% : stable power generation becomes theoretically possible year-round, regardless of the seasonal cooling (down to 27°C) observed in the southern waters (Port Moresby) due to the Southeast Trade Winds.
Technical potential	High feasibility 1. This potential applies the efficiency of currently commercializing membrane technologies (~30%) (Gross potential) × (System efficiency) 2. Approximately, 368 MW of power generation is technically feasible.	High feasibility The technological barrier related to the Cold Water Pipe (CWP), which is the biggest challenge in OTEC construction, is drastically lowered. 1. Reduced intake depth (1,000 m → 200 m): There is no need to lower pipes to deep sea levels. Intake is possible at a relatively shallow depth of 200 m, reducing pipeline length and installation difficulty by more than 80%. 2. System downsizing Thanks to the high efficiency, the required seawater flow rate to generate the same amount of power is significantly reduced. This decreases the parasitic load and allows for smaller heat exchanger and piping.
Economic potential		High Economic Viability 1. CAPEX reduction: The cost of seawater intake pipeline, which accounts for 40-50% of OTEC construction costs, is drastically reduced due to the shortened depth (200 m) 2. Infrastructure connectivity: The project becomes viable near Port Moresby, which has the highest power demand and existing grid infrastructure.

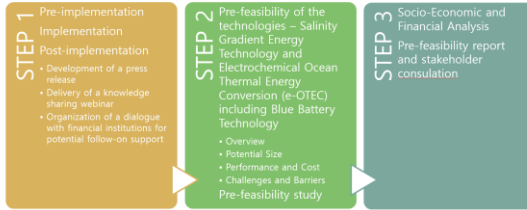
Barriers → Activities → Outputs → Impacts Framework

CTCN Technical Assistance: Ocean Energy Pre-feasibility Study in Papua New Guinea

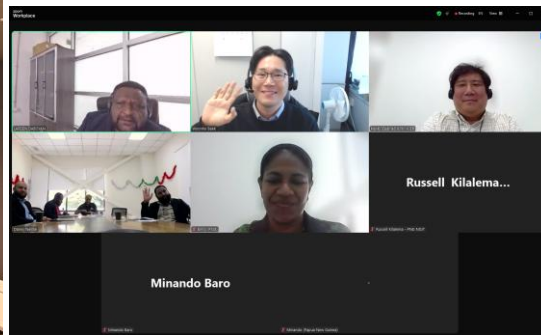
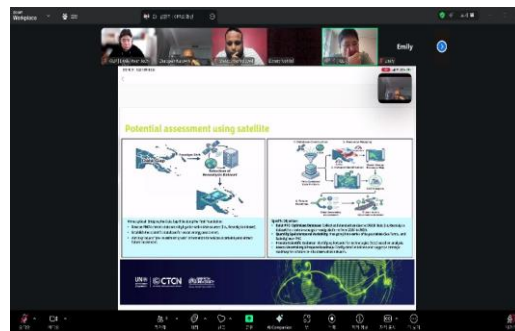


3.3 Major outputs

KIER



1. GCF Concept note and In-person Workshop
2. Development of 1 GCF Concept Note
3. In-person workshop



4. Impact Statement

The information in the table below will be used to communicate results and anticipated impacts of this technical assistance publicly. Please copy information from impact statement developed in the M&E Plan and update as relevant.

Challenge	Papua New Guinea, with vast coastal and marine resources, faces significant challenges in transitioning its energy sector toward sustainable, climate-resilient sources. Remote and island communities depend heavily on diesel and limited grid hydropower, resulting in high energy costs, unreliable supply, and continued GHG emissions. Although emerging ocean energy technologies (Salinity Gradient Energy (SGE) and Electrochemical Ocean Thermal Energy Conversion (e-OTEC), including Blue Battery Technology) hold significant potential for PNG's geographic context, their adoption has been constrained by chronic data scarcity, the absence of feasibility studies tailored to local conditions, and limited national institutional capacity to plan and oversee marine renewable energy projects.
CTCN Assistance	• Establishment of a multi-institution Project Steering Committee (PSC) of PNG energy, climate, regulatory, standards, environmental and academic institutions, with stakeholder mapping screening of candidate sites on the Central Province coast. • Screening-level oceanographic analysis (HYCOM ocean model 2024–2025, AI-based satellite interpretation, historical river-gauge records, initial in-situ sampling at Kalo), addressing PNG's chronic data scarcity for marine energy assessment. • Installation of lab-scale Reverse Electrodialysis (RED) equipment and oceanographic monitoring instruments at UPNG, with capacity-building seminars and a dedicated KIER-UPNG young professionals workshop on marine energy. • Pre-feasibility study of SGE, e-OTEC and Blue Battery technologies in PNG conditions, covering technical, socio-economic and financial analyses with stakeholder consultation.

