PROJECT DESIGN DOCUMENT FORM
FOR CDM PROJECT ACTIVITIES (F-CDM-PDD)
Version 04.1

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	Grid connected electricity generation plant using natural gas at Jurong Island in Singapore
Version number of the PDD	05.1
Completion date of the PDD	~~0~~16/~~11~~03/201~~3~~4
Project participant(s)	Pacific Light Power Pte. Ltd.
Host Party(ies)	Singapore
Sectoral scope and selected methodology(ies)	Sectoral scope: 01- Energy industries (renewable - / non-renewable sources) Selected Methodology: AM0029 "Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas" (Version 03, EB 39)
Estimated amount of annual average GHG emission reductions	~~474,238~~286,755 tCO_2e

SECTION A. Description of project activity
A.1. Purpose and general description of project activity

PacificLight Power Pte. Ltd.[1] has taken up development of a new, grid connected 800 MW natural gas fired combined cycle power plant. Once completed, the plant, through its use of natural gas and advanced combined cycle technology, will provide consumers in Singapore with a clean, highly efficient source of electricity.

Purpose of the project activity
The purpose of the project activity is construction and operation of a new 800 MW natural gas based power plant. The electricity generated will be exported to the Singapore national grid. The project activity once operational will help in reducing the carbon intensity and projected power deficit in the grid.

At the site ambient conditions and a frequency of 50 Hz, the rated capacity of plant will be 800 MW ±10% (two units)[2]. Each of the two units has one combustion turbine, one Heat recovery Steam Generators (HRSG) and one Steam Turbine Generator (STG). The heat content of the exhaust gas from the combustion turbine would be recovered in individual heat recovery steam generators. The steam generated would then be expanded in a condensing type steam turbine driving an electric generator.

Pre-project scenario: The project activity is a new, independent natural gas based power plant and thus no power generating equipment existed in the project site before the project activity plant. Thus, the pre-project scenario is continuation of existing carbon intensive fuel mix in the grid to generate power.

Baseline Scenario: As identified in Section B.4 of this PDD, the baseline scenario is generation of equivalent power from coal based power plant (due to lower cost of electricity generation from same and hence financially viable). There is at least one coal based power plant that will operate based on imported coal and hence there is no restriction on coal based power plants and import of coal in Singapore. This is discussed further in Section B.4.

How the project activity reduces greenhouse gas emissions
In the absence of the project activity the PP would have opted for a coal based power plant as described in the section B.4. The project activity thus reduces anthropogenic GHG emissions into the atmosphere due to the use of relatively lower GHG intensive fuel (Natural Gas and / or Re-gasified-LNG) and much higher efficient[3] power generation due to combined cycle operation in comparison to coal.

Sustainable Development Criteria
The sustainable development criteria as per the Singapore DNA (National Environment Agency, NEA, Singapore Government)[4] are as follows:

1) **Environmental Sustainability:**
   i) The project activity will meet NEA's Environmental Protection requirements, standards and regulations

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[1] a profile of company from Accounting and Corporate Regulatory Authority, Singapore is submitted to the DOE
[2] As per technical specifications of the EPC contract with Siemens
[3] project activity uses Siemens F-class advanced turbines having net plant efficiency = 58.16% (Ref: Heat Flow Diagram of project activity from EPC contractor)
[4] http://app2.nea.gov.sg/clean_development_mechanism.aspx

ii) The electricity generated by project activity will be supplied to Singapore grid, which otherwise would have been generated by more carbon intensive fossil fuels and existing old power plants that are less efficient. Hence the project activity will help in reduction of the greenhouse gases emission and air pollutants (especially NOx).

2) **Economic Sustainability**
The project activity is utilizing latest F class turbines and this advanced technology more efficient[5] and environment friendly compared to existing old power plants in the grid. This will result in the CO_2 emission reduction when compared with the build margin of the grid as discussed Section B.6.3 of this PDD.

3) **Social Sustainability:**
The project activity will provide direct employment to persons during the construction and during the normal operation. In addition it is expected that some more persons will be directly benefited through casual work, subcontracts, trading etc. Thus, the project activity helps to improve quality of life by creating opportunities for jobs and business.

Thus, the project activity contributes to the sustainable development of the country.

A.2. Location of project activity
A.2.1. Host Party(ies)
Singapore

A.2.2. Region/State/Province etc.
District: Jurong Island

A.2.3. City/Town/Community etc.
City: Jurong Island

A.2.4. Physical/Geographical location
The proposed project activity is near City & District: Jurong Island, Singapore
The project site is located at Lot 01962A PT MK34, Seraya Place, Jurong Island

Geographic location and accessibility:
Nearest airport: Singapore
The geographical coordinates of the project activity are
1°17’24’’ N and 103°43’30’’ E.

[5] Siemens F-class advanced turbines have this efficiency - This link shows rounded off value 56%. http://www.siemens.com/about/en/businesses/energy/energy_service.htm

