Project design document form
(Version 11.0)

BASIC INFORMATION	
Title of the project activity	Farahantsana hydropower plant
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	2
Completion date of the PDD	05/03/2020
Project participants	Mahitsy Hydro SARLU
Host Party	Madagascar
Applied methodologies and standardized baselines	**Selected methodology:** ACM0002 “Grid-connected electricity generation from renewable sources” (version 19.0)
Sectoral scopes	**Sectoral scope:** 1, Energy Industries (renewable and non-renewable sources)
Estimated amount of annual average GHG emission reductions	85,581 t CO_2e/year

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The project

The Farahantsana Hydro Power Plant (hereafter referred to as "FHPP") consists of the construction and operation of a greenfield 28.8 MW hydroelectric plant. The plant is located along the River Ikopa at the Farahantsana Falls, in the rural municipality of Ambohimasina (Mahitsy), Madagascar.

The FHPP is composed of a run-of-river hydropower plant with a capacity of 28 MW and a back-up micro-hydro power plant of 800 KW (for construction use and low flow operations; in fact only one of the two 400 kW turbines is to be used at a time) with a total estimated average gross electricity generation of 136 GWh per year, fed by a 180,000 m^2 reservoir. The plant will be connected via a 63 kV transmission line to the Interconnected grid of Antananarivo.

The project will be implemented by Mahitsy Hydro SARLU, a company created in 2015, responsible for the construction and the exploitation of the FHPP.

The project is a type I project activity under sectoral scope: 1, Energy Industries (renewable and non-renewable sources). It will generate approximately 85,581 tCO_2e emission reductions per year and 599,067 tCO_2e of emission reductions over the 7 years crediting period.

The context

Electricity in Madagascar is currently heavily reliant on imported fossil fuels currently consumed by thermal power stations (514 MW) versus hydropower plants (162 MW)[1], thus a baseline scenario also considered as the scenario prior to the implementation of the project activity leading to considerable greenhouse gas (GHG) emissions. The project activity undertaken by project promoter Mahitsy Hydro will therefore substitute grid electricity by clean and renewable energy, and cut down GHG emissions.

Sustainable Development

The project is expected to help the country meet its increasing demand for power reliably in a cost-effective and environment-friendly manner.
The implementation of the project activity contributes to sustainable development in Madagascar. In particular, the project:

- diversifies sources for electricity generation and decreases dependence on imported energy sources, above all fuel oil.
- supports the Madagascar's government to achieve the goal of accessible and adequate energy supply at competitive costs.
- increases employment opportunities to local people (up to 750 local jobs expected during construction, and over 10 permanent positions during operation of the project).
- improves the regional facilities through the implementation of a new bridge.

A.2. Location of project activity

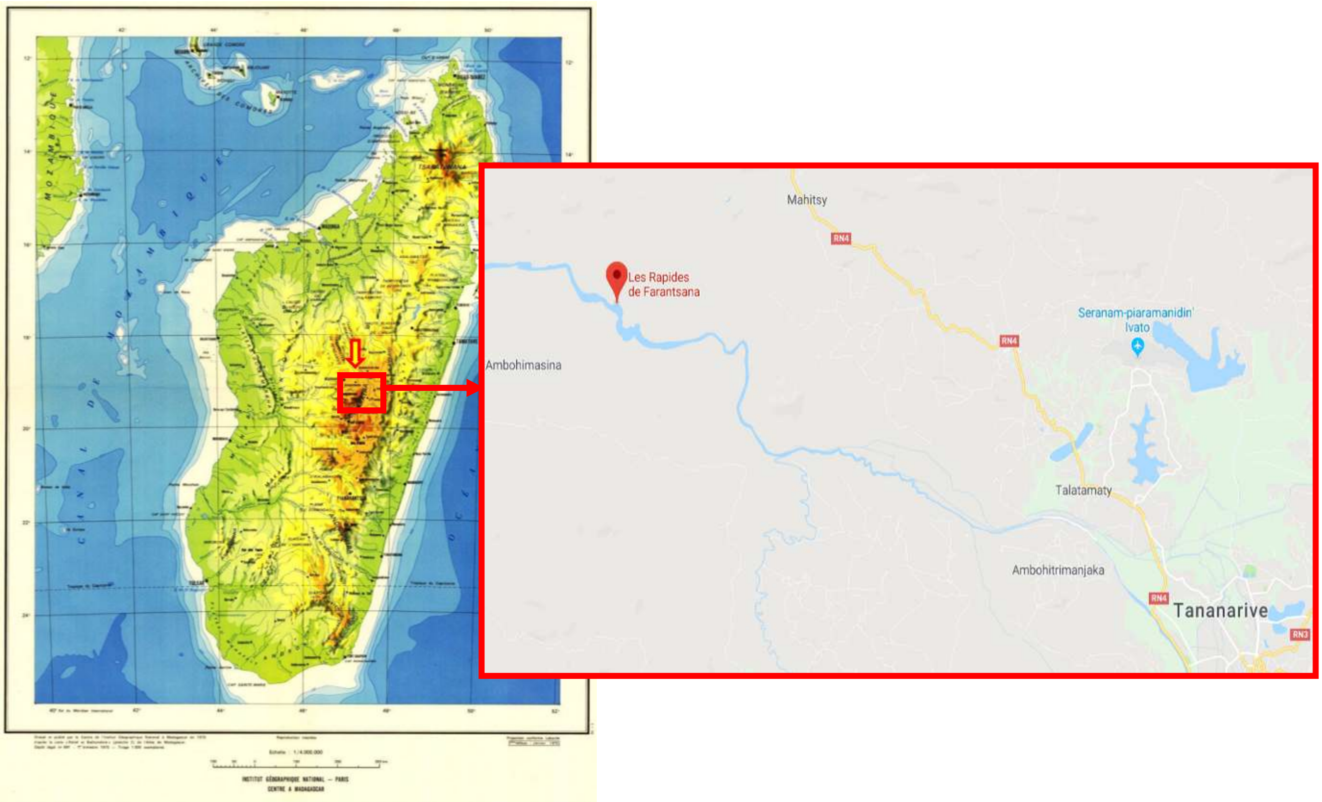
<u>Host Party</u>: Madagascar
<u>Region/State/Province</u>: Region Itasy, District of Arivonimamo,
<u>City/Town/Community</u>: The major part of the site is located in the rural municipality of Ambohimasina, near the commune of Mahitsy, and around 43km North-West of Antananarivo, Madagascar.

The plant is located along the River Ikopa at the Farahantsana Falls.
The project geo-coordinates are: Latitude: 18°47'9" S; Longitude: 47°16'16" E. The physical location of the project is shown in Figure 1.

[1] https://www.africa-eu-renewables.org/market-information/madagascar/energy-sector/

The Ikopa River is the second longest river in Madagascar and passes through the capital, Antananarivo. It is the largest tributary of the Betsiboka River and originates on the eastern edge of the plateau located south-east of Antananarivo at an elevation of 1 810 mt. It is formed by the Varahina-North and Varahina-South Rivers. The river basin, at the site of the project, covers an area of 4 498 km^2. Because of flooding threats to the city of Antananarivo, the River Ikopa is regularly monitored, especially some flow data are collected at the Bevomanga Station, located 7 km upstream of the point of interest. The average flow of the river over the years examined in preliminary studies is around 77 m^3/s.

Figure 1: Localisation of project site



A.3. Technologies/measures

The proposed project consists of implementing a hydroelectric plant with an installed capacity of 28 MW to produce electricity to be exported to RI-Tana grid, operated by JIRAMA, the national electricity company. Besides, a 800kW micro-hydro power plant will be installed to provide electricity during the construction phase and may also be used during exploitation of the FHPP, when the hydroelectric plant machines cannot work, during maintenance or in exceptional cases when the river flow is too low (below 6 m^3/sec).
The main hydroelectric plant will use four Francis type horizontal axis generator turbines, each with an installed capacity of approximately 7.0 MW, complemented by four Leroy-Somer Nidec AC LSA60 generators of 8,059 kVa (7,253 kW) each.

The FHPP, which will be developed from the intake systems at the elevation of 1230,25 m to the discharge point, at the elevation of 1198,63 m, basically consists of:

- a barrage in the riverbed consisting of a series of gates (139 m long, 5 m high);
- an intake structure with adduction pipelines;
- a sedimental trap/forebay tank structure;
- 2 penstocks;
- a powerhouse with electromechanical works and a discharge channel;
- a power line connection;
- other works including the bridge over the River Ikopa.

The 800 kW micro-hydro power plant, will use two single-phase Kaplan-type turbines from Ming Yang Turbine Co. Ltd SF400 – 10/990 model.

It is estimated that the project activity would generate about 136 GWh of electricity, to be exported to the interconnected grid RI-Tana.
The project will reduce greenhouse gas emissions by substituting peak thermal electricity produced on the grid by clean and renewable energy.