	• Preparation of a GCF Concept Note for follow-on financing, with a wrap-up workshop program in South Korea (8–13 March 2026) including the CTCN TA cRD&D Marine Energy Specialist Workshop at GLAD Yeouido (Seoul, 11 March 2026) with 13 invited Korean academic and industry experts from 10 institutions, a Concept Note review session with Ecosian advisory partner.
Anticipated impact	• Quantified marine energy potential for PNG: SGE ≈ 1.2 GW gross / ≈ 360–368 MW technically feasible from four Central Province rivers; e-OTEC thermal gradient of ≈ 23–26 K with a $\sim 1,000$ m intake, with a shallower-intake option to be evaluated. • Technical and financial basis for follow-on pilot deployment of SGE and/or e-OTEC on the Central Province coast, with infrastructure connectivity to PNG's highest-demand grid area. • Improved national institutional capacity to plan, regulate and oversee ocean energy projects. • Credible pathway to mobilizing follow-on climate finance through the GCF Concept Note (Core Indicator 4-anticipated GCF funding leveraged), complemented by potential funding alignment with MSIT (Republic of Korea), ADB, and AIIB articulated during the specialist workshop. • Core Indicators 1 and 2: Anticipated metric tons of CO₂e emissions avoided through follow-on pilot/full project displacing fossil-fuel generation and anticipated increased resilience of energy infrastructure to climate-induced disturbances in coastal/island areas. • Catalytic potential for replication across other Pacific Small Island Developing States (SIDS).
Co-benefits: Achieved or anticipated co-benefits from the TA	• Freshwater production through co-located desalination: water-energy nexus; potential aquaculture co-location with ocean energy installations. • Creation of skilled employment opportunities in coastal communities;

	reduced reliance on imported diesel fuel and associated foreign-exchange savings. • Improved energy reliability for remote and island communities, with associated benefits for healthcare access, education and economic activity. • Long-term cooperation with the broader Korean marine renewable energy ecosystem, including academic institutions (Hanyang University, Korea University, Pusan National University, Korea Maritime & Ocean University, Catholic University, public institutes (Korea Testing Laboratory, KEITI), and industry providers (Toray Membrane, Prione, Drive Force), established through the Day 4 specialist workshop. • Screening-level data foundation that reduces uncertainty and supports future investment. • Pioneering position for PNG as a Pacific SIDS leader in frontier marine renewable energy demonstration.
Gender aspects of the TA	• Gender mainstreaming integrated throughout the TA in line with CTCN gender requirements, with a minimum of 1% of the budget allocated to gender-specific activities. • KIER-UPNG young professionals' workshop on marine energy organized during the May 2025 in-country mission with explicit gender equity focus, providing opportunities for women students at UPNG. • Gender-disaggregated participation tracking across all PSC meetings, technical seminars, the inception workshop, the CTCN TA cRD&D Marine Energy Specialist Workshop, and the wrap-up workshop program; women made up ~22% of participants against a GAAP target of ~30%. • Empowering women in coastal-community decision-making: women in PNG coastal communities are disproportionately affected by unreliable electricity (in their roles in household energy management, water collection, and small-scale economic activity), and stand to

