JCM/BOCM Feasibility Study (FS) 2012
Final Report

"Hybrid System to Stabilize PV Power Generation"

(Implementing by Hitachi Zosen Corporation)

FS Partners	[Japan] Mizuho Corporate Bank, Solar Frontier [Host Country] Differ/ Eco Power
Location of Project/ Activity	Indonesia, Nias Island
Category of Project /Activity	Renewable Energy
Description of Project/Activity	A power supply project to introduce a small to medium-scale MW class hybrid power generation system that combines PV and diesel engine power generation. Introduction of this system will enable a reduction in fossil fuel consumption through PV power generation offset and increased diesel engine efficiency. Accordingly, this project through reducing fossil fuel consumption will result in a corresponding reduction in the amount of CO_2 emissions. This hybrid system, through highly advanced integrated controls, compensates for output fluctuations in PV power generation by incorporating a low-load type diesel engine. The system optimizes power generation at the same time as stabilizing power output which in turn keeps the usage of high cost rechargeable batteries to a bare minimum and also minimizes both construction and running (fuel) costs.
Eligibility Criteria	This methodology is applicable to a project activity that involves a power generation system that combines PV and diesel engine power generation and satisfies all of the followings: (a) An activity that, through application of software that compensates for fluctuations in the PV power output, controls diesel engine power output, stabilizes the total PV and diesel engine power output and in particular uses stable power to provide base-load electricity for small or medium sized systems (MW class or smaller). (b) An activity that uses a low-load type diesel power generator and one that uses a CIS type PV cell. (c) An activity that by application of the software technology developed in Japan as described in (a) above to the diesel power generator output control component, reduces power output fluctuations.
Reference Scenario and Project/Activity Boundary	As the reference scenario (small-scale grid connected power), while 100% of power is presently generated by diesel engines, it is envisaged that in the near future power generation will be supplied by a combination of coal, coal gas and diesel engine plants. (Replacement only as basically new establishment will not be approved.)
Calculation Method Options	The method of setting a grid's CO_2 emission factor to calculate a reference emission factor (EF) varies according to the size of the grid. Here the following two calculation methods have been selected: (1) Grid size; and (2) Use of default values. To apply (1), the judgment criteria is whether or not it is a large-scale grid owned and managed by PLN which in Indonesia has a monopoly on power distribution. Under (2), regardless of whether or not connected to a large or small-scale grid, the default values may be applied. If default values are used, the CO_2 reduction amount must be calculated in a conservative manner.
Default Values set in Methodology	The default emission factor values for a large-scale grid, that are regularly calculated and published by the Ministry of Energy and Mineral Resources (ESDM) and the National Council on Climate Change (DNPI),

	are applied. Having been supplied by the Indonesian government for use in CDM, these values are considered appropriate for use in JCM/BOCM. Further, the default values for the CO_2 emission factor of a small-scale grid power generation plant are calculated solely on the consumption of liquid fossil fuels. Under this scenario, and based upon a continuous 24hr/per day power supply, a mini-grid emission factor of 0.8 t-CO_2/MWh is deemed appropriate.
Monitoring Method	The quantity of net electricity generation will be monitored under the following criteria: - The quantity of net electricity generated by the PV power generation system; - The quantity of net electricity generated by the diesel power generator; - The quantity of net electricity generated by the PV power generation system to calculate the reference emissions; - The grid EF; and - The diesel engine's fuel consumption.
GHG Emissions and its Reductions	With a 4MW hybrid power generation plant assuming a capacity utilization for a PV power generation system on Nias island at 15.39% and an EF of 0.7 tCO_2/MWh (In accordance with calculations provided by Wärtsilä) a reduction in GHG emissions to 7,243 tCO_2/year is forecast.
Method of Verification	Based upon the MRV methodology as outlined herein, an on-site investigation has confirmed that the required third party verifications will be able to be performed. As implementing bodies, in addition to the Indonesian DOE, it is assumed that approximately 10 companies or other entities that perform ISO certification etc. will perform the verifications.
Environmental Impacts	It is necessary to take into consideration that the installation of PV panels and diesel engine, through acquisition of a large amount of land for private use, will have an impact on land development, will influence the use of bio-fuels (in particular palm oils) as fuels for the diesel engine used as a part of this system, will as this project becomes more widespread strengthen the power supply on Nias Island and will also greatly expand those areas on the island with access to power.
Financial Plan	In the event that no subsidies are provided by the Japanese government, based upon repayment of loans together with interest on the same, profitability on investment over a 20-year period is considered to be IRR 5.21% which is the standard for consideration as an investment. If subsidies are provided it is considered that sufficient profitability for investors can be assured. However, as fluctuations in diesel oil prices and retail electricity prices will have a major influence on cash flow, consideration of long-term hedging measures to minimize risk due to fluctuations at the time of actual investment is considered preferable.
Promotion of Japanese Technology	If stable PV power output can be used as the primary power generation source, this provides the best solution for places such as Nias Island that presently use independent systems which produce an inferior quality of power. Further, the CIS type PV cell modules used in this system are able to minimize the loss of generation efficiency even in hot temperatures such as those that predominate in Indonesia. Accordingly it is expected that use of this type of PV cell will penetrate the market due to its compatibility with the climate characteristics.
Sustainable Development in Host Country	Through expanding the electricity supply capacity on Nias Island, attracting factory rollouts by both Indonesian and foreign companies through improvements in electricity quality and also through use of bio-fuels creating employment opportunities on local plantations, this project will indeed contribute to local development.

Title of the Study: JCM/BOCM Feasibility Study "Hybrid System to Stabilize PV Power Generation"

FS Entity:Hitachi Zosen Corporation

1. FS Implementation Scheme

[Japan] Mizuho Corporate Bank (Policy and local market investigation / commercial feasibility evaluation)
Solar Frontier (Technical evaluation of PV power generation system)
[Host Country] Differ / Eco Power (Appointment of local bodies / local investigations support)

2. Overview of Project/Activity

(1) Description of Project/Activity Contents:

This project envisages electricity supply through introduction of a MW class hybrid power generation system that combines PV and diesel engine power generation (After, "the System") on the Indonesian Island of Nias located approximately 140km off shore of North West Sumatra, (see **Figure 1**)