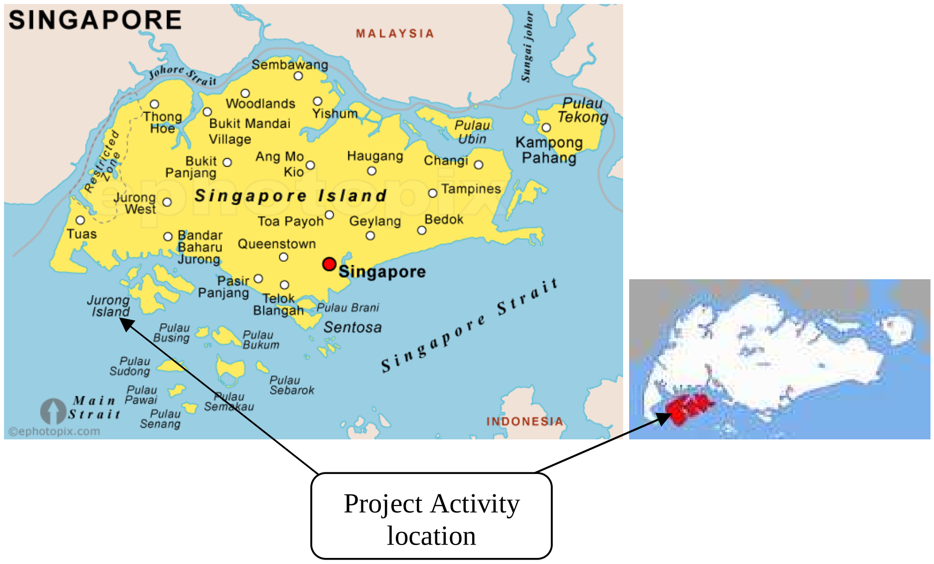


Figure 1: Map of (A) Singapore and (B) Map showing the site of project activity (Jurong Island)

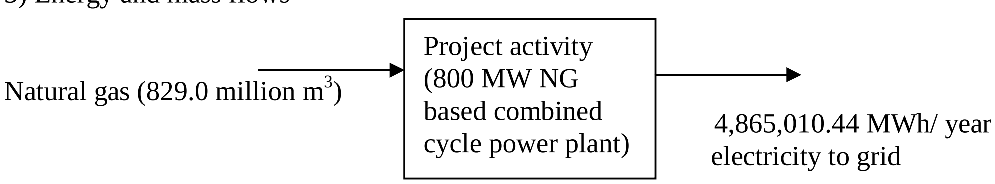
A.3. Technologies and/or measures

The pre-project scenario is continuation of existing fuel mix in the grid to generate power. No power generation units existed at the project activity location in the pre-project scenario.

1) List and the arrangement of the main manufacturing/production technologies:
The project activity has chosen advanced Siemens Gas Turbine SGT5-4000F[6]. The project activity plant will have two units of net capacity of 385.5 MW each. The plant will use natural gas and / or re-gasified LNG as primary fuel. Diesel oil will be used as back up fuel for which LPG is start up fuel[7]. The HRSG is is unfired type and no supplementary fuel firing will happen in it. No other start-up or auxiliary fuel is envisaged for the plant. The plant is expected to operate at 72% annual capacity utilization[8] and the power power will be sold to the Singapore grid.

2) systems and equipment involved
(1) Gas Turbines - two numbers; (2) Heat recovery steam generators – two numbers; (3) steam turbine generator – two numbers; (4) two Power transformers; (5) Auxiliary equipments of Gas Turbines and Generators, HRSGs and Steam Turbines and Generators; meters (gas, electricity) and gas supply pipelines.

3) Energy and mass flows



6 http://www.energy.siemens.com/hq/pool/hq/power-generation/gas-turbines/SGT5-4000F/downloads/SGT5-4000F_Brochure_2008.pdf

7 These will be monitored and is expected to be within 1% of total fuel used on annual energy basis

8 Based on estimated 72% capacity utilization annual operations from the PP's business plan

The choice of the technology will further reduce the GHG emission associated with the most probable alternative choice – coal fired thermal power plant option. In addition, the emissions of CO_2, particulates (fly ash) will also be reduced compared to the identified alternate. The project activity will abide by all the regulatory norms of the pollution control board and will maintain environmentally safe and sound process.

There is no technology transfer from Annex I countries involved in the project activity.

In absence of the project activity, as identified in the section B.4, the PP could have chosen a coal fired power plant of similar power output resulting in substantially higher GHG emissions. The main equipments in the baseline include coal fired boilers and turbine generators equivalent to the same electricity export as that of the project activity.

A.4. Parties and project participants

Party involved (host) indicates a host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Singapore (host)	PacificLight Power Pte. Ltd. (Private entity)	No

PacificLight Power Pte. Ltd. is the sole owner of the project activity and the generated CERs.

A.5. Public funding of project activity

The total project cost will met by the PP by debt finance from banks and financial institutes. Public funding from Annex I countries and diversion of official development assistance (ODA), is not involved in this project activity.

As per the loan sanction mandate letter, 57% project cost is met by loan and 43% by equity[9].

SECTION B. Application of selected approved baseline and monitoring methodology
B.1. Reference of methodology

The approved baseline methodology applied to this project is:

AM0029 Version 3, EB 39 titled: "Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas".

Reference: http://cdm.unfccc.int/methodologies/DB/WW4I82DG7LJUQE5E5YGT1NZE4PNS60

- **Tool for the demonstration and assessment of additionality** (Version 07.0.0, EB 70, Annex 8)

- **Tool to calculate the emission factor for an electricity system (**Version 03.0.0, EB 70, Annex 22)

B.2. Applicability of methodology

[9] Evidence submitted to the DOE

The project activity is construction and operation of a new natural gas fired grid-connected electricity generation using combined cycle power plant.

Requirements as per the selected Baseline Methodology mentioned in B.1	**Applicability to this Project Activity**
The project activity is the construction and operation of a new natural gas fired grid-connected electricity generation plant.	The project activity involves the construction and operation of a new natural gas fired electricity generation plant. Natural Gas is the primary fuel to be used in the project activity. Back up fuel diesel and start up LPG in that case will be monitored and is expected to be within 1% of total fuel used on annual energy basis. There