	benefit substantially from improved energy reliability through marine renewable energy. • Integration of gender dimensions into the socio-economic analysis chapter of the pre-feasibility study and the safeguards section of the GCF Concept Note.
Anticipated contribution to NDC	• Supports PNG's commitments under its Nationally Determined Contribution (NDC) and National Adaptation Plan (NAP) on renewable energy uptake and climate-resilient infrastructure, by establishing the technical and financial groundwork for ocean energy contribution to NDC implementation. • Generates screening-level marine energy data for PNG, reducing uncertainty for follow-on investment and policy development. • Integrates climate-proofed design standards (≥ 10 m intake depth based on the Port Moresby halocline analysis, climate-resilient marine infrastructure) into pre-feasibility recommendations, aligned with national priorities on infrastructure resilience. • The follow-on GCF-financed project enabled by the Concept Note is expected to displace fossil fuels on the Port Moresby grid and, through replication, in coastal and island systems, and contribute measurable emission reductions toward NDC targets.
The narrative story	Papua New Guinea is a Pacific Small Island Developing State whose population of about 10 million is dispersed across a mainland and hundreds of islands. Many remote coastal and island communities remain dependent on diesel generation, with high costs and unreliable supply. At the same time, PNG's marine geography offers significant potential for emerging ocean energy technologies. The country's coastal waters around Port Moresby exhibit stable salinity profiles favorable for Salinity Gradient Energy (SGE), with four target rivers contributing a combined flow of approximately 455 m³/s and a gross SGE potential of about 1.2 GW. Sea-surface

	temperature variation of 26.4–31.5 °C between seasons and cold deep water offshore support the application of Electrochemical Ocean Thermal Energy Conversion (e-OTEC), a turbine-free technology currently at laboratory scale. Through this CTCN technical assistance, the National Energy Authority (NEA) and the Climate Change and Development Authority (CCDA) partnered with the Korea Institute of Energy Research (KIER) (a leading institution in Salinity Gradient Energy and electrochemical ocean energy systems, operator of Korea’s first 5 kW Reverse Electrodialysis plant in Jeju, South Korea), to conduct the first comprehensive pre-feasibility study of these frontier marine renewable energy technologies in PNG. The assistance combined ocean-model analysis and AI-based satellite interpretation with initial in-situ sampling at Kalo, installed lab-scale Reverse Electrodialysis equipment at the University of Papua New Guinea for ongoing local research and training, and conducted a KIER-UPNG young professionals workshop with an explicit gender equity focus. The pre-feasibility study quantified for the first time that PNG has approximately 360–368 MW of technically feasible SGE capacity at ~30% membrane efficiency in four Central Province rivers, and assessed e-OTEC potential off the Central Province coast. The technical assistance was concluded through an integrated 6-day wrap-up workshop program in the Republic of Korea (8-13 March 2026, Jeju-Seoul-Incheon), comprising Jeju site visits and the final PSC meeting at Maison Glad (Day 2, including a GCF Concept Note review session with the Ecosian advisory partner), Jeju Provincial Government engagement and KIER Jeju Global Research Center technical tours (Day 3), the CTCN TA cRD&D Marine Energy Specialist Workshop at GLAD Yeouido in Seoul (Day 4, with 13 invited Korean academic and industry experts from 10 institutions across marine energy system development, energy materials, energy potential investigation, and system integration), a cultural program (Day 5); a joint visit to the GCF planned for Day 6 was cancelled. The wrap-up program established the foundation for sustained Korea-PNG cooperation, identified follow-
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	on financing pathways across MSIT, GCF, ADB and AIIB channels, and positioned PNG to lead the demonstration of ocean energy technologies in the Pacific region.
Contribution to SDGs A complete list of SDGs and their targets is available here: https://sustainabledevelopment.un.org/partnership/register/	SDG 7. (Affordable and Clean Energy) The TA establishes the technical and financial basis for renewable, affordable, reliable energy access in PNG's coastal and island communities by deploying frontier marine renewable energy technologies (SGE, e-OTEC, Blue Battery), targeting displacement of fossil-fuel generation that currently constrains energy reliability and affordability. SDG 13. (Take urgent action to combat climate change and its impacts) The TA enables future displacement of fossil-fuel generation, contributing to PNG's NDC implementation through renewable energy. The pre-feasibility study integrates climate-proofed design standards into marine renewable energy infrastructure recommendations, contributing to PNG's NAP priority on infrastructure resilience (SDG 13.1- Strengthen resilience and adaptive capacity to climate-related hazards; SDG 13.2- Integrate climate change measures into national policies, strategies and planning). SDG 14 (Life Below Water) The TA promotes sustainable use of marine resources through environmentally responsible ocean energy deployment, integrated with marine biodiversity considerations in the candidate area, including Coral Triangle Initiative areas SDG 9. (Industry, Innovation and Infrastructure) The TA pioneers deployment of frontier marine energy technologies in a Pacific SIDS, building infrastructure innovation through the lab-scale RED installation at UPNG and laying the basis for follow-on full-scale deployment.