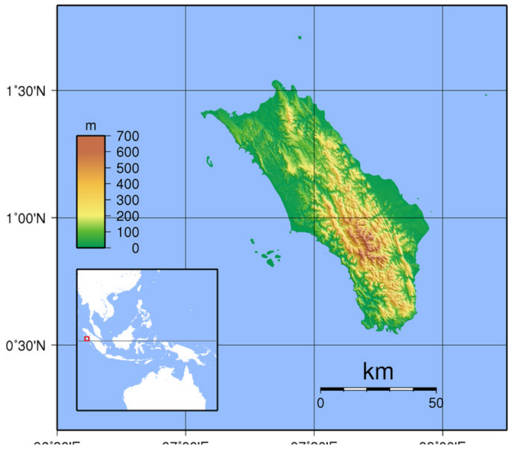


Figure 1: Nias Island topographical map

Introduction of the System will enable a reduction in fossil fuel consumption by offsetting it with PV power generation. Accordingly, this project, through reduced fossil fuel consumption and increased efficiency in diesel engine operation, will result in a corresponding reduction in the amount of CO_2 emissions. The System, through highly advanced integrated controls, levels out output fluctuations in PV power generation and also incorporates a low-load type diesel engine. The System optimizes power generation at the same time as stabilizing power output which in turn keeps the usage of high cost rechargeable batteries to a bare minimum and also minimizes both construction and running (fuel) costs.

While it is envisaged that the Indonesian state owned power company, PLN (group) will be the major stakeholder in the introduction of the System, a role for IPP is also envisaged.

(2) Situations of Host Country:

1) Current Status of Electricity and Other Energy

- While traditionally Indonesia's state owned power company PLN has enjoyed a monopoly in the electricity business, as part of the New Electricity Law (approved September 2009), authorization rights have been granted to the central and state governments. Accordingly the entry of new participants into the electricity business is expected.
- Presidential decree (No.5/2006) outlined a major shift in fossil fuels from oil to coal derived sources. Further an increasing trend in the use of renewable energy sources has been noted. (However, solar power ranks far behind the other major renewable energy sources bio-fuels, geothermal and hydroelectric power generation.)
- To reduce consumption of oil (Reduction in power generation costs), as a general rule simply introducing further new diesel power generators is not permitted. (Replacement of existing units is possible.)
- The present electrification ratio within Indonesia (2010 National average 67%) is expected to grow nationwide by 2.8% annually with a target of 93% in 2025. This represents an average annual increase in the demand for electricity of 9.2%.
- While on the remote islands of Indonesia there is presently a focus on diesel engine power generation, given both the sharp increase in the price of fuels for power generation, as well as a rise in shipping costs, this has placed a large financial burden both on PLN and the government which subsidizes its operations.

2) Renewable Energy and CO_2 Emission Reductions

- A reduction target for GHG emissions, based upon BAU comparison, of 26% by 2020 has been set. (If international support, 41% reduction.)
- By 2015 on 1,000 islands throughout Indonesia, the introduction of PV power generation (small-scale) including Nias Island has been planned. However, the introduction plan has experienced major delays and as of 2011 only 35 sites (planned 100 sites) have been established.
- The expansion of the Feed-in Tariff system to include PV power generation is under consideration. A feed-in-tariff for 10MW or less is forecast. The Indonesian government is currently considering a purchase price of approximately 2,500Rp/kWh for electricity produced using PV panels from overseas manufacturers and approximately 2,800Rp/kWh for that produced by locally manufactured PV panels.
- PLN, as part of its efforts to reduce CO_2 emissions, is in both the planning and implementation stages of strategies that prioritize the use of renewable energy sources in both remote mainland and also island communities as well as the development and rollout of geothermal power generation projects on both Java and Sumatra.

3) Use of Bio-Fuel

- The diesel engine utilized in the System has the additional advantage of being able to accept bio-fuel. While bio-fuels, palm oil, jatropha oil and others can be used, for the electricity business in Indonesia palm oil is considered to be the best alternative.

(3) Complementarity of the CDM:

JCM/BOCM projects based upon the methodology of the study complement CDM projects in the following ways.

1) Non-existence of applicable methodology

A methodology able to be applied to hybrid power generation systems does not exist for the CDM.

2) No match with additionality

The influence that profit on sales of credits (CER) has on commercial feasibility, when compared to the influence that base factors such as initial investment and electricity purchase price have, is relatively low. Presently, the result of investment analysis is either “There is low profitability that even with credit profits makes commercialization difficult” or “Even if profitable, from the viewpoint of demonstration of additionality, it cannot be approved.” The applicable scope for the CDM can only be considered to have narrowed.

3) No match with the project planning timespan

A lengthy time period to obtain CDM project accreditation is required. Taking into consideration the speed at which equipment costs for PV power generation are falling, a significant issue is that during the CDM accreditation process assumed parameters for the plan together with the commercialization evaluation based upon the same will soon become obsolete.

As a result, even when looked at solely from the perspective of ongoing credits being provided for grid connected PV power generation on a global basis, the number of accredited projects have stalled at 12 (standard scale) and 39 (small-scale). When compared to wind power generation, projects at 754 (standard scale) and 235 (small-scale) as well as hydroelectric power generation 565 (standard scale) and 620 (small-scale), this number is extremely low by comparison.

The percentage of validated projects that have successfully obtained accreditation (accreditation ratio) for grid connection is only 12% (standard scale) and 25% (small-scale). When compared to other renewable power projects, that have an accreditation ratio of around 40%, accreditation of PV power generation projects is comparatively extremely low.

For an ordinary business if risk is estimated at 80-90% taking into consideration the small expected returns it is judged that the development costs incurred do not justify CDM implementation.

3. Study Contents
(1) Issues to be Addressed in FS:

Issues considered and study methods are outlined in Table 1 below.

Table 1: Issues Considered and Study Methods

	Issues Considered	Study Methods
Eligibility Criteria for Application of MRV Methodology	Clarification of technical criteria - Fluctuations in PV power generation output - Power source quality of the Nias Island grid	As the local bureau of meteorology does not have a second by second sampling cycle for insolation data, this was actually measured on Nias Island.
		To fully understand the grid power source quality on Nias Island, power source waveforms were measured.
Setting of Reference Scenario	PV power generation planning and progress on Nias Island and throughout Indonesia	Through local interviews and written surveys, the strategies and policies of the Indonesian government, PLN, etc. were studied.
		Existing PV power generation plants were visited and the power generation conditions, problems, etc. studied.
	Current condition of Nias Island power generation plants	The condition, operation method, etc. of existing diesel power generation plants were studied.
Setting of Default Values	Setting method for CO_2 emission factor (EF)	Data collection based upon local interviews and written surveys regarding EF values and setting methods were performed.
	Evaluation of the appropriateness of using the values published by the Indonesian government	Opinion exchange with local bodies was undertaken.
Quantification of Reduction in GHG Emissions	Calculation method for capacity utilization for a PV power generation system	Through acquiring and applying climate data (insolation amounts, temperature, etc.), obtained from the Bureau of Meteorology for both Nias Island and Indonesia as a whole, an evaluation calculation was performed.
Setting of Boundaries	Selection of Project Implementation Site	Based upon site inspections, meteorological information, etc. the ideal project site was selected.
		The current situation of roads and transport infrastructure on the island was fully studied.
Implementation of Project Activity	Envisaged project implementation form and issues	Through local interviews and written surveys, the type of project implementation forms, problems, etc. was fully studied.
Financial Planning	Feed-in Tariff system	Through local interviews and written surveys, the Feed-in Tariff system was fully studied.
Additional Items	Trends concerning bio-fuels	Through local interviews and written surveys, the penetration of bio-fuels, suppliers, subsidies, etc. was fully studied.