The intended position of the barrage on the River Ikopa is upstream of the Farahantsana Falls and downstream of the structures necessary for the construction of the new bridge over the River Ikopa.
The work will be carried out by laying a series of radial gates and vertical sliding gates placed transversely to the river. The artefact has the aim of conveying the waters to the adjacent water intake and at the same time of ensuring de-sanding in the upstream basin. The water surface elevation adjustment level in the upstream basin, in case of maximum flow is 1 230.25 mt. The dam will have a total length of approximately 150 m. Above the gates, for the whole extension of the dam, a walkway will be built, so to make maintenance and adjustment of the gates possible.

Figure 2: Map of the planned hydropower plant

Transformers and 63 kV transmission line of FHPP will ensure transportation of electricity produced by the hydropower plan to the RI-Tana grid.

The expected operational lifetime of the project equipment is 20 years, as per conservative hydropower industry standards in such context and PPA duration.

Meters (main/back-up) will be installed at the substation of the hydro power plant to measure directly and continuously the electricity supply to (and, if any, import from) the grid. Accuracy class of the expected Cewe electricity meter is 0.2.

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Madagascar	Mahitsy Hydro SARLU	No

A.5. Public funding of project activity

No public funding is involved - according to the OECD definitions for Official Development Assistance (ODA).

A.6. History of project activity

This proposed project is neither registered as an individual CDM project activity nor included in another registered CDM PoA as a CPA nor a project activity that has been deregistered or excluded from a registered CDM PoA. There is no registered CDM project activity or a CPA under a registered CDM PoA whose crediting period has or has not expired, which exists in the same geographical location as the proposed CDM project activity.

A.7. Debundling

Not applicable

SECTION B. Application of methodologies and standardized baselines

B.1. Reference to methodologies and standardized baselines

The approved baseline and monitoring methodology selected for to the proposed project activity is: ACM0002 version 19 - “Large –scale Consolidated Methodology: Grid-connected electricity generation from renewable sources”.

The methodology also refers to the latest approved versions of the following applied tools, which are:
- Methodological Tool: “TOOL01: Tool for the demonstration and assessment of additionality” (version 7.0);
- Methodological Tool: “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (version 3.0);
- Methodological Tool: “TOOL07: Tool to calculate the emission factor for an electricity system” (version 7.0).

B.2. Applicability of methodologies and standardized baselines

The choice of the ACM0002 methodology is accurate since the proposed project activity respects all the applicability conditions required.

Table 1: Compliance of the project activity project activity regarding ACM0002 applicability conditions

ACM0002 version 19.0 applicability conditions	Project activity applicability
This methodology is applicable to grid-connected renewable energy power generation project activities that: (a) Install a Greenfield power plant; (b) Involve a capacity addition to (an) existing plant(s); (c) Involve a retrofit of (an) existing operating plants/units; (d) Involve a rehabilitation of (an) existing plant(s)/unit(s); or (e) Involve a replacement of (an) existing plant(s)/unit(s).	The project activity is a greenfield hydropower plant substituting electricity produced on the grid by renewable energy.
The project activity may include renewable energy power plant/unit of one of the following types: hydro power plant/unit with or without reservoir, wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit.	The project activity is the construction and operation of a hydropower plant with reservoir and hence the methodology is applicable.
In the case of capacity additions, retrofits, rehabilitations or replacements (except for wind, solar, wave or tidal power capacity addition projects) the existing plant/unit started commercial operation prior to the start of a minimum historical reference period of five years, used for the calculation of baseline emissions and defined in the baseline emission section, and no capacity expansion, retrofit, or rehabilitation of the plant/unit has been undertaken between the start of this minimum historical reference period and the implementation of the project activity.	The project activity does not involve any capacity additions, retrofits, rehabilitations or replacements.
In case of hydro power plants, one of the following conditions shall apply: (a) The project activity is implemented in existing single or multiple reservoirs, with no change in the volume of any of the reservoirs; or (b) The project activity is implemented in existing single or multiple reservoirs, where the volume of the reservoir(s) is increased and the power density, calculated using equation (3), is greater than 4 W/m2; or (c) The project activity results in new single or multiple reservoirs and the power density, calculated using equation (3), is greater than	The project activity results in new single reservoir and the power density, calculated using equation (3), is greater than 4 W/m^2: $PD = (Cap_{PJ} - Cap_{BL}) \ / \ (A_{PJ} - A_{BL})$ Installed capacity is 28.8 MW

4 W/m2; or (d) The project activity is an integrated hydro power project involving multiple reservoirs, where the power density for any of the reservoirs, calculated using equation (3), is lower than or equal to 4 W/m2, all of the following conditions shall apply: (i) The power density calculated using the total installed capacity of the integrated project, as per equation (4), is greater than 4 W/m2; (ii) Water flow between reservoirs is not used by any other hydropower unit which is not a part of the project activity; (iii) Installed capacity of the power plant(s) with power density lower than or equal to 4 W/m2 shall be: a. Lower than or equal to 15 MW; and b. Less than 10 per cent of the total installed capacity of integrated hydro power project.	and expected reservoir area is 180,000,000 m^2 thus resulting into power density of 160 W/m^2
In the case of integrated hydro power projects, project proponent shall: (a) Demonstrate that water flow from upstream power plants/units spill directly to the downstream reservoir and that collectively constitute to the generation capacity of the integrated hydro power project; or (b) Provide an analysis of the water balance covering the water fed to power units, with all possible combinations of reservoirs and without the construction of reservoirs. The purpose of water balance is to demonstrate the requirement of specific combination of reservoirs constructed under CDM project activity for the optimization of power output. This demonstration has to be carried out in the specific scenario of water availability in different seasons to optimize the water flow at the inlet of power units. Therefore, this water balance will take into account seasonal flows from river, tributaries (if any), and rainfall for minimum five years prior to implementation of CDM project activity.	Not applicable, the project is not an integrated project as it concerns a unique hydro power plant.
The methodology is not applicable to: (a) Project activities that involve switching from fossil fuels to renewable energy sources at the site of the project activity, since in this case the baseline may be the continued use of fossil fuels at the site; (b) Biomass fired power plants/units.	The proposed project activity neither involves: - switching from fossil fuels to renewable energy sources at the site of the project activity, since in this case the baseline may be the continued use of fossil fuels at the site, nor - biomass fired power plants/units.
In the case of retrofits, rehabilitations, replacements, or capacity additions, this methodology is only applicable if the most plausible baseline scenario, as a result of the identification of baseline scenario, is "the continuation of the current situation, that is to use the power generation equipment that was already in use prior to the implementation of the project activity and undertaking business as usual maintenance".	The project activity does not involve capacity additions, retrofits, rehabilitations or replacements.
In addition, the applicability conditions included in the tools referred to above apply.	Applicability conditions of the applied tools are justified underafter.

From the above, it is concluded that the project activity meets all the applicability conditions of the methodology ACM0002 version 19 "Grid connected electricity generation from renewable sources".

TOOL01: "Tool for the demonstration and assessment of additionality" (version 7.0) is also applicable since "Once the additionally tool is included in an approved methodology, its application by project participants using this methodology is mandatory".

TOOL05: "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (version 3.0) is also applicable as "referred to in [ACM0002 §68] methodologies to provide procedures to monitor amount of electricity generated in the project scenario", since the following project scenario applies to the recipient of the electricity generated:

(a) Scenario I: Electricity is supplied to the grid.

The project activity also meets the following applicability conditions of "Tool to calculate the emission factor for an electricity system".

Table 2: Compliance of the project activity project activity regarding applicability conditions of "Tool to calculate the emission factor for an electricity system"

No	Applicability condition	Applicability to this project activity
1	This tool may be applied to estimate the OM, BM and/or CM when calculating baseline emissions for a project activity that substitutes grid electricity that is where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects).	The project activity substitutes grid electricity by supplying renewable power to grid. Hence the tool is applicable.
2	Under this tool, the emission factor for the project electricity system can be calculated either for grid power plants only or, as an option, can include off-grid power plants. In the latter case, two sub-options under the step 2 of the tool are available to the project participants, i.e. option IIa and option IIb. If option IIa is chosen, the conditions specified in "Appendix 1: Procedures related to off-grid power generation" should be met. Namely, the total capacity of off-grid power plants (in MW) should be at least 10 per cent of the total capacity of grid power plants in the electricity system; or the total electricity generation by off-grid power plants (in MWh) should be at least 10 per cent of the total electricity generation by grid power plants in the electricity system; and that factors which negatively affect the reliability and stability of the grid are primarily due to constraints in generation and not to other aspects such as transmission capacity.	The emission factor for the project electricity system is calculated for grid power plants only.
3	In case of CDM projects the tool is not applicable if the project electricity system is located partially or totally in an Annex I country.	Since the project electricity system is not located partially or totally in an Annex I country, the tool is applicable.
4	Under this tool, the value applied to the CO_2 emission factor of biofuels is zero.	No biofuels have been identified in the baseline grid emission factor determination

The project activity also meets the following applicability conditions of "Methodological tool: Determining the baseline efficiency of thermal or electric energy generation systems", which is referred to in TOOL07: "Tool to calculate the emission factor for an electricity system" and applied[2].