Annex 1 Technical assistance data collection

Please add quantitative and qualitative values for the indicators selected in the M&E plan and monitored throughout the technical assistance in the tables below. Indicators which have been monitored in addition to the proposed indicators below may be added at the end of table A. Non-relevant indicators should be left blank.

A. Output and outcome indicators

Indicator	Quantitative value Value and unit	Qualitative description List the various elements corresponding to the quantitative value as well as timelines and responsible institutions
Please note indicators below highlighted as anticipated		
Number of communication and outreach activities conducted by proponents and implementing partners to showcase CTCN support	≥7	• Inception workshop (in person, 11-13 November 2024) • 1st PSC meeting (online, 19 February 2025) • 2nd PSC meeting (online, 19 March 2025) • PSC in-person meeting series at UPNG / Port Moresby (25-30 May 2025) • KIER-UPNG young professionals workshop on marine energy (May 2025) • 3rd PSC meeting (online, 19 December 2025) • Korea wrap-up program (8–13 March 2026): Final PSC meeting at Maison Glad Jeju (Day 2, 9 March); CTCN TA cRD&D Marine Energy Specialist Workshop at GLAD Yeouido Seoul (Day 4, 11 March)
Number of participants in the events above	55	Aggregated across all events listed above
a) Number of men	43	From PSC meeting attendance, workshop registers, mission attendance lists
b) Number of women	12	From PSC meeting attendance, workshop registers, mission attendance lists (~22%)

Number of training sessions and capacity strengthening activities	≥3	• Lab-scale Reverse Electrodialysis (RED) operation training at UPNG (May 2025) • Oceanographic monitoring instrument operation training at UPNG (CTD, RBR sensors) • Capacity-building training program during the Korea wrap-up program, including KIER Jeju Global Research Center facility tours (10 March 2026) and the 5-session capacity-building portion of the CTCN TA cRD&D Specialist Workshop (11 March 2026)
Number of people who received the training	28	Aggregated across trainings
a) Number of men	18	
b) Number of women	10	
Total number of institutions trained	9	PNG: UPNG, Unitech, PNG Power Limited (PPL), Department of Petroleum & Energy, Climate Change and Development Authority (CCDA), National Energy Authority (NEA), Independent Consumer and Competition Commission (ICCC), Conservation and Environment Protection Authority (CEPA), National Institute of Standards and Industrial Technology (NISIT)
a) Number of research organisations, laboratories and universities	2	UPNG; Unitech
b) Number of private companies	0	
c) Number of cities and local government	0	
d) Number of communities	0	
e) Number of ministries	1	Department of Petroleum & Energy
f) Number of specialised governmental institutions and state-owned enterprises	6	CCDA; NEA; ICCC; CEPA; NISIT; PPL
g) Number of non-profit organisations	0	-
Percentage of participants reporting satisfaction with CTCN training (from CTCN training feedback form)	N/A	Satisfied= 3+ on 5-pt scale Indicate breakdown of categories here based on the results of the CTCN training feedback forms
Percentage of participants reporting increased knowledge, capacity and/or understanding as a result of CTCN training (from CTCN training feedback form)	N/A	Increased knowledge, capacity and/or understanding= 3+ on 5-pt scale Indicate breakdown of categories here based on the results of the CTCN training feedback forms

a) Number of men	N/A	
b) Number of women	N/A	
Total number of deliverables produced during the assistance (excluding mission, progress and internal reports)	≥9	Detailed work plan; M&E plan; Gender Assessment & Action Plan; Closure Report; Site selection/inception report (Output 2); Final pre-feasibility study (Output 3); GCF Concept Note (Output 4.1); Final compiled report (Output 4.2); plus PSC consolidated meeting reports.
a) Number of tools and technical documents strengthened, revised or developed	≥4	• OGCM-based marine energy potential assessment for PNG • Pre-feasibility study report (technical, socio-economic, financial) • GCF Concept Note with supporting documents (reviewed with Ecosian on 9 March 2026; delivered to CTCN as a TA deliverable; GCF submission once an Accredited Entity is identified). • Lab-scale Reverse Electrodialysis (RED) operational protocols at UPNG
b) Number of other information materials strengthened, revised or created (For example training and workshop reports, Power Points, exercise docs etc.)	≥5	• PSC meeting decks (1st, 2nd, in-person, 3rd, 4th) • Inception workshop materials • KIER-UPNG young professionals workshop materials • Day 4 specialist workshop materials: 3 keynote speeches + 5 capacity-building session materials • Ecosian Concept Note review session notes
Total number of policies, strategies, plans, laws, agreements or regulations supported by the assistance	0	The TA is aligned with the NDC and NAP but did not support their preparation or revision
a) Adaptation related	0	
b) Mitigation related	0	
c) Both adaptation- and mitigation related	0	
Anticipated number of policies, strategies, plans, laws, agreements or regulations proposed, adopted or implemented as a result of the TA	N/A	<i>List the type of documents anticipated to be proposed, adopted or implemented</i>
a) Adaptation related	N/A	<i>List the type of documents anticipated to be proposed, adopted or implemented</i>