(2) Process to Solve the Issues in FS:

The content of the study and outline of results are shown in Table 2 below.

Table 2: Content of the Study and Outline of Results

Issues Considered	Content of the Study and Outline of Results
Clarification of technical criteria - Fluctuations in PV power generation output - Power source quality of the Nias Island grid	As part of the second local investigation, insolation data on Nias Island has been measured. Maximum insolation amounts were 1.2kW/m^2 which confirmed that Nias Island is a suitable location for PV power generation. Further, as a maximum insolation fluctuation of approximately 65W/ m^2 per second has been measured, consideration of an output fluctuation compensation control is required. Further, to collect long-term insolation data, ongoing measurements from the third local investigation onwards are being implemented.

Issues Considered	Content of the Study and Outline of Results
	The results of power source measurements on Nias Island are frequency fluctuations in the range of 49.6Hz - 50.3Hz which are far greater than those experienced by large-scale grids. Accordingly, without output leveling, introduction of a large-scale renewable energy power source is considered difficult. Further, frequency declines are particularly noted in the evening, when power demand suddenly increases. Based upon measured data a shortfall in power source generation capacity as well as a weakness in operation control has been identified.
PV power generation planning and progress on Nias Island and throughout Indonesia	The potential for PV power generation in Indonesia is high with planned facilities introduction on 1,000 islands. However, with high power generation costs from renewable energy, a low priority is place on PV power.
	In the third local investigation, existing PV power generation plants at 3 locations Nusa Penida, Gili Trawangan and Bunaken were visited and investigations concerning power generation capacity, construction methods, problems, etc. were performed. The Eastern region of Indonesia receives the most sunlight. In addition, facilities affected by landslides were observed. Accordingly full consideration must be given to prevention of damage caused by rainwater runoff and other negative geographical and environmental factors. Caution must be exercised when selecting local contractors.
Condition of Local Power Generation Plants	In the first and second local investigations, the existing PLN power generation facilities on Nias Island were visited and fully investigated. Operating data, etc. was also obtained. Existing power generation facilities were roughly divided into those in Gunungsitoli in the North and those in Teluk Dalam in the South, all of which rely on diesel engine for power supply. Maintenance is poor and there is an increasing anxiety that supply capacity will be further reduced due to factors such as breakdowns, facility shutdowns, etc. Automated operation controls have not been introduced. The fact that introduction of additional power generation plants may also necessitate a corresponding increase in power transmission lines must also be considered, as in the case of an IPP, that utility company must bear these costs.
Setting Method for CO_2 Emission Factor	Based upon consultations with local bodies, it has been confirmed that use of the values published by the Indonesian government for a large-scale grid as well as those default values according to type of equipment introduced for a small-scale grid being both appropriate and conservative, raise no significant issues.
Appropriateness of Use of Emission Factor (EF) Default Values	The local authority stated that it is difficult to obtain from PLN the individual power generation data necessary to calculate an EF. This is even more difficult in the case of an IPP. Accordingly, for methodology simplification, use of default values is recommended. Further, as large-scale grid EFs are ultimately approved by the National Council on Climate Change "NCCC" (In Indonesian, DNPI) this data is actually compiled by the Energy Bureau of Ministry of Energy and Mineral Resources (MEMR/DGE).
Calculation Method for Capacity Utilization of a PV Power Generation System	Sunlight (average over one hour) as well as temperature data has been purchased from climate monitoring posts on both Nias Island and Medan (North Sumatra). Using PVSYST (PV power generation design support software) the capacity utilization has been calculated. This is reflected in the system's design.
Selection of the Project Site	PLN Nias has proposed the two sites Walo Beach and Lotu. During the second local investigation both sites were visited and a comparative evaluation was performed. Taking into consideration its superior location (length of power transmission lines, water supply, access), a power shortage due to underdevelopment resulting from establishment as an independently governed region three years ago, and also its inland location on stable high ground that makes it comparatively less susceptible to damage from earthquakes and tsunamis, the Lotu region was selected. Further as within the Lotu region PLN is reclaiming the forested area and planning to construct a coal-fired thermal power plant, it is envisaged that the System could be located within this site.

Issues Considered	Content of the Study and Outline of Results
	The earthquake that occurred off Sumatra at the end of 2004 as well as that which occurred off Nias Island in March 2005 caused widespread damage and significantly worsened road conditions on the West side of the island. In addition the roads which run from Gunungsitoli located centrally on the East side of the island to the Southern regions, with support from Japan, are currently undergoing earthquake resistance repairs and bridge replacement. Further these new bridges when completed will have a load bearing capacity of 20 tons. Being free from such concerns, it is ideally suited as the site for this project.
Envisaged Implementation Form of the Project and Issues	Based upon local interviews two forms were considered being EPC (Main stakeholder PLN) and IPP. As the power purchase price by an EPC is low, it is considered that use of an IPP poses a higher risk to the Japanese side.
Status of the Feed-in Tariff System	During the third local investigation it was learned that the new Feed-in Tariff system for PV power generation would soon be decided. The Indonesian government is currently considering a purchase price of approximately 2,500Rp/kWh for electricity produced using PV panels from overseas manufacturers and approximately 2,800Rp/kWh for locally manufactured PV panels.
Trends Concerning Bio-Fuels	Based upon local interviews, taking into consideration price, production and distribution factors the use of palm oil is recommended. For the System, direct purchase from suppliers is highly likely meaning that purchase price can be directly negotiated with those suppliers. Presently government subsidies for bio-fuels only apply to transportation and shipping and not to manufacturing or power generation.

4. Results of JCM/BOCM FS

(1) GHG Emission Reduction Effects by the Implementation of Project/Activity:

Under this project (after "the Project") a hybrid system that is a combination of 1) PV power generation system and 2) diesel-engine power generator system will be introduced.