Table 3: Compliance of the project activity project activity regarding applicability conditions of "Methodological tool: Determining the baseline efficiency of thermal or electric energy generation systems"

No	Applicability condition	Applicability to this project activity
1	This tool is applicable to energy generation systems that: (a) Generate only electricity (and no heat); or (b) Produce only thermal energy (and no	The baseline grid energy generation systems only generate electricity (and no heat). Hence the tool is

[2] "Default value for Average net energy conversion efficiency of power units calculated as per Table 2, Appendix of TOOL09: "Determining the baseline efficiency of thermal or electric energy generation systems" as specified in TOOL07 for Parameter $\eta_{m,y}$ option c)"

	electricity); or (c) Produce both electricity and thermal energy (cogeneration).	applicable.
2	Also, the following conditions apply: (a) The tool is not applicable to waste heat recovery systems; (b) The tool can be applied only if load is the main operating parameter that influences the efficiency of the energy generation system. For cogeneration systems, the heat to power ratio may also be considered a main operating parameter.	(a) No waste heat recovery systems have been identified in the baseline grid energy generation systems (b) No cogeneration systems have been identified in the baseline grid energy generation systems
3	Methodologies referring to this tool should specify for which energy generation systems the tool is used and whether a load-efficiency function and/or a constant efficiency should be determined	The tool is referred from and applied in conjunction with the Tool to calculate the emission factor for an electricity system.

Other tools mentioned in the methodology are not applicable to this project activity.

B.3. Project boundary, sources and greenhouse gases (GHGs)

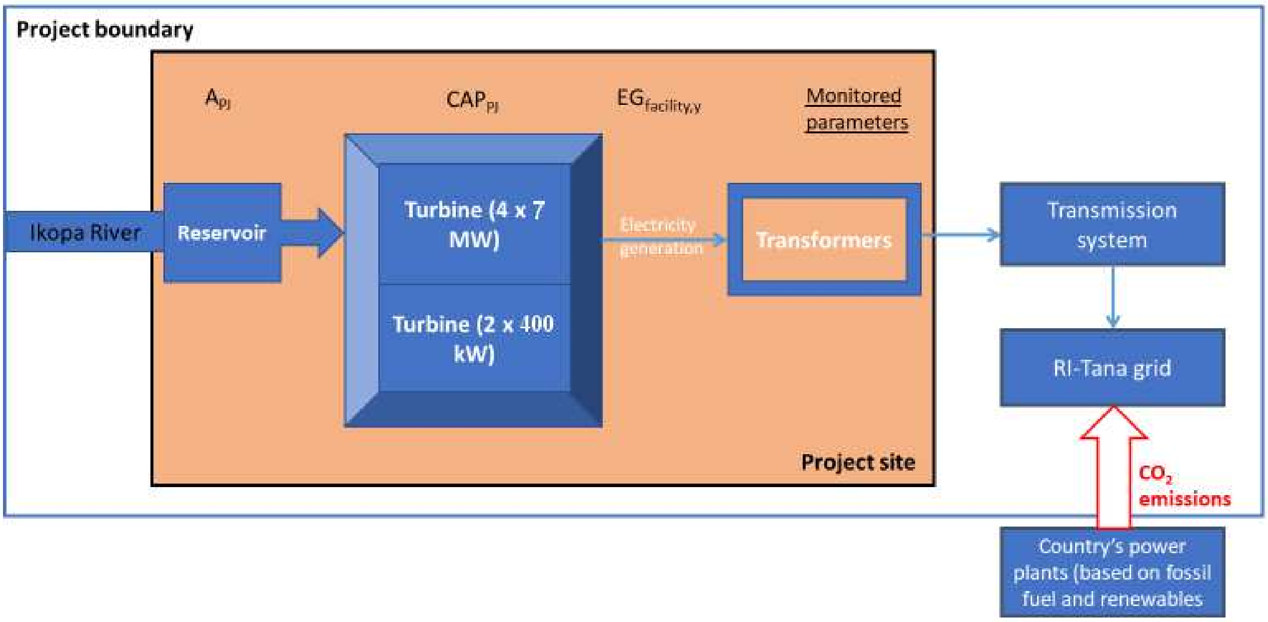
Table 4: Emission sources included in or excluded from the project boundary

Source		GHG	Included?	Justification/Explanation
Baseline	CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity	CO_2	**Yes**	Main emission source (fossil fuel-fired power plants of RI-Tana)
		CH_4	**No**	Minor emission source
		N_2O	**No**	Minor emission source
Project activity	For hydro power plants, emissions of CH_4 from the reservoir	CO_2	**No**	Minor emission source
		CH_4	**No**	Main emission source (Power density is higher than 10 W/m^2)
		N_2O	**No**	Minor emission source

In accordance with the methodology ACM0002 methodology “Grid-connected electricity generation from renewable sources”: “the spatial extent of the project boundary includes the project power plant and all power plants connected physically to the electricity system that the CDM project power plant is connected to”. The electricity displaced by the project is the electricity generated within the interconnected grid of RI-Tana. The spatial scope of the project boundary covers the project site including the area of influence of the power line up to the substation and all power plants connected physically to RI-Tana grid.

Therefore, the project boundary will include all the direct emissions related to the electricity produced by the power plants connected to RI-Tana grid that will be replaced by the proposed project activity as it is shown below.

Figure 3: Project boundary – Simplified flow diagram



B.4. Establishment and description of baseline scenario

According to methodology ACM0002 and since the project is the installation of a new grid-connected renewable power plant the baseline scenario is the following:

"Electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in the combined margin (CM) calculations described in the "Tool to calculate the emission factor for an electricity system." Version 7.0.

So, continuation of current practice for power generation in Madagascar involves a significant share of fossil fuel consumption, including in capacity additions to meet the demand increase, as reflected by the rather high Combined Margin emission factor of 0.6293 tCO_2/MWh calculated in B.6.1

B.5. Demonstration of additionality

According to the definition of the CDM glossary of terms (version 07.0), the start date of the project is 10/11/2017 when the EPC contract signature & investment decision occurred.

Project participants had initially notified Executive Board and host country DNA of the intention to develop the Project as a CDM activity on 31/07/2015 in compliance with the requirements of the CDM project cycle procedure, and further updated UNFCCC (through its Regional Collaboration Center) on a yearly basis. The CDM benefits were considered necessary in the project's undertaking, as evidenced by the intention to develop FHPP as a proposed CDM project activity from the very beginning.

In accordance with ACM0002 methodology, the additionality of the project activity is demonstrated and assessed using the latest version of the "Tool for the demonstration and assessment of additionality" version 7.0.

Step 0: Demonstration whether the proposed project activity is the first-of its-kind

This step is optional; it is not applied as it is considered that the proposed project activity is not the first-of-its-kind.

Step 1: Identification of alternatives to the project activity

According to Para. 7.7.6.4.2. of VVS version 02.0 (CDM-EB93-A05-STAN), the identification of alternatives is not required since the baseline scenario has already been prescribed in the applied methodology ACM0002 version 19.0.

Step 2: Investment analysis

Under step 2, it will be demonstrated that project activity is not economically or financially feasible, without the revenue from the sale of certified emission reductions (CERs)

Sub-step 2a: Determine appropriate analysis method

Since the proposed project will generates other financial/economic benefits than CDM related income, the simple cost analysis method (Option I) is not appropriate. Also, investment comparison analysis method (Option II) is only applicable to projects whose alternatives are similar investment projects. Indeed, if the alternative to the project activity is the supply of electricity from a grid this is not to be considered an investment and a benchmark approach is considered appropriate. Therefore, the benchmark analysis (Option III) is applied.

Sub-step 2b: Option III. Apply benchmark analysis

The financial/economic indicator identified as most suitable for the project type and decision context is the project Internal Rate of Return (post-tax Project IRR).

This indicator allows for effective comparison of the project returns with an appropriate benchmark. Therefore, the financial analysis is based on parameters that (a) are standard in the market and (b) consider the specific characteristics of the project type, but not linked to the subjective profitability expectation or risk profile of a particular project developer. The benchmark represents the minimum rate of return that would justify the financial viability of the project and therefore its implementation.

Project IRR

In accordance with the "Methodological tool - Investment analysis" (Version 8), all input values were known before the investment decision and can therefore be considered realistic and appropriate values to be used in the financial calculation of the proposed project activity.