b) Mitigation related	N/A	List the type of documents anticipated to be proposed, adopted or implemented
c) Both adaptation- and mitigation related	N/A	List the type of documents anticipated to be proposed, adopted or implemented
Anticipated number of technologies transferred or deployed as a result of CTCN support	3	• Salinity Gradient Energy (SGE) — including Reverse Electrodialysis (RED) • Electrochemical Ocean Thermal Energy Conversion (e-OTEC) • Blue Battery Technology (seawater-based energy storage) • Per CTCN taxonomy: Energy supply > Renewable energy > Marine energy
Number of South-South collaborations enabled during or through CTCN TA support	0	
Number of climate technology RD&D related outreach activities	≥4	• workshop with UPNG and Unitech faculty, Port Moresby (Nov 2024) • Lab-scale Reverse Electrodialysis equipment installation and operation training at UPNG (May 2025) • KIER-UPNG young professionals workshop on marine energy (May 2025) • CTCN TA cRD&D Marine Energy Specialist Workshop at GLAD Yeouido (11 March 2026), with 3 keynote speeches and 5 capacity-building sessions delivered by 13 invited Korean experts from 10 institutions
Number of participants in climate technology RD&D related workshops and events	54	Disaggregate by country
a) Number of men	42	
b) Number of women	12	
Anticipated number of cooperative research, development, and demonstration programs facilitated as a result of CTCN TA	3	(1) KIER-UPNG joint operation of the lab-scale Reverse Electrodialysis (RED) installation at UPNG (2) Follow-on GCF-financed pilot/demonstration project

		(3) Korea-PNG marine energy RD&D cooperation framework
Number of countries with strengthened National System of Innovation as a result of CTCN support	1	Papua New Guinea : established marine renewable energy R&D capacity at UPNG, Korea-PNG bilateral cooperation framework, GCF Concept Note pathway
Number of organisations engaged through CTCN support	24	a) Research organisations, laboratories and universities: UPNG; Unitech; KIER; HYU (Hanyang Univ.); KU (Korea Univ.); PNU (Pusan National Univ.); KMOU (Korea Maritime & Ocean Univ.); CUK (Catholic Univ. of Korea) b) Private companies: Toray; Prione; Drive Force c) Cities and local government: Jeju Special Self-Governing Provincial Government d) Communities: Kalo community e) Ministries: Department of Petroleum & Energy, PNG f) Specialised governmental institutions and state-owned enterprises: CCDA (NDE); NEA (Proponent); ICCG; CEPA; NISIT; PPL; KTL; KEITI; Water PNG; Ecosian
Insert any additional indicators here		

B. Core impact indicators

Please fill in the tables for anticipated impacts of the CTCN assistance. Every technical assistance should contribute to at least one of the indicators below. For guidance on how to report on core indicators see the [‘M&E Guidance Document for TA Implementers’](#).

Core indicator 1	Anticipated metric tons of CO ₂ equivalent (CO ₂ e) emissions reduced or avoided as a result of CTCN TA	
	Anticipated metric tons of CO ₂ , equivalent emissions reduced or avoided as a result of the TA on annual basis	Anticipated metric tons of CO ₂ , equivalent emissions reduced or avoided as a result of the TA in total
Quantitative value	≈ 550–1,020 tCO ₂ e per year for the hybrid pilot (SGE 100 kW: ≈ 365–510 t; e-OTEC 50–100 kW: ≈ 180–510 t). Based on ≈ 1,095–1,460 MWh/yr at 20/24 h availability and an indicative operating-	≈ 16,000–31,000 tCO ₂ e over the 30 -year operating life (Concept Note A.6). Indicative; to be confirmed by the