It is regarded that the electricity generated by using 1) PV power generation system, will replace the power generated by fossil fuels, which will lead to a major reduction in all CO_2 emissions (reference emissions).

It is judged that for the electricity generated by a 2) diesel-engine power generator system, there is a difference in CO_2 emissions between the power generated by fossil fuels assumed under the reference scenario and that generated using diesel fuel under the Project scenario. (see **Figure 2**.)

Furthermore, the diesel-engine used in the Project can accept bio-fuel (100%). In that case the large amount of CO_2 emissions resulting from diesel engine power generation is regarded as zero. (see **Figure 3**.)

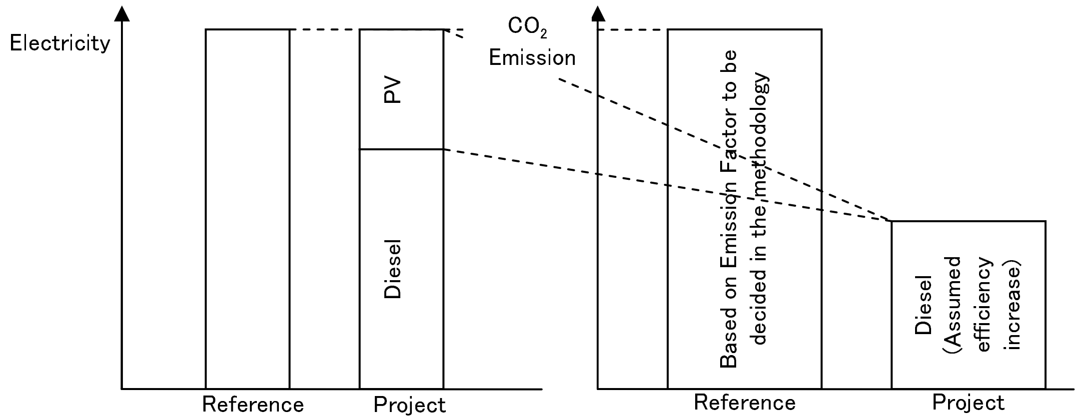


Figure 2: Emission Reduction (Ratio of bio-fuel is 0%)

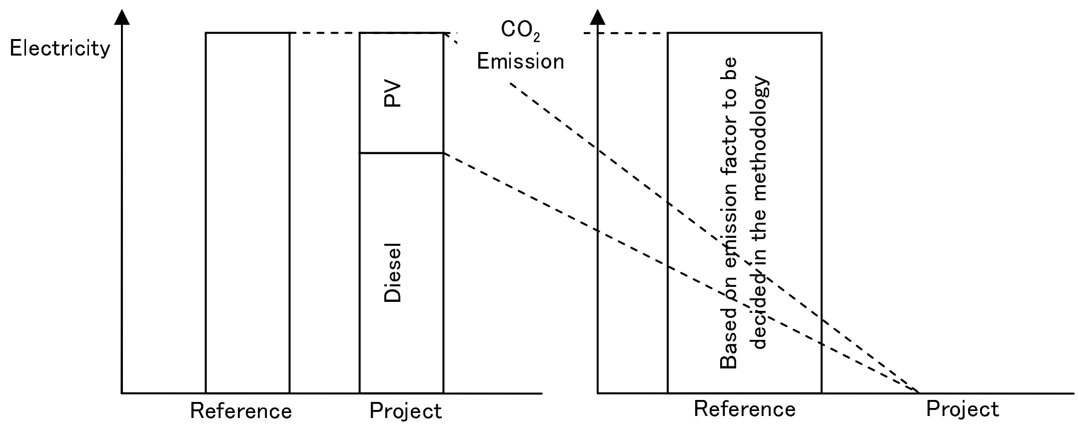


Figure 3: Emission Reduction (Ratio of bio-fuel is 100%)

(2) Eligibility Criteria for MRV Methodology Application:

1) Eligibility Criteria

This methodology is applicable to a project activity that involves a power generation system that combines PV and diesel engine power generation and satisfies all of the following technological features and characteristics.

(a) An activity that, through application of software that compensates for fluctuations in the PV power output, controls diesel engine power output, stabilizes the total PV and diesel engine power output and in particular uses stable power to provide base-load electricity for small or medium sized systems (MW class or smaller).

(b) An activity that uses a low-load type diesel power generator (For example a diesel power generator made by Wartsila that at a minimum load of 10% is able to continuously operate) and one that uses a CIS type PV cell (For example a PV cell module made by Solar Frontier that even in high temperature regions minimizes loss of power generation efficiency).

(c) An activity that by application of the software technology developed in Japan as described in (a) above to the diesel power generator output control component, reduces power output fluctuations and therefore keeps the usage of the rechargeable batteries to a minimum (ideally no usage).

(3) Calculation Method Options:

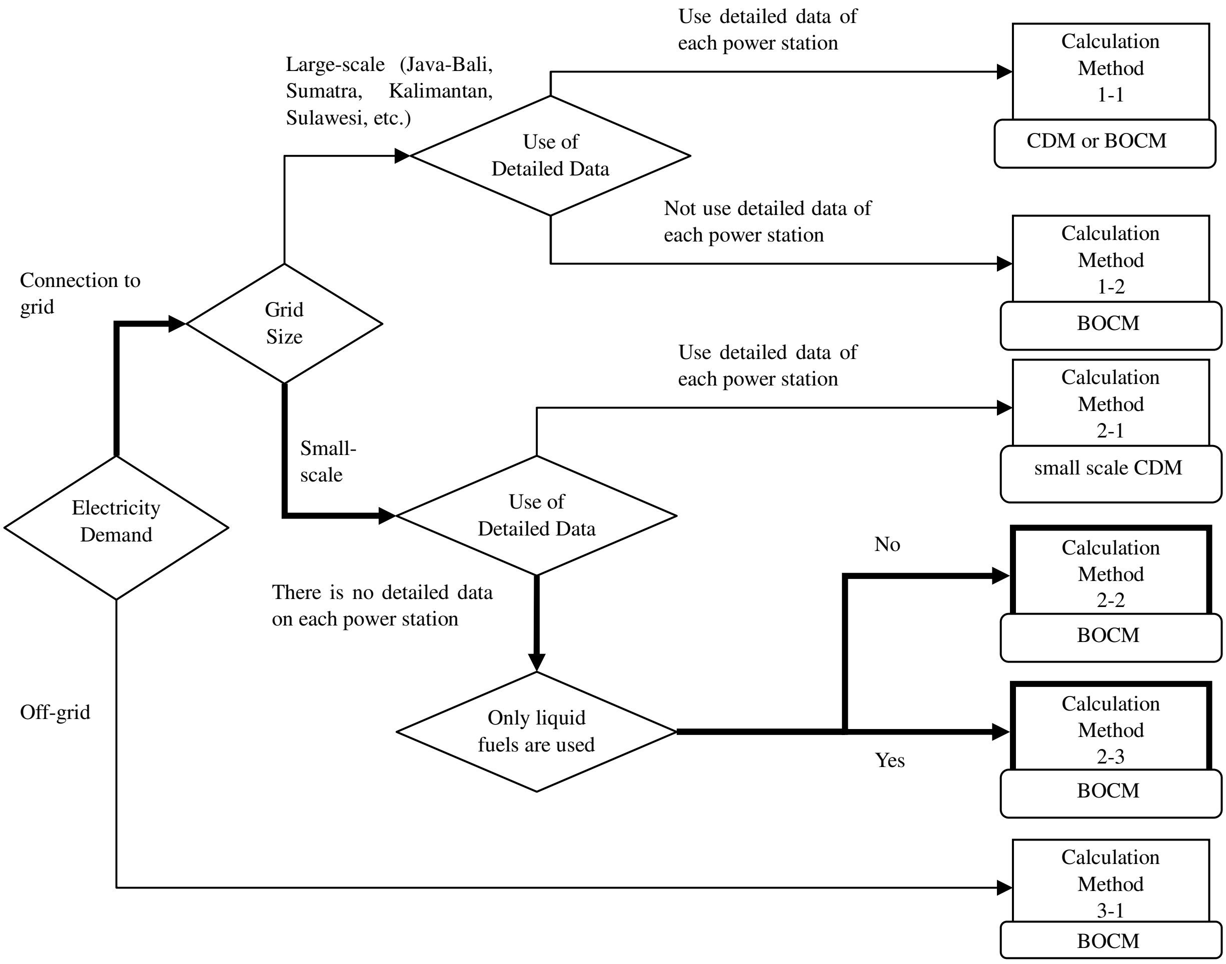
The method of setting a grid's CO_2 emission factor (EF) to calculate a reference emission factor varies according to the size of the grid.

Here the following two calculation methods have been selected:

1) Grid size; and
2) Use of default values.

If default values are used, the CO_2 reduction amount must be calculated in a conservative manner.

The calculation selection method is shown in the flow chart below (**Figure. 4**).



* **Bold Line: Main type to apply the MRV methodology**

Figure 4: Calculation Method Selection Flowchart

Table 4: CO_2 Emission Factor Used in Each Calculation Method

Calculation Method	CO_2 Emission Factor	Calculation or Default	Use under **the Project** (Nias Island)
1-1	CM (Combined Margin) calculated according to "Tool to calculate the emission factor for an electricity system" of CDM	Calculation	N/A
1-2	Latest CM (Combined Margin) calculated and published by the Indonesian government	Default value	N/A
2-1	CM (Combined Margin) calculated according to "Tool to calculate the emission factor for an electricity system" of CDM	Calculation	N/A
2-2	The weighted average emission factor according to fuel used throughout the entire grid	Calculation	N/A Reference: 0.83 t-CO_2/MWh
2-3	Set values based on type of technology	Default value	0.80 t-CO_2/MWh
3-1	As for 2-2 or 2-3 above	Calculation or Default	N/A

(4) Necessary Data for Calculation:

For this methodology, monitoring of the data below is required.

- $EG_{PJ,y}$ Quantity of net electricity generation that is produced and fed to the grid or to direct customer(s) as a result of the implementation of the Project activity in year y [MWh/yr]
- $EG_{DJ,y}$ Quantity of net electricity generation using a diesel engine that is produced and fed to the grid or to direct customer(s) as a result of the implementation of the Project activity in year y [MWh/y]
- FCD_y Quantity of fuel consumed by a diesel engine as a result of the of the Project activity in year y [t/y]
- NCV Net calorific value of the fossil fuel used by a diesel engine as a result of the Project activity [TJ/kg]
- EF Emission factor of the fossil fuel used by a diesel engine as a result of the Project activity [kgCO_2/TJ]

This data has been outlined in **Table 5** below.

Table 5: Monitoring Items

Information and Data	Parameter	Preparations	Notes
Yearly quantity of net electricity generation through the hybrid system (kWh)	$EG_{PJ,y}$	At the time of equipment installation, installation of electricity meters to monitor power supply to the electricity system. Daily power supply monitoring.	Introduction of a system that makes sequential monitoring possible. Monthly checks with PLN as power purchaser. (Cross checks between monthly cumulative value and bills.)
Yearly quantity of net electricity generation (kWh) through the PV power generation system (*{$EG_{PJ,y}$})	$EG_{DJ,y}$	At the time of equipment installation, installation of electricity meters to monitor power supply to the electricity system. Daily power supply monitoring.	Introduction of a system that makes sequential monitoring possible. Monthly checks with PLN as power purchaser. (Cross checks between monthly cumulative value and bills.)
Quantity of fossil fuel consumed by diesel engine (ton)	FCD_y	Installation of a flow meter on the fuel supply line. Daily fuel flow quantity monitoring.	A system able to provide real time monitoring.
Emission factor of fossil fuel used for diesel engine (kgCO_2/TJ)	EF	Use of default values stated under "2006 IPCC Guidelines for National Greenhouse Gas Inventories". Periodic revision in accordance with revisions, etc. to guidelines.	
Net calorific value of fossil fuel used for diesel engine (TJ/kg)	NCV	Use of default values stated under "2006 IPCC Guidelines for National Greenhouse Gas Inventories". Periodic revision in accordance with revisions, etc. to guidelines.	

Leakage was considered. As regards shipping of the plant and equipment required for establishment of a new power plant, CO_2 emissions to ship both the diesel and PV generation PV power generation plant were roughly approximated. The results were that emissions to transport a 1MW hybrid power generation plant were approximately 90t-CO_2. Accordingly for a 4MW plant, a conservative estimate would be

$$4 \times 88.9 = 355.6\text{t-}CO_2$$

Over a 20 year lifespan reductions in CO_2 emissions would be expected to be 144,860t-CO_2. As CO_2 emissions resulting from shipping account for only approximately 0.25%, these are considered to be negligible.

(5) Default Value(s) Set in MRV Methodology:

Default values will be set for the CO_2 emission factor (EF). The applied calculation method is as stated in **Table 6** below. Generally, when compared to the CDM, if a developer seeks to use default values, GHG emissions must be calculated conservatively. This basically means that the CO_2 EF values under the reference scenario should be conservative. The default values used in **Table 7** are conservative values.