Table 5 – Parameters used in the investment analysis (as of 10/11/2017 investment decision date)

Item	Value	Unit	Source
Installed capacity	28	MW	Project documentation, concession agreement/amendment
Annual net power generation	136	GWh	Project's technical studies and Plant Load Factor ((a) as provided to banks and equity financiers)
EPC costs	40.5	Million EUR (excl. VAT)	EPC contract
Grid connection costs	8	Million EUR	EPC contract
Annual O&M costs	1.5	Million EUR	O&M summary term sheet
Investment horizon	20	Years	Project financial model (as per PPA duration - conservative according to the Default value of 150,000 hours for Technical Lifetime of Hydro turbines)[3]
Expected power price	0,108	€/kWh	PPA amendment n°3 (at 11/10/2017 MGA/EUR rate[4])
Annual Depreciation	10 to 20	years	Preparatory works: 10 years, EM equipment: 20 years
Income tax	20	% of earnings before taxes	www.impots.mg

One of biggest project risks is the weak financial situation of JIRAMA. Since 2003 JIRAMA has experienced difficulties, *"…mainly due to incompetent management. It made poor decisions on investments and committed errors in the choice of power generation technology, notably by opting for diesel-fired thermal*

[3] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-10-v1.pdf
[4] https://www.xe.com/fr/currencytables/?from=MGA&date=2017-11-10

plants instead of hydroelectricity. This option was selected because the initial investment cost of thermal plants is lower, but production costs in such plants are at the mercy of changing world oil prices…"[5]

The risk of non-payment or payment delays by JIRAMA is an essential parameter of the project as all the revenues of the power plant come only from JIRAMA being the only purchaser of electricity. A World Bank commissioned audit of JIRAMA by Castalia & Mazars released on September 24th 2019 further evaluated its cumulative arrears to 1 600 billion Ariary (Euro 400 millions)[6].

Sub-step 2c: Calculation and comparison of financial indicators

The IRR calculation compares the real IRR with a real benchmark which in both cases takes out the effects of general price increases due to inflation.

An adequate project benchmark is determined below following the Weighted Average Cost of Capital (WACC) method, based on parameters that are standard in the market since the Greenfield project activity could be undertaken by other promoters.

The Weighted Average Cost of Capital (WACC) is calculated as follows:

$$WACC = re \times We + rd \times Wd \times (1 - Tc)$$

Where:

- re = Cost of equity (-)
- We = Percentage of financing that is equity (-)
- rd = Cost of debt (-)
- Wd = Percentage of financing that is debt (-)
- Tc = Corporate tax rate (-)

As no typical debt/equity finance structure observed in the sector of the country is readily available, 50% debt and 50% equity financing is assumed as a default, therefore $w_d = w_e = 50\%$.

Cost of debt is assumed as the commercial lending rate in the country, since the benchmark is based on parameters that are standard in the market, and no documented cost of debt financing of comparable projects (e.g. commercial lending rates and guarantees required for the country and the type of project activity concerned) is available. The average commercial lending-debit rates from Madagascar Central Bank statistics is chosen, reflecting $r_d = 21.6\%$[7].

Cost of equity is determined among the default values for the expected return on equity provided in Appendix of the Guidelines on the Assessment of Investment Analysis (Madagascar – Group 1), thus $r_e = 14\%$.

The applicable corporate tax is taken as per the Project financing assumptions displayed in **Table** above, $T = 20\%$.

➔ The calculated[8] WACC results in **15,64%**, higher than the Project IRR of 9,48% in the absence of the CDM.

Sub-step 2d: Sensitivity analysis

A variation of ±10% in the critical assumptions (i.e. total investment, annual O&M cost, and power sales revenues) is considered. The results are shown in the following table.

Table 6 – Sensitivity analysis; impact of variations in assumptions on the IRR without CDM revenues

Percentage Variation	-10%	0%	+10%
Power generation	7,93%	9,48%	10,90%
Electricity tariff	7,45%		11,27%
Annual O&M costs	9,76%		9,18%
Total CAPEX	10,52%		8,44%

[5] See OECD's African Economic Outlook 2005-2006, page 317

[6] http://www.rfi.fr/afrique/20190925-madagascar-eau-electricite-audit-compagnie-nationale-jirama-finance

[7] Central Bank of Madagascar max long-term bank credit rate [https://www.banky-foibe.mg/pdf_minimum-et-maximum-des-taux-dinteret-des-banques-commerciales] - 2017

[8] $WACC = re \times We + rd \times Wd \times (1 - Tc)$ = 14% * 50% + 21,6% * 50% * (1 - 20%)

The sensitivity analysis confirms that the project's IRR without CDM revenues is unlikely to meet the required benchmark of 15,64%.

Such benchmark would only be exceeded if either the power sales revenues increase by 39%, or the investment costs decrease by 47%, which is absolutely unlikely given the fixed PPA and EPC terms. Even no O&M costs would not make the project IRR breach the benchmark; and a power generation increase of 50% would be necessary to reach the IRR benchmark, which is out of probability and rather contrary to the projected climate variabilities in Madagascar, primarily reduced rainfall and higher temperatures, which could impact its water resources for hydropower generation[9].

Outcome of Step 2

Therefore, it can be stated that the proposed project activity is unlikely to be financially/economically attractive (project IRR being lower than the benchmark).

Step 3: Barriers analysis;

Project proponent can use either investment analysis or barrier analysis step. As project proponents already apply the investment analysis it is not required to elaborate on barriers analysis.

Step 4: Common practice analysis.

The latest version 03.1 of the *methodological tool Common practice* is applied:

Step 1: Calculate applicable capacity or output range as +/-50% of the design capacity or output of the proposed project activity.

From a project activity capacity of 28 MW, the applicable output range is calculated as 14 to 42 MW of power generation capacity.

Step 2: Identify similar projects (both CDM and non-CDM) which fulfil all of the following conditions:

(a) The projects are located in the applicable geographical area **(Madagascar host country)**;

(b) The projects apply the same measure as the proposed project activity (**power generation based on renewable energy**);

(c) The projects use the same energy source/fuel and feedstock as the proposed project activity, if a technology switch measure is implemented by the proposed project activity **(hydropower)**;

(d) The plants in which the projects are implemented produce goods or services with comparable quality, properties and applications areas (e.g. clinker) as the proposed project plant;

(e) The capacity or output of the projects is within the applicable capacity or output range calculated in Step 1 **(14 to 42 MW)**;

(f) The projects started commercial operation before the project design document (CDM-PDD) is published for global stakeholder consultation or before the start date of proposed project activity, whichever is earlier for the proposed project activity **(10/11/2017).**

In the host country of Madagascar, the **similar** power plants operating before the start date of the project and belonging to the 14-42 MW output range are:

Power plant[10]	Installed capacity	Commissioning date	Technology
Mandraka	24 MW	1956	Hydro
Sahanivotry (CDM)	16.5 MW	2008	Hydro

[9] https://www.climatelinks.org/sites/default/files/asset/document/2016%20CRM%20Factsheet%20Madagascar_use%20this.pdf

[10] Please refer to RI-TANA Grid EF data sheet provided to the DOE.

Step 3: within the projects identified in Step 2, identify those that are neither registered CDM project activities, project activities submitted for registration, nor project activities undergoing validation. Note their number N_{all}.

Only one of the projects identified in Step 2 is neither registered CDM project activities, project activities submitted for registration, nor project activities undergoing validation.
Therefore $N_{all} = 1$.

Step 4: within similar projects identified in Step 3, identify those that apply technologies that are different to the technology applied in the proposed project activity. Note their number N_{diff}.

The technology used in the project activity is not different from **the similar activity** with regard to its energy source/fuel which is hydraulic. Therefore $N_{diff} = 0$.

Step 5: Calculate factor $F=1- N_{diff}/N_{all}$ representing the share of similar projects (penetration rate of the measure/technology) using a measure/technology similar to the measure/technology used in the proposed project activity that deliver the same output or capacity as the proposed project activity.

$F=1- N_{diff}/N_{all} = 1-0 = 1$

$N_{all} - N_{diff} = 1$.

The proposed project activity is a "common practice" within a sector in the applicable geographical area if the factor F is greater than 0.2 and $N_{all}-N_{diff}$ is greater than 3.

➔ Since F = 1 but $N_{all}-N_{diff} =1$, it can be concluded that **the project activity is not common practice** i.e. that its technology has not diffused in the relevant sector and region.

N.B. Besides, the hydro power plant identified as similar was implemented more than 60 years ago. Local expertise of implementing such projects is lacking nowadays; moreover the political and economic context in which it was developed was different and has deteriorated.