	margin emission factor of 0.5–0.7 tCO ₂ /MWh for the Port Moresby grid (gas and diesel/HFO units), to be replaced by the national value from CCDA/NEA. The Blue Battery provides storage and is not counted.	feasibility-stage MRV design. Reductions from the subsequent scale-up toward a 10 MW-class plant are not included.
Unit	tCO ₂ e / year	tCO ₂ e (over project/asset lifespan, 30 years)
Methodology Explain the method or process of verifying the indicator and how data was gathered	The CTCN TA itself (pre-feasibility study, GCF Concept Note, capacity building) does not directly generate emission reductions; it enables a future investment project that does. Anticipated reductions are estimated as fossil generation displaced on the Port Moresby grid by the marine renewable system (SGE + e-OTEC + Blue Battery storage). The 100 kW SGE unit is expected to generate ~730 MWh/yr (20/24 h availability). Reductions = (baseline diesel emissions) – (project emissions). Data gathered from KIER technology modeling and the GCF Concept Note (A.6). To be confirmed by feasibility-stage MRV design.	Same methodology applied across the 30-year asset lifespan stated in the GCF Concept Note (A.12). Total = annual reduction × lifespan, adjusted for ramp-up and capacity factor at feasibility stage.
GHG assessment boundary Identify expected post-TA activities, associated effects and assess boundary for quantification of GHG emission reductions	Grid-connected electricity supply on the Central Province coast (Port Moresby grid or local network). Boundary covers fossil generation displaced on the Port Moresby grid by the pilot marine renewable plant. Excludes upstream fuel-supply-chain and construction/embody emissions unless captured in feasibility-stage MRV.	Same boundary, applied across the 30-year lifespan.
Baseline candidates Define alternative technologies or practises used in baseline calculation to represent possible alternatives to the project activities	Continued operation of the Port Moresby grid mix (of 311 MW nominal capacity: ~40% hydro, ~33% gas, ~25% diesel/HFO); the prevailing alternative for urban and critical-facility power, including emergency diesel gensets during frequent outages. Alternative renewables (solar PV, small hydro) were considered but do not provide the dispatchable, marine-	Same baseline scenario, applied across the 30-year lifespan.

	environment-suited baseload that the project targets.	
Baseline emissions Describe baseline scenario and emissions calculated	Baseline scenario: electricity equivalent to the project's output is supplied by the marginal generation (mainly gas and diesel/HFO) on the Port Moresby grid. Baseline emissions calculated as: displaced kWh × emission factor of the displaced Port Moresby generation.	Annual baseline × operating life.
Assumptions Describe assumptions made during calculation and quantification of GHG reductions	(i) Plant operates as designed at stated capacity and capacity factor; (ii) Generated electricity directly displaces fossil generation 1:1; (iii) emission factor of the displaced Port Moresby generation, to be confirmed by CCDA/NEA; (iv) operating life of 30 years per Concept Note A.12; (v) No leakage from cold-water pipe deployment, membrane manufacture or construction phase included at this stage; (vi) Figures are indicative pending feasibility-stage MRV design and confirmation of grid emission factor by CCDA/NEA.	Same assumptions extended across the lifespan; ramp-up profile and capacity factor to be refined at feasibility stage

Note: This CTCN TA is preparatory (pre-feasibility study, GCF Concept Note and capacity building; the ESIA, FPIC and engineering design belong to the follow-on project) and does not itself install generation capacity or directly reduce emissions. The CO₂e figures above are the anticipated downstream emission reductions of the future investment project that this TA enables, as estimated in the GCF Concept Note (section A.6).