Table 6: Calculation Method for Setting Default Values

Calculation Method	Content
Calculation Method 1-2 (Large-scale grid)	CM (Combined Margin) values are regularly calculated and published by the Ministry of Energy and Mineral Resources (ESDM) and National Council on Climate Change (DNPI), are applied. Having been supplied by the Indonesian government for use in CDM, these values are also considered appropriate for use in JCM.
Calculation Method 2-2 (Small-scale grid)	The default values for the CO_2 emission factor are used when all power plants connected to the grid rely solely on the consumption of liquid fossil fuels (fuel oil, diesel oil). On Nias Island, the subject of the Project, all power plants have only diesel power generators and based upon a continuous 24hr/per day power supply, a mini-grid emission factor of 0.8 t-CO_2/MWh is deemed appropriate.

Table 7: Use of Default Values and Conservativeness Trade-Off

Calculation Method	Explanation
1-2	■ The CO_2 emission factors for large-scale grids as published by the Indonesian government are the CMs (Combined Margins) calculated using the "Tool to calculate the emission factor for an electricity system" of the CDM. ■ While data that will form the base for calculation as well as detailed calculation methods are not yet determined, an equal weighting of 50% for OM (Operating Margin) and BM (Build Margin) is considered. ■ However as regards the "Tool to calculate the emission factor for an electricity system", for both wind power generation and PV power generation OM (Operating Margin) and BM(Build Margin) are weighted at 75% and 25% respectively. ■ For a grid where OM is higher than BM the default values calculated as CM are less than those obtained by strict application of the "Tool to calculate the emission factor for an electricity system". Accordingly default values are regarded as conservative. ■ If the Indonesian government provides not only CM but also OM and BM for each Large-scale grid, this calculation method will be more conservative. Here: $EF_{y} = EF_{OM,y} \times w_{OM} + EF_{BM,y} \times w_{BM}$ Where: EF_{y} CM: Combined Margin (in year y) $EF_{OM,y}$ OM: Operating Margin (in year y) $EF_{BM,y}$ BM: Build Margin (in year y) w_{OM} Weighting of operating margin emissions factor (-) w_{BM} Weighting of build margin emissions factor (-)
2-3	■ The default values are the standard modern values and therefore can be regarded as conservative. ■ The calculation result based upon the latest data in respect of the grid that currently exists on Nias Island, the subject of this study, is 0.83 t-CO_2/MWh. Accordingly the default value of 0.80 t-CO_2/MWh is conservative.

(6) Setting of Reference Scenario and Project/Activity Boundary:

On Nias Island the presently required power supply must be increased by 15MW. The plan to be implemented based upon the results of a local investigation is shown in **Table 8** below. Presently while 100% of power is being generated by diesel engine, it is planned to supplement this through the use of coal, being a comparitively cheaper fuel source. Further, at the same time the replacement of aging diesel engines and/or the introduction of PV power generation is also being considered.

As the reference scenario for Nias Island (small-scale grid connected power), while 100% of power is presently generated by diesel engine, it is envisaged that in the near future it will be generated by a combination of coal, coal gas and diesel fired plants. (Replacement only as basically new establishment will not be approved.)

Prior to implementation of the Project, the calculation methods used for CO_2 emission factor given 100% diesel engine power generation are as shown in 2-2 (grid weighted average) or 2-3 (default values). Further if a fossil fuel other than diesel is used, as a post-project implementation calculation, the calculation method shown in 2-2 (grid weighted average) will be used.

Table 8: Future Power Source Development Plan on Nias Island

No.	Plan Content			Progress	Information Source
	Type	Scale	Other		
1	Coal-fired	7MW x 3	IPP, Gunungsitoli, base-load power source	Planned for 2015	PLN Medan Office
2	Coal gassification	4MW x 2	Rental, Nias Northern region, peak power source	Planned for 2013	PLN Medan Office
3	Diesel Engine	Unknown	Replacement	Unknown	PLN Medan Office
4	PV Power Generation	Unknown	Focus on off-grid power source for domestic use	By 2015	PLN Medan Office

(7) Monitoring Methods:

As monitoring items in accordance with ACM0002 and AMS-I.D under CDM methodology calculation information and data monitoring is required.

1) The quantity of net electricity generated by the PV power generation system (MWh)

Within the hybrid system, the electricity generated by the PV power generation system and the diesel power generator are separated, and continuous monitoring is provided by an electricity trade meter. This electricity trade meter through the SCADA (Supervisory Control And Data Acquisition) system is able to provide constant monitoring.

2) The quantity of net electricity generated by the diesel power generator (MWh)

Just as for the quantity of net electricity generated by the diesel power generator, utilization of SCADA provides constant monitoring.

3) The quantity of net electricity generated by the PV power generation system to calculate the reference emissions

Deducting the power generated by the diesel generator (B) from the value of the net electricity actually transmitted to the small-scale system on Nias Island (Point A: Electricity trade meter), power generated by the PV power generation system (F) is calculated.

4) The grid emission factor

At present quantification of GHG emissions can only be determined in accordance with the default grid EF calculated in accordance with the composition of the power generation system on Nias Island.

Accordingly for new power generation plant construction or planned improvements bi-annual monitoring must be conducted. At the time of new power plant construction or planned improvements, whether or not CM calculation using detailed data from each power plant is possible must be confirmed. Further it is necessary to check whether or not EF will be published by the Ministry of Energy and Mineral Resources (ESDM).

5) The diesel engine's fuel consumption

Constant monitoring will be conducted by a monitoring control system that receives data from the fuel flow meter installed in the diesel engine.

(8) Quantification of GHG Emissions and its Reductions:

Here, CO_2 emission reductions achieved by 1) the PV power generation system will be calculated. CO_2 emissions in 2) diesel engine power generation will also be calculated based upon the difference between the emission factor from the System (tCO_2/MWh) and the reference emission factor (0.80 tCO_2/MWh).