Outcome of Step 4:
Step 4 is satisfied, i.e. the proposed project activity is not regarded as "common practice". In conclusion of the overall additionality demonstration, the proposed project activity is deemed additional

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

According to the approved methodology ACM0002 (Version 19.0), Emission reductions are calculated as:

$$ER_y = BE_y - PE_y \quad \textbf{(1)}$$

Where:

ER_y	=	Emission reductions in year *y* (tCO_2e/yr)
BE_y	=	Baseline emissions in year *y* (tCO_2/yr)
PE_y	=	Project emission in year *y* (tCO_2e/yr)

Project emissions

Project emissions shall be accounted by using the following equation:

$$PE_y = PE_{FF,y} + PE_{GP,y} + PE_{HP,y} \quad \textbf{(2)}$$

Where:

PE_y	=	Project emissions in year *y* (tCO_2e/yr)
$PE_{FF,y}$	=	Project emissions from fossil fuel consumption in year y (tCO_2/yr)
$PE_{GP,y}$	=	Project emissions from the operation of dry, flash steam or binary geothermal power plants in year *y* ($t\ CO_2e/yr$)
$PE_{HP,y}$	=	Project emission from water reservoirs of hydro power plants in year y (tCO_2e/yr)

Project emissions from fossil fuel consumption ($PE_{FF,y}$)

No project emissions are expected as the project activity only involves renewable electricity generation from the run-of-river hydroelectricity power plant without fossil fuel consumption, and according to para 36 of ACM0002 “for all renewable energy power generation activities, emissions due to the use of fossil fuels for the backup generator can be neglected, hence $PE_{FF,y}$ = 0.

Project emission from the operation of dry, flash steam or binary geothermal power plants ($PE_{GP,y}$)

Project is hydro power plant hence inapplicable and $PE_{GP,y}$ = 0.

Emissions from water reservoirs of hydro power plants ($PE_{HP,y}$)

The power density (PD) is calculated as follows:

$$PD = \frac{Cap_{PJ} - Cap_{BL}}{A_{PJ} - A_{BL}} \quad \textbf{(3)}$$

Where:

PD	= Power density of the project activity (W/m^2)
Cap_{PJ}	= Installed capacity of the hydro power plant after the implementation of the project activity (W)
Cap_{EL}	= Installed capacity of the hydro power plant before the implementation of the project activity (W). For new hydro power plants, this value is zero
A_{PJ}	= Area of the single or multiple reservoirs measured in the surface of the water, after the implementation of the project activity, when the reservoir is full (m^2)
A_{BL}	= Area of the single or multiple reservoirs measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m^2). For new reservoirs, this value is zero.

Nominal installed capacity is 28.8 MW (actually 28 MW of permanent power generation and 800 kW of construction, maintenance & low-flow back-up) and expected reservoir area, net of the original river bed, is 180,000 m^2. Therefore, the resulting power density is:

PD = 28,800,000 / 180,000 = 160 W/m^2 > 4 W/m^2

For hydro power project activities that result in new single or multiple reservoirs and hydro power project activities that result in the increase of single or multiple existing reservoirs, project proponents shall account for CH_4 and CO_2 emissions from the reservoirs, estimated as follows:

According to para 41 c): “if the power density of the project activity is greater than 10 W/m^2, $PE_{HP,y}$ = 0”.

Consequently $PE_{HP,y}$ is not monitored.

Baseline Emissions

Baseline emissions include only CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity. The methodology assumes that all project electricity generation above baseline levels would have been generated by existing grid-connected power plants and the addition of new grid-connected power plants. The baseline emissions are to be calculated as follows:

$$BE_y = EG_{PJ,y} \times EF_{grid,CM,y} \quad \textbf{(4)}$$

Where:

BE_y	= Baseline emissions in year y (tCO_2/yr)
$EG_{PJ,y}$	= Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year *y* (MWh/yr)

EFgrid,CM,y = Combined margin CO_2 emission factor for grid connected power generation in year *y* calculated using the latest version of "TOOL07: Tool to calculate the emission factor for an electricity system" (t CO_2/MWh)

Calculation of EGPJ,y

Since the project activity is *the installation of a new grid-connected renewable power plant at a site where no renewable power plant was operated prior to the implementation of the project activity*, it verifies the case of a Greenfield renewable energy power plant of the ACM0002 methodology Version 19.0 whereby:

$$EG_{PJ,y} = EG_{facility,y} \quad \textbf{(5)}$$

Where:

$EG_{PJ,y}$ = Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year *y* (MWh/yr)

$EG_{facility,y}$ = Quantity of net electricity generation supplied by the project plant/unit to the grid in year *y* (MWh/yr)

EGfacility,y is therefore the quantity of net electricity supplied by the project plant to the RI-Tana electricity grid. It is determined as a difference between (i) quantity of electricity supplied by the project plant to the grid and (ii) quantity of electricity delivered to the project plant from the grid (please refer to section B.7 for monitoring details). The methodology ACM0002 Version 19.0 assumes that all project electricity generation above baseline levels would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in $EF_{grid,CM,y}$.

Calculation of EFgrid,CM,y

The grid emission factor ($\mathbf{EF_{grid,CM,y}}$) is determined ex-ante. As per the "Tool to calculate the emission factor for an electricity-system" (Version 07.0.0), the emission factor is not monitored during the crediting period of each project activity but shall be updated at the renewal of the crediting period of the project activity.

This methodological tool further determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "combined margin" emission factor (CM) of the electricity system. The CM is the result of a weighted average of two emission factors pertaining to the electricity system: the "operating margin" (OM) and the "build margin" (BM). The operating margin is the emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the project activity. The build margin is the emission factor that refers to the group of prospective power plants whose construction and future operation would be affected by the project activity.

This tool provides procedures to determine the following parameters:

Table 7: Main parameters of grid emission factor calculation.

Parameter	SI Unit	Description
$EF_{grid,CM,y}$	tCO_2/MWh	Combined margin CO_2 emission factor for the project electricity system in year *y*
$EF_{grid,BM,y}$	tCO_2/MWh	Build margin CO_2 emission factor for the project electricity system in year *y*
$EF_{grid,OM,y}$	tCO_2/MWh	Operating margin CO_2 emission factor for the project electricity system in year *y*

The tool indicates six steps for the calculation of the combined margin (CM) emission factor:

STEP 1. Identify the relevant electricity systems.

For determining the electricity emission factors, identify the relevant project electricity system. Similarly, identify any connected electricity systems.

If a connected electricity system is located partially or totally in Annex I countries, then the emission factor of that connected electricity system should be considered zero.

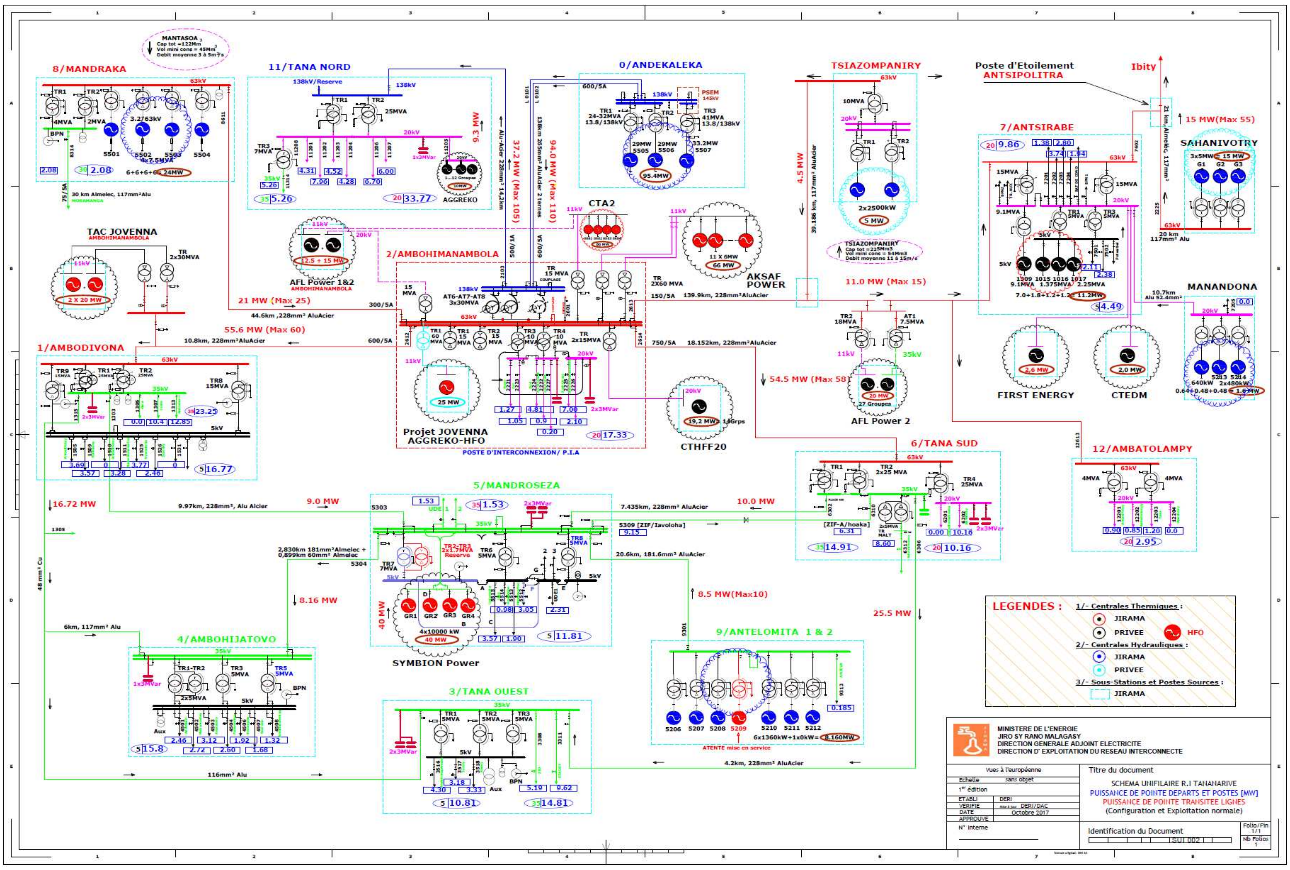
In the case of the proposed project activity, there is no connected electricity system connected located partially or totally in Annex I countries.