Core indicator 2	Anticipated increased economic, health, well-being, infrastructure and built environment, and ecosystems resilience to climate change impacts as a result of technical assistance Please provide a qualitative description of the anticipated impacts on the categories below
Infrastructure and built environment Anticipated increased infrastructure resilience (avoided/mitigated climate induced damages and strengthened physical assets)	Climate-resilient design of marine energy infrastructure (corrosion-resistant offshore structures, ≥10 m intake depth based on the Port Moresby halocline analysis, climate-proofed intake/discharge systems sized for sea-level rise and extreme wave events) is expected to increase the resilience of the energy supply system in coastal/island areas to climate hazards including sea-level rise, extreme wave events, and tropical cyclones. The pre-feasibility study integrates these climate-proofing standards into design recommendations. Compared with diesel generators (which are vulnerable to fuel-supply disruptions during cyclone events), marine renewable energy infrastructure offers improved continuity of supply for coastal communities under climate stress.
Ecosystems and biodiversity Anticipated increased ecosystem resilience (areas with increased	The TA includes environmental and social risk screening for the candidate area (GCF Concept Note Annex G.3) and identifies mitigation measures for marine biodiversity, including intake entrainment, discharge plumes, anti-fouling agents and Coral

resistance to climate-induced disturbances and with improved recovery rates)	Triangle habitats. SGE and e-OTEC technologies have low local ecosystem impacts compared with diesel generation: zero air pollution, no fuel-spill risk, and minimal land footprint (500–3,000 m ² per MW, vs. 15,000–30,000 m ² per MW for solar PV). Replacing diesel with marine renewable energy is expected to reduce localized marine and coastal pollution from diesel storage, transport, and combustion. The pre-feasibility findings include recommendations for marine biodiversity monitoring during full project implementation.
Economic Anticipated increased economic resilience (e.g. less reliance on vulnerable economic sectors or diversification of livelihood)	Reduced exposure of coastal/island communities to volatile diesel fuel prices and supply chain disruptions. Marine renewable costs are not yet competitive (SGE ~USD 0.42/kWh in the KIER model); the pilot is designed to demonstrate cost reductions. Potential creation of skilled employment in renewable energy operation and maintenance. Co-benefit potential through aquaculture co-location (water-energy-food nexus) and freshwater production via desalination. Reduced reliance on imported diesel fuel leads to foreign-exchange savings for PNG.
Health and wellbeing Anticipated increased health and wellbeing of target group (e.g. improved basic health, water and food security)	More reliable electricity supply enables continuous operation of healthcare facilities, water pumping/treatment, vaccine cold-chain, and lighting in remote PNG communities, with associated health and wellbeing benefits. Reducing diesel combustion lowers exposure to local air pollution. Co-benefit potential through desalinated freshwater production improves water security. Aquaculture co-location supports food security. Women in coastal communities, typically responsible for water collection, cooking, and food preservation, benefit disproportionately from improved energy reliability.

Core indicator 3	Anticipated number of direct and indirect beneficiaries as a result of the TA		
	Direct beneficiaries	Indirect beneficiaries	Means of verification
Adaptation related	Population captured by both (see row below)	Population captured by both (see row below)	Population that benefits both from improved climate resilience of energy supply and from displaced diesel emissions
Mitigation related	Population benefiting from displaced diesel emissions	Population benefiting from displaced diesel emissions	Population in the catchment area of the displaced diesel generation, plus broader PNG population benefiting from contribution to NDC implementation. Use methodology consistent with the GCF Concept Note targeting.
Both adaptation-and mitigation related	Population in coastal/island areas with improved resilience of energy supply to climate hazards.	Population in coastal/island areas with improved resilience of energy supply to climate hazards. ~756,754 – population of the Port Moresby	Coastal/island population in the project's catchment area benefiting from improved energy reliability under climate stress (cyclones, sea-level rise). Use Central Province / National Capital District population estimates. As cited in the CCDA

	Population served by the pilot's connected loads	demand area (~7.5% of PNG)	Technical Review (April 2026); direct beneficiaries from the pilot connection design
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Core indicator 4	Amount of funding/investment leveraged (USD) as a result of TA (disaggregated by public, private, national, and international sources, as well as between anticipated/confirmed funding)		
	Quantitative value Value and currency	Qualitative description List the various elements corresponding to the quantitative value as well as expected timelines and responsible institutions	Methods Describe method use for quantification of funds leveraged including assumptions made and attention paid to causality, attribution and avoidance of double-counting
Total anticipated amount of funding/investment mobilised or leveraged (USD) as a result of the TA	~USD 20.96 million (indicative total project cost)	Total follow-on project cost per the GCF Concept Note (section A.9): Pilot construction & commissioning ~USD 20.5 M (SGE 100 kW ~USD 4.0 M; e-OTEC 50–100 kW ~USD 3.0–3.5 M; 800 kWh / 4 h Blue Battery storage ~USD 2.5–3.0 M; remainder to be itemised) Project Development (feasibility, site survey, basic design, CEPA permitting) ~USD 0.35 M Capacity Building ~USD 0.11 M Lead institutions: NEA (Executing Entity), CCDA (NDA), KIER (technology partner); Accredited Entity to be identified. Timeline: identification of an Accredited Entity (2027); feasibility study, ESIA and FPIC (2027–2028), to be funded through the GCF	Sum of GCF grant request plus co-financing commitments as set out in the GCF Concept Note (sections A.9, A.10, D.1). GCF-to-co-finance split to be finalized at Funding Proposal stage once feasibility cost estimate and PPA terms are confirmed.