Reference Emissions	$RE_y = EG_{PJ,y} \times EF_y$ RE_y Reference emissions(tCO_2) $EG_{PJ,y}$ Quantity of net electricity generation that is produced and fed to the grid as a result of the implementation of the Project activity in year y (MWh) EF_y Grid produced CO_2 emissions factor (EF) in year y(tCO_2/MWh)
Project Emissions	$PE_y = PE_{FF,y}$ $PE_{FF,y}$ Project emissions from fossil fuel (diesel fuel) consumption in year y (tCO_2) EFD_y CO_2 emissions factor (EF) of diesel engine (Wartsila) in year y (t CO_2/MWh)
Leakage	$L_y = 0$

Reference Emissions

$RE_y = EG_{PJ,y} \times EF_y = 35,040 \times 0.8 = 28,032$ tCO_2/y

$EG_{PJ,y}$ = 4MW × 24h/d × 365d/y = 35,040MWh

$EF_y = 0.8$ tCO_2/MWh (Default value)

The quantity of net electricity generated by the PV power generation system

4MW * 24h/d*365d/y *15.39%[Note)] (Gross PLF) = 5,392MWh

(Assuming a capacity utilization for a PV power generation system on Nias island at 15.39%)

Project Emissions

$EG_{DJ,y} = EG_{PJ,y}$ - PV power generation = 35,040 - (5,392 - 50) = 29,698MWh

(Assuming power consumption by hybrid plant of 50MWh/year)

For 1MWh of diesel power generation,

Fuel required = 3,600 (MJ) / 0.378 = 9,523MJ

Required fuel = 9,523MJ / 42.7 (MJ/kg) /0.86 (kg/l) / 1,000 = 0.259kl

Accordingly:

EFD_y = 0.259(kl) × 2.71 (tCO_2/kl) = 0.70 tCO_2 / MWh

(Assuming diesel engine operation at 50% load, fuel consumption 37.8% (including related equipment))

$PE_y = PE_{FF,}y = EG_{DJ,y} \times EFD_y = 29,698 \times 0.7 = 20789$ tCO_2/y

Leakage emissions

$L_y = 0$

CO_2 reduction amount

$ERy = RE_y - PE_y - L_y$ = 28,032 tCO_2/y - 20,789 - 0 = 7,243 tCO_2/y

CO_2 reduction from PV cells

= PV power generation × EF_y=5,340 × 0.8 = 4,272 tCO_2/y

PV power generation

= 4MW × 24h/d × 365d/y × 15.39% (Gross PLF) - 50MWh = 5,342MWh

(Assuming power consumption by hybrid plant of 50MWh/year)

(Assuming a capacity utilization for a PV power generation system on Nias island at 15.39%)

CO_2 emission reductions according to replacement of diesel engine

= $EG_{DJ,y} \times (EF_y - EFD_y)$ = 29,698* (0.8-0.7) = 2,970 tCO_2/y

(9) Verification of GHG Emission Reductions:

- Monitoring

- Monitoring of items stated in (4) will be performed.

- Verification by Third Parties
  - Initially during the first local investigation it was confirmed that preparations for introduction of DOE in the host country Indonesia were in the advanced stage.
  - In addition approximately 10 companies able to provide ISO certification, etc. are in existence. This makes the required third party verifications possible.

(10) Ensuring Environmental Integrity:

The best methods to alleviate negative impacts resulting from the introduction of the System were investigated.

- Influence of the acquisition of a large amount of land for private use for the installation of PV panels and diesel engine.
  - When preparing the site, civil engineering works to ensure sufficient drainage to eliminate the risk of landslides will be performed.
  - As a reclamation strategy, every effort will be made to plant grass on the ground beneath the panels to conserve the environment and also to prevent local temperature increase.
  - Every effort should be made to leave undisturbed vegetation that supports conserved animal species, establish paths to allow paths for animals to cross through the site and in any other way minimize environmental impact.

- Influence of using bio-fuels to power the diesel engine in the System (jatropha oil, palm oil, used cooking oil, etc.)
  - As bio-fuels, use of those able to be used in cooking should be avoided. Basically the use of low quality and cheap raw materials as well as used cooking oil is preferred.
  - The cultivation of plantations to produce bio-fuel should be in strict compliance with the environmental conservation policy of the host country.
- Additional Items
  - This project will strengthen the power supply on Nias Island and greatly expand those areas on the island with access to power. Accordingly full consultations with the host country's government are required.

(11) Comments from Local Stakeholders:

Those parties interested in the implementation of the Project include government bodies (Ministry of Energy and Mineral Resources (ESDM), Ministry of Environment, etc.), utility companies (PLN headquarters, PLN North Sumatra, PLN Nias) and local residents (those in close proximity to the planned construction site on the Nias Island). They have all commented on their expectations for the Project.

In particular the regional governor for North Nias has welcomed the construction of a power plant and has shown an interest in the power generation business itself. When interviewed he said that the region would actively cooperate in any project that promotes electrification within the region. Further he clearly stated to PLN that he will support approval of the Project.

(12) Structure to Implement Project/Activity:

The Project and activity implementation system is shown in **Figure 5** below.

While the Indonesian government has been planning the introduction of large scale PV power generation facilities, actual progress has been slow. It is assumed that one of the major reasons for this is the fragility of grid networks particularly those on the smaller islands.

Looking at the results of power source measurements taken on Nias Island, major voltage fluctuations particularly in the mornings and evenings have been recorded. Accordingly it is judged that under present conditions installation of an independent 1MW class PV power plant would be problematic.

It is considered that introduction of a comprehensive hybrid system that combines a low-load type diesel engine, PV panel system and also utilizes Japan's advanced control technologies would eliminate disruption at the point of exit from the power plant. Although they may on the surface appear mutually incompatible, the System would both increase green energy use and at the same time maintain system stability.

Compared to diesel power generation systems, construction costs are significantly higher for hybrid systems. To expand sales of hybrid systems and associated mechanisms it is vital that a portion of the plant and equipment costs are subsidized by the Japanese government and/or offset by the introduction of the credit purchase mechanism.

Through the implementation of the System it is considered that, following on from this first project, there will be ongoing introduction of similar systems and sales of the related Japanese technologies will expand.