If the DNA of the host country has published a delineation of the project electricity system and connected electricity systems, these delineations should be used.

> The DNA of Madagascar has not published a delineation of the project electricity system and connected electricity system.

Option 2: The following map shows the geographical boundary of RI-Tana grid, managed by JIRAMA dispatch center.

Figure 4: Project electricity system i.e. RI-Tana Grid



For the proposed project activity, the spatial extent to determine the build margin emission factor is limited to the project electricity system.

STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional).

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:
Option I: Only grid power plants are included in the calculation.
Option II: Both grid power plants and off-grid power plants are included in the calculation.

Option I is applied.

STEP 3: Select a method to determine the operating margin (OM)

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods, which are described under Step 4:
(a) Simple OM; or
(b) Simple adjusted OM; or
(c) Dispatch data analysis OM; or
(d) Average OM.

The Simple OM method (a) is applied since:
- Low-cost/must run share is greater than 50% in recent 5 years, but
- Average load by LCMR is less than average LASL over three years[11]

For the simple OM, the emissions factor can be calculated using either of the two following data vintages:

a) Ex ante option: if the ex-ante option is chosen, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, use a 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation.
For off-grid power plants, use a single calendar year within the five most recent calendar years prior to the time of submission of the CDM-PDD for validation;

b) Ex post option: if the ex post option is chosen, the emission factor is determined for the year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required to calculate the emission factor for year y is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year y-1 may be used. If the data is usually only available 18 months after the end of year y, the emission factor of the year proceeding the previous year y-2 may be used. The same data vintage (y, y-1 or y-2) should be used throughout all crediting periods.

For the purpose of this project, option a) ex ante option is selected. Thus, the emission factor is determined once at the validation stage, and no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, a 3-year generation-weighted average has been used, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation (2016-2018).

Power plants registered as CDM project activities should be included in the sample group that is used to calculate the operating margin if the criteria for including the power source in the sample group apply.

In Madagascar and at the time of request for registration, there are 4 projects activities and 1 programme of activities registered under the CDM. Among these projects and programmes of activities, there are three power plants connected to the project electricity system: Small-Scale Hydropower Project Sahanivotry in Madagascar, and Tsiazompaniry Hydropower Project in Madagascar, as well as Ambatolampy 20 MW solar PV registered in 2019.

STEP 4. Calculate the operating margin emission factor according to the selected method.

Simple OM

The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (t CO_2/MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units, by the following option:

Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit

Determination of $EF_{EL,m,y}$

The emission factor of each power unit *m* is determined as follows[12]:

Option A2: If for a power unit m only data on electricity generation and the fuel types used is available, the emission factor should be determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, as follows:

$$EF_{EL,m,y} = \frac{EF_{co2,m,i,y} \times 3.6}{\eta_{m,y}} \quad (6)$$

Where:

$EF_{EL,m,y}$ — CO_2 emission factor of power unit *m* in year *y* (t CO_2/MWh)

[11] cf. RI-TANA GEF calculation sheet 2016-2018 provided to the DOE

[12] Due to unavailability or unreliability of most fuel consumption data, and for conservative application of the default efficiency approach throughout the grid data vintage

$EF_{CO2,m,i,y}$	Average CO_2 emission factor of fuel type *i* in year *y* (t CO_2/GJ)
$\eta_{m,y}$	Average net energy conversion efficiency of power unit *m* in year *y* (ratio)
m	All power units serving the grid in year y except low - cost/must – run power units
y	The relevant year as per the data vintage chosen in Step 3

Determination of $EG_{m,y}$

For grid power plants, EGm,y are determined as per the provisions in the monitoring tables, once for each crediting period using the most recent three historical years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (based on JIRAMA national power utility data as shared publicly through the Power Regulation Authority website's statistics).

The result of the calculation for the most recent 3 years average returns an **Operating Margin of 0.597 tCO_2/MWh.**

STEP 5. Calculate the build margin (BM) emission factor.

In terms of vintage of data, project participants can choose between one of the following two options:

Option 1: for the first crediting period, calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

Option 2: for the first crediting period, the build margin emission factor shall be updated annually, ex post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated ex ante, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

For the purpose of this project, option 1 is applied.
Capacity additions from retrofits of power plants should not be included in the calculation of the build margin emission factor.

In the project electricity system, there is no capacity addition from retrofits of power plants.

The sample group of power units *m* used to calculate the build margin should be determined as per the following procedure, consistent with the data vintage selected above:

(a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\ units}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$, in MWh);

The set of five power units that have been built most recently represents a gross electricity production (in the year 2018) of 137,033 MWh ($SET_{5\text{-}units}$).

(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20 per cent of AEG_{total} (if 20 per cent falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\ per\ cent}$) and determine their annual electricity generation ($AEG_{SET\geq 20}$ *per cent*, in MWh);

20% of gross electricity production in 2018 (AEG_{total} = 1,260,917 MWh) represented 252,183 MWh. $SET_{\geq 20\ per\ cent}$ thus comprise a total of 352,020 MWh.

(c) From $SET_{5\text{-}units}$ and $SET_{\geq 20\ per\ cent}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample}); Identify the date when the power units in SET_{sample} started to supply electricity to the grid. If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin.

In the present case, $SET_{\geq 20\ per\ cent}$ comprises the larger annual electricity generation and none of its power units started to supply electricity to the grid more than 10 years ago, thus $SET_{sample} = SET_{\geq 20\ per\ cent}$.

The build margin emission factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units m during the most recent year y for which electricity generation data is available (2018 in present case), calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}} \quad (7)$$

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year *y* ($t\ CO_2/MWh$)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* ($t\ CO_2/MWh$)
m	=	Power units included in the build margin
y	=	Most recent historical year for which electricity generation data is available.

The CO_2 emission factor of each power unit *m* ($EF_{EL,m,y}$) should be determined as per the guidance in Step 4 section 6.4.1 for the simple OM, using Options A1, A2 or A3, using for *y* the most recent historical year for which electricity generation data is available, and using for *m* the power units included in the build margin.
In the case of this project, the CO_2 emission factor of each power unit *m* ($EF_{EL,m,y}$) is determined as per option A2.

On the basis of the above, the **Build Margin (2018) results in 0.662 tCO_2/MWh**.

STEP 6. Calculate the combined margin (CM) emission factor

The calculation of the combined margin (CM) emission factor ($EF_{grid,CM,y}$) is based on one of the following method:
(a) Weighted average CM;

(b) Simplified CM.

For the purpose of this project and since data to determine BM is available, option a) is selected. The combined margin emission factor is calculated as the Weighted average CM:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM} \quad (8)$$

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,OM,y}$	=	Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
w_{OM}	=	Weighting of operating margin emissions factor (%)
w_{BM}	=	Weighting of build margin emissions factor (%)

The following default values should be used for w_{OM} and w_{BM}: in case of hydro power generation project activities are:
$w_{OM} = 0.5$
and
$w_{BM} = 0.5$ for the first crediting period, and
$w_{OM} = 0.25$ and $w_{BM} = 0.75$ for the second and third crediting periods.

The combined margin emission factor and **grid emission factor value** used to calculate the emission reductions of the project is **0.6293 tCO_2/MWh**.

B.6.2. Data and parameters fixed ex ante

Data/Parameter	$EF_{grid,CM,y}$
Data unit	tCO_2/MWh
Description	Combined margin CO_2 emission factor for grid connected power generation in year *y* calculated using the latest version of the “Tool to calculate the emission factor for an electricity system”
Source of data	JIRAMA 2016-2018 data
Value(s) applied	0.6293
Choice of data or measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$EF_{grid,OM,y}$
Data unit	tCO_2/MWh
Description	Operating Margin CO_2 emission factor for grid connected power generation in year *y* calculated using the latest version of the “Tool to calculate the emission factor for an electricity system”
Source of data	JIRAMA 2016-2018 data
Value(s) applied	0.597
Choice of data or measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	$EF_{grid,BM,y}$
Data unit	tCO_2/MWh
Description	Build Margin CO_2 emission factor for grid connected power generation in year *y* calculated using the latest version of the “Tool to calculate the emission factor for an electricity system”
Source of data	JIRAMA 2016-2018 data
Value(s) applied	0.662
Choice of data or measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	Cap_{BL}
Data unit	W
Description	Installed capacity of the hydro power plant before the implementation of the project activity.
Source of data	Project site
Value(s) applied	0
Choice of data or measurement methods and procedures	For new hydro power plants, this value is zero.
Purpose of data	Calculation of project emissions
Additional comment	This parameter is used to calculate the power density.