		Project Preparation Facility once the Accredited Entity is confirmed, and/or Korean R&D funding; Funding Proposal submission targeted for December 2028; implementation 2029–2034, following GCF approval; project lifespan 30 years.	
Anticipated amount of public funding mobilised from national sources (USD)	National Indicative: in-kind + counterpart contribution (to be confirmed at FP stage)	Government of PNG counterpart contribution to the follow-on pilot/full project, if applicable; potential PNG Power Limited (PPL) contribution. Responsible institutions: National Energy Authority (NEA), Climate Change & Development Authority (CCDA), PNG Power Limited (PPL).	Per GCF Concept Note co-financing assumptions (section D.1). Quantification to be confirmed during Funding Proposal preparation.
Anticipated amount of public funding mobilised from international and regional sources as a result of the TA	International-multiple channels: GCF (Proposal Approval Process); MSIT/NRF (Republic of Korea) for the Stage 1 R&D demonstration; ADB; AIIB; World Bank Pacific facility.	As articulated during the CTCN TA cRD&D Marine Energy Specialist Workshop (11 March 2026, GLAD Yeouido), follow-on financing is being pursued across multiple complementary channels: (i) GCF Concept Note revised in response to NDE comments and delivered as a TA deliverable; to be submitted to the GCF once an Accredited Entity is identified; (ii) MSIT (Ministry of Science and ICT, Republic of Korea) potential support for cRD&D programs;	GCF funding as a grant or concessional finance via the appropriate Accredited Entity; complementary funding from MSIT, ADB, AIIB and bilateral partners. Causality/attribution: pipeline activated through CTCN TA outputs (Concept Note, specialist workshop).

		(iii) Asian Development Bank Pacific facility; (iv) Asian Infrastructure Investment Bank (AIIB); (v) Complementary financing from KOICA, Korea Eximbank, World Bank Pacific Energy program. PNG NDA engagement is expected to support the receipt of the Non-Objection Letter (NOL).	
Anticipated amount of private investment mobilised (in USD) from national sources as a result of the TA	N/A	N/A	N/A
Anticipated amount of private investment mobilised (in USD) from international and regional sources as a result of the TA	N/A	N/A	N/A

Annex 2 (for internal use – to be filled in by the CTCN)

CTCN evaluation

This section will be completed by the relevant CTCN Technology Manager.

- Evaluation of the timeliness of the TA implementation as measured against the timeline included in the response plan;
There were two Amendments on 29 August 2025 and 16 December 2025 to extend the end date of the TA implementation on 31 May 2026 due to the unexpected events such as PNG's situations. There was 5 month-delay in the submission of deliverables which happened on 7 October 2026 due to personal issue of the Principal Investigator of the Implementing Partner
- Evaluation of TA quality as defined in the response plan; The quality is very good considering identifying target sites and socio-economic and financial benefit analysis
- Overall performance of the Implementers; Good performance considering the sincere efforts for the implementation and training workshops and communications in the Project Steering Committee and stakeholder engagements
- Overall engagement of the NDE and Proponent; Very good. The proponent and NDE were the member of the PSC and they were also participated in training workshop in Jeju and PNG.
- Lessons learned on the CTCN process and steps taken by the CTCN to improve.
 - More regular PSC Meeting and follow up meeting between implementing partner and CTCN Secretariat are needed

- Active communication and collaboration with NDEs and key stakeholders in target country is very critical for the success of the TA project
- Early communication on the scale up funding organizations based on the expertise and focusing areas of each funding organization is very important
- PNG was struggling with the identification of AEs for the GCF because each international AEs has their own mandates and missions and they are not available for the implementation of the proposed project