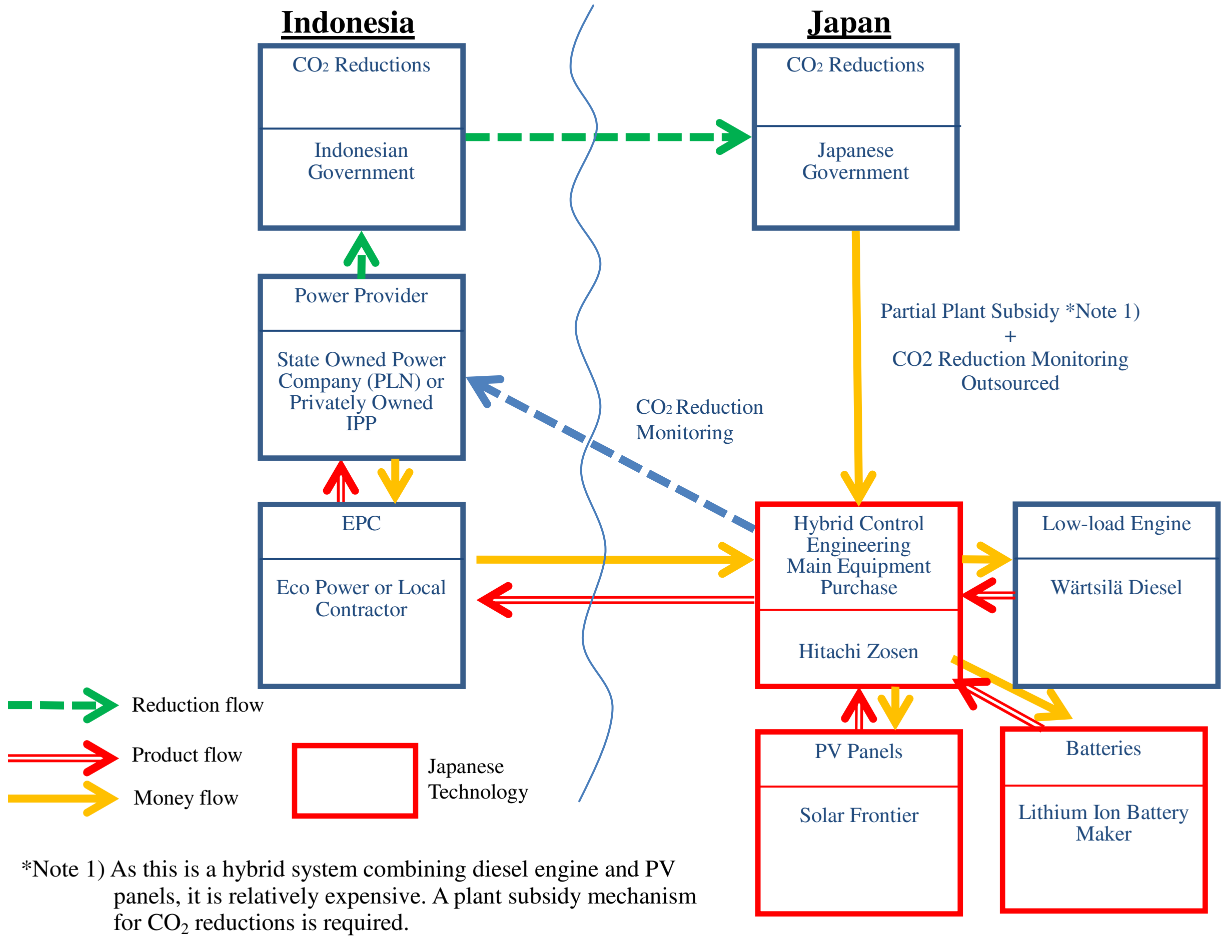


Figure 5: Project and Activity Implementation System

(13) Financial Plan to Implement Project/Activity:

The cash flow assuming introduction of a 4MW hybrid power generation system has been considered here.

As shown in **Table 9** below, from within the initial investment cost of 1,500 million yen to establish a 4MW output system, 30% (450 million yen) self-funding is required. In respect of the remainder, three cases based on the amount of available subsidies have been considered. The cash flow for each has been analyzed over a 20-year period which is the expected lifespan of the plant.

Table 9: Assumed Finance Patterns

Case	Self-Funding	Japanese Government Subsidy	Private Loan	Total
Case 1	30%	0%	70%	100%
Case 2	30%	33%	37%	100%
Case 3	30%	50%	20%	100%

- Case 1 assumes that no subsidies will be provided by the Japanese government or other related bodies and therefore with the exception of self-funding the remainder must be obtained through loans from financial institutions and that income will be derived from sales of emission credits according to CO2 emissions.
- Case 2 assumes an initial subsidy by the Japanese government or other related bodies of 33%, and Case 3 an initial subsidy by the Japanese government or other related bodies of 50%. In either of these cases, as emission credits resulting from CO2 reductions will be handed over to the Japanese side free of charge, sales revenues are not considered.

Further, as regards the sales revenues for PV power generation, while the Feed-in Tariff applicable to overseas manufactured products is IDR2500/kWh, and for diesel produced power the actual retail price is IDR700/kWh, a price of IDR2000/kWh has been applied taking into account government subsidies.

The calculated IRR based upon cash flow analysis is shown in **Table 10** below.

Table 10: Calculation Results of IRR

	Case 1	Case 2	Case 3
IRR	5.21%	12.28%	18.61%

- In Case 1 where no subsidies are provided by the Japanese government, based upon repayment of loans together with interest on the same, profitability on investment over a 20-year period is considered to be IRR 5.21%. From the viewpoint of being able to maintain a stable electricity supply, this makes it a subject for investment worthy of full consideration.
- In Case 2 or 3 where IRR exceeds 10% the Project can be considered attractive to investors in terms of profitability.
- As fluctuations in diesel oil prices and retail electricity prices will have a major influence on cash flow, consideration of long-term hedging measures to minimize risk due to fluctuations at the time of actual investment is considered preferable.

(14) How to Promote the Introduction of Japanese Technologies:

According to the paper entitled “Interconnected System with Wind and PV Power Generation Systems on Remote Islands” (Kyushu Electric Power Company), the maximum allowable power output of wind and PV power generation systems on remote islands is 10% or less of the daily minimum load demand in order to maintain grid frequency within the allowable tolerance.

The System applies software developed in Japan to stabilize PV power generation.PV generation equipment with the same capacity as the diesel generator is possible and the hybrid system can be used as a base load power source.

Use of the low-load type diesel power generator made by Wärtsilä (Finland) is assumed. This generator, that is able to maintain continuous operation over a wide load from 10% (Grade A heavy fuel oil use) to 100% (90% range), is considered ideal for providing maximum efficiency to PV cells.

In addition, as the CIS type PV module used in the System minimizes loss of power generation efficiency even in high temperature regions such as Indonesia, increased market penetration of that module into other such regions is expected.

(15) Prospects and Challenges Onward:

In February 2013, letters of support for implementation of the Project are expected to be received from the Nias Island regional government as well as PLN which indicates a strong desire for implementation of the Project on the local side.

The planned construction period for the plant is approximately 18 months which must be taken into consideration when considering commercialization. Further a major issue is prompt establishment of the Project implementation system according to whether or not ordinary diesel or a bio-fuel will be used in the diesel engine.

5. Contribution to Sustainable Development in Host Country

Contributions to sustainable development in the host country are as follows:

- Expansion of the electricity supply capacity on Nias Island;
- Attracting factory rollouts by both Indonesian and foreign companies through improvements in electricity quality and reliability; and
- Through use of bio-fuels creating employment opportunities on local plantations

The diesel engine used for the System has merit in that it is able to use bio-fuel. Comments received from various sources have indicated this to be the preferred option as it would create employment on plantations located on Nias Island.