Data/Parameter	A_{BL}
Data unit	m^2
Description	Area of the single or multiple reservoirs measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m^2).
Source of data	Project site
Value(s) applied	0
Choice of data or measurement methods and procedures	For new reservoirs, this value is zero.
Purpose of data	Calculation of project emissions
Additional comment	This parameter is used to calculate the power density.

B.6.3. Ex ante calculation of emission reductions

	Value/Result	**Source/reference**
Total installed capacity	28[13] MW	Project documents
Net electricity delivered to the grid ($EG_{PJ,y}$)	136,000 MWh/yr	Project documents $[EG_{PJ,y} = EG_{facility,y}]$
Baseline emission factor of RI-Tana grid ($EF_{grid,CM,y}$)	0.6293 tCO_2e/MWh	Section B.6
Baseline emissions (BE_y)	85,581 tCO_2e	Section B.6 $BE_y = EG_{PJ,y} \cdot EF_{grid,CM,y}$
Project emissions (PE_y)	0 tCO_2e	Section B.6
Emission reductions (ER_y)	85,581 tCO_2e	$ER_y = BE_y - PE_y$

13 actually 28 MW of permanent power generation and 800 kW of construction, maintenance & low-flow back-up

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions ($t CO_2e$)	Project emissions ($t CO_2e$)	Leakage ($t CO_2e$)	Emission reductions ($t CO_2e$)
01/04/2020 - 31/12/2020	64 186	0	0	64 186
2021	85 581	0	0	85 581
2022	85 581	0	0	85 581
2023	85 581	0	0	85 581
2024	85 581	0	0	85 581
2025	85 581	0	0	85 581
2026	85 581	0	0	85 581
01/01/2027 - 31/03/2027	21 395	0	0	21 395
Total	599 067	0	0	599 067
Total number of crediting years	7			
Annual average over the crediting period	85,581	0	0	85,581

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data/Parameter	$EG_{facility,y}$
Data unit	MWh/yr
Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year *y*
Source of data	Electricity meter(s)
Value(s) applied	136,000
Measurement methods and procedures	This parameter should be calculated as difference between (a) the quantity of electricity supplied by the project plant/unit to the grid, and (b) the quantity of electricity delivered to the project plant/unit from the grid. Bi-directional meters (main & back-ups) will be installed at the substation of the hydro power plant to measure directly and continuously the electricity supply to (and, if any, import from) the grid. Accuracy class of the expected Cewe electricity meter is 0.2. Annual calibration on-site in accordance with the national practice set by JIRAMA, in the absence of specific metering specifications from the national electricity code yet [14], besides an initial verification by commissioning[15].
Monitoring frequency	Continuous measurement and at least monthly recording
QA/QC procedures	The data is cross-checked for quality control against electricity transmission records from JIRAMA dispatching department before approval of the billing. Billing is then processed under a monthly invoice to JIRAMA based on measurements of electricity supplied. In case of malfunctional main meter, back-up meter reading will be applied and reconciled anyway with grid operators' records.
Purpose of data	Calculation of baseline emissions

[14] Law n° 2017-020 acting as Electricity Code in Madagascar - http://www.ore.mg/TextesDoc/Loi2017-020_CODELEC.pdf

[15] §69 of Decree N° 2001 – 173 fixing the Electricity sector conditions and modalities - http://www.ore.mg/TextesDoc/Decret-2001-173%20%20cadre%20LOI%20ELEC.pdf

Additional comment	-

Data/Parameter	Cap_{PJ}
Data unit	W
Description	Installed capacity of the hydro power plant after the implementation of the project activity
Source of data	Project site
Value(s) applied	28,800,000
Measurement methods and procedures	Determine the installed capacity based on manufacturer's specifications or commissioning data or recognized standards
Monitoring frequency	Once at the beginning of each crediting period
QA/QC procedures	-
Purpose of data	Calculation of project emissions
Additional comment	Actually 28 MW of permanent power generation and 800 kW of construction, maintenance & low-flow back-up

Data/Parameter	A_{PJ}
Data unit	m^2
Description	Area of the single or multiple reservoirs measured in the surface of the water, after the implementation of the project activity, when the reservoir is full
Source of data	Project site
Value(s) applied	180,000
Measurement methods and procedures	Measured from topographical surveys, maps, satellite pictures, etc.
Monitoring frequency	Once at the beginning of each crediting period
QA/QC procedures	-
Purpose of data	Calculation of project emissions
Additional comment	-

B.7.2. Sampling plan

n/a

B.7.3. Other elements of monitoring plan

Monitoring organization

The project owner will take the responsibility of the monitoring plan implementation and appoint a CDM manager, who will be responsible for the supervision of the monitoring process, the data measuring, collection and recording, QA/QC, audit and reporting.

The staff from technical and financial departments will undertake the monitoring tasks including watching metering equipments periodically, collecting electricity data and completing records, checking and analyzing the data, archiving relevant records, reporting to the CDM manager.

Quality assurance and quality control

The electricity delivered to RI TANA will be monitored trough metering equipment at the project site and invoiced monthly to JIRAMA. The data will be cross-checked for quality control against electricity transmission records from JIRAMA dispatching department before approval of the billing.

Calibration of meters occurs annually according to the national practice set by JIRAMA. All relevant data records obtained from the monitoring are kept by the project owner during the crediting period and for at least two years after the end of crediting period.

Operational procedures, including emergency response in case of meters failure and troubleshooting measures, will be described in the implementing manuals based on which the project staff will be trained.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

10/11/2017

The starting date has been determined as the date on which the EPC contract was signed, as the earliest date when the real action on the project begins, as per Glossary definition of “implementation or construction or real action of a CDM project activity”.

Table 8: Project implementation milestones

Milestones	Date
EIA study, incl. local stakeholders consultations	oct-2014
CDM Prior Consideration Form submission	31/07/2015
EPC contract signature & investment decision	10/11/2017 **>> start date**
Lending agreement and building permit signature	30/11/2017
Environmental Clearance	feb-2019
Commissioning Date	01/04/2020 (est.)

According to EB41 clarifications, minor pre-project expenses, e.g. the contracting of services /payment of fees for feasibility studies or preliminary surveys, should not be considered in the determination of the start date as they do not necessarily indicate the commencement of implementation of the project.

C.2. Expected operational lifetime of project activity

The expected operational of the project activity is more than 20 years after start of operation (240 months).

C.3. Crediting period of project activity

C.3.1. Type of crediting period

The project crediting period is 7 years and 0 month, renewable twice.

C.3.2. Start date of crediting period

The project crediting period starts on 01/04/2020 (or the date of registration, whichever is later)

C.3.3. Duration of crediting period

The duration of crediting period is 7 years and 0 month (i.e. 84 months).

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

As per the amended Environmental Protection Act (EPA, 2008), an Environment Impact Assessment (EIA) is required for “Power Generating Plants”.

A first EIA was realized in 2002 for the FHPP, following which an environmental permit was issued by the Ministry of Energy in 2008.
In accordance with Article 3 of the said authorisation, "any modification of the works envisaged in the initial EIA must be the subject of a declaration which will be deposited with the environmental unit, together with the relevant technical file". The main change brought by the project is the extension of the installed capacity from 8MW to 28MW, which consequently modified the dimensions of some structures such as the dam, and the construction of a micro-hydro power plant of 800 KW.
The environmental assessment was thus updated in 2014 by CEExI (Cabinet d’Etudes Environnementales et d’Expertise Industrielle), and then amended in 2018 following another extension of the installed capacity (22 to 28 MW). The standards used for this assessment are the International Finance Corporation’s (IFC) Performance Standards (2012).

The objective of this assessment was to identify the key environmental and social sensitivities in the Project area, key potential impacts associated with the Project, and how to manage those in the next stages of Project planning and implementation.

An environmental and social action plan (ESAP) will be implemented from the start date of project activity. This plan specifies who is responsible for implementing mitigation measures and for their monitoring, control and follow-up. It also provides for the means of implementing the indicated measure. Especially, an Environmental Manager of the project will be recruited, and will be under the direct authority of the Project Manager and/or his HSE Manager. He will be in charge of following up the ESAP, to ensure good application of mitigation measures and will be the focal point for stakeholders for every environmental or social aspects.

After submission of the relevant documents to the Ministry in charge of Energy, an environmental authorization was obtained in December, 10th, 2008.
Consecutive to the extension of the installed capacity and related ESAP (28 MW PREE, October 2018), a new environmental permit of the Project was approved by a ministerial decision in February, 2019.

D.2. Environmental impact assessment

The following environmental and social aspects were identified and expected to be of negligible to minor significance:

- Air quality: The only source of atmospheric emissions is exhaust gas from vehicles and generators, which will follow a frequent maintenance. Dust arising in the construction phase will be mitigated through covering trenches in the course of pipes installation, and trucks transporting dusty materials will be covered. Workers will be provided with anti-dust masks.
  There is no significant source of air quality pollution during operations.
- Noise: The construction phase will generate only low and temporary impacts on noise level. Explosives use will be strictly supervised, with safety and information procedures.
  During operations, the generator will be the main source of noise. It will be equipped with a silent system meeting the standard of 75 dB(A) maximum at a distance of 7m.
- Biodiversity: the EIA concluded that there is no specific biodiversity sensitivity in the Project area and the Project is well delineated with a limited footprint.
- Traffic and transport: the traffic generated by the project will be limited in time and intensity during construction and decommissioning phase. Work signs will be placed on the road, and speed limitations will apply for plant's vehicles, especially in residential areas.

The following environmental aspects were identified with a significant impact, and corresponding mitigation measures are necessary:

- Hydrology and hydrogeology: According to hydrological studies, the presence of the dam will not change the hydrological regime of Ikopa. Thus, the probability of flooding risks in the upstream part of the dam is low.
  However, debris carried by the runoff water and work in the riverbed may impact water flow. In consequence, the Project will store excavated material away from rivers, avoid obstructing the normal flow of water, as well as sensitize workers not to pollute the water.
- Soils: Excavation work will imply soils changes (Increased soil compactness, reduced infiltration capacity, increased erosion risks). The Project will adopt some mitigation measures, including:
  - Avoid earthworks outside the boundary of the infrastructure siting area
  - Avoid digging outside the surface required for the installation of penstocks
  - Comply with good practice after the penstocks have been laid by properly plugging the trenches and applying appropriate erosion control measures, if necessary
  - Grass the bare parts sensitive to erosion and the two sides of the track
  - Comply with stability standards for slopes
- Waste: Waste, accidental oil spills and waste oils may pollute soils and/or water. As a consequence, the Project plans to:
  - Minimize the production of waste that needs to be treated or disposed of. Sort solid waste. To this end, make waste collection devices available to the site and separate biodegradable and non-polluting waste. Dispose of them in authorized areas.
  - Collect used oils in a drum and dispose of them off-site or recycle them.
  - Monitor the placement of all construction waste (including excavation materials) in approved disposal sites (> 300m from rivers)
- Landscape and visual: the change to landscape will be limited to the infrastructure to be build. One measure adopted is to limit visual pollution from excavated material (by reutilisation of the excavated

material for backfilling the platform of the power plant building, or storing them on a flat area with a height of no more than 2.5m).
Integration of the infrastructure into the landscape will be improved by developing green spaces around the infrastructure.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

Stakeholder engagement has been undertaken from 2008 during the first EIA and was repeated in 2013-2014. Updates were also communicated in 2018 to local authorities and local communities.
Thus, during this complementary environmental study, interviews were carried out beforehand with the local authorities (Municipalities, Fokontany) and which aimed to inform them about the situation of the project initiated since 2002. Subsequently, consultations with the population directly concerned by the project were carried out in the rural municipalities of Ampanotokana and Ambohimasina.
It should be noted that all these public consultations were chaired by the local authorities present and were always assisted by the Representatives of the project proponent.
These meetings were organized in order to adequately inform the public about the progress of the project and to hear their opinions and concerns. This is in order to promote the social acceptability of the project and its sustainability.

Individual interviews were also conducted with households directly affected by the project, following which amicable negotiations were held on prices and compensation.
These privileged information and consultation activities had gradually established a climate of exchange between the project proponent and the stakeholders affected by the project.

Stakeholder meetings held on July 23, 2014:

On July 23, 2014, 2 public consultations were led by HYDELEC[16] in the two rural communes concerned by the Project, respectively Ambohimasina and Ampanotokana. 59 and 21 people attended these public consultations, according to the attendance lists, with the following key stakeholder groups represented:

Stakeholder	Stakeholder category	Type of meeting
July 23, 2014 – from 3.00 PM - Ampanotokana		
Ampanotokana mayor	Local authority	Focus group
Fokontany president	Local authority	Focus group
Representative of the Ministry of Energy	National authority	Focus group
Representatives of the population of Ampanotokana.	Local community	Focus group
July 23, 2014 –9.30 AM to 1.30 PM - Ambohimasina		
Ambohimasina mayor	Local authority	Focus group
Ambohidrazana Fokontany president	Local authority	Focus group
Representative of the Ministry of Energy	National authority	Focus group
Representatives of the population of Ambohimasina.	Local community	Focus group

Stakeholders participation were invited directly by the local authority representative (Fokontany chief) through direct communication and public display.
The following information were disclosed :

[16] carrying the preliminary studies of the project later taken over by Mahitsy Hydro SARLU as from 2nd amendment to the power generation concession with Ministry of Energy since July 2017, and formally recognised in the environmental approval process since April 2018 too

- A brief description of the project and its objectives as well as the actions planned,
- A presentation of the likely environmental impacts of the project and the measures to be taken.

Figure 5: Pictures of the stakeholder meetings in the rural municipalities of Ampanotokana and Ambohimasina on July 23, 2014.

E.2. Summary of comments received

Category	**Stakeholder comment**
Key concerns	
Project execution	Community representatives asked to be informed prior to the implementation of the project. They also asked project developers to respect customs and traditions (including the sacrifice of zebus on each side of the river before the start of the work). Security measures shall be implemented, especially during construction phase
Land availability	Landowners affected by the Project have to be indemnified/compensated.
Key expectations	
Economic development	The Project will generate employment opportunities, in priority for local population.
Access to electricity	The Project may give access to electricity to local communities.
Transportation	The Project will improve transportation thanks to the construction of the bridge linking the rural municipalities of Ampanotokana and Ambohimasina.
Access to basic services	The Project may improve the access to health and education for local population.

Comments were invited verbally during focus groups. Considering the level of details disclosed to stakeholders during the simplified ESIA process and its early stage nature, stakeholders' feedback on the Project was limited, but considered to be nonetheless representative of the key concerns and expectations associated with the Project.

E.3. Consideration of comments received

The comments received were duly considered in the project's development and reflected in the Environmental Impacts complements (PREE Annex 4 : revised Environmental & Social Clauses)
, which objective is to set out the key actions to be undertaken by the Project in order to achieve compliance with the applicable environmental and social standards, and in particular those from the IFC:

- IFC Performance Standards 1 - Assessment and Management of Environmental and Social Risks and Impacts
- IFC Performance Standard 2 - Labor and Working Conditions
- IFC Performance Standard 3 - Resource Efficiency and Pollution Prevention
- IFC Performance Standard 4 - Community Health, Safety, and Security
- IFC Performance Standard 5 - Land Acquisition and Involuntary Resettlement
- IFC Performance Standard 6 - Biodiversity Conservation and Sustainable Management of Living Natural Resources
- IFC Performance Standard 8- Cultural Heritage

Subsequent monitoring requirements of the same are set out in Ministry of Energy's Terms of Reference (CCE, February 2019).

Some complaints about houses cracks due to rock-blasting were later received during construction and addressed by agreeing on free-of-charge cement supply for the repairs, amounting to 128 cement bags delivered in August 2019.

Community liaison officers were further designated as:

- Mr. Mamisoa Razafindrazaka (consultant CEEXI) on site
- Mr. Tolojana Ramanivosoa (TGM) responsible for HS part.

Mahitsy Hydro SARLU will monitor the implementation of the actions and will assess the efficiency and effectiveness of the action and require corrective actions where necessary.

SECTION F. Approval and authorization

LoA from host party was issued on November 25th 2019.

Appendix 1. Contact information of project participants

Organization name	Mahitsy Hydro SARLU
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Appendix 2. Affirmation regarding public funding

n/a

Appendix 3. Applicability of methodologies and standardized baselines

n/a

Appendix 4. Further background information on ex ante calculation of emission reductions

n/a

Appendix 5. Further background information on monitoring plan

n/a

Appendix 6. Summary report of comments received from local stakeholders

n/a

Appendix 7. Summary of post-registration changes

n/a

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Document information

Version	Date	Description
11.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: • Improve consistency with the “CDM project standard for project activities” and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the “CDM project standard for project activities” (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the “Project design document form for small-scale CDM project activities” (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the “Standard: Applicability of sectoral scopes” (CDM-EB88-A04-STAN) (version 01.0).
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).

Version	*Date*	*Description*
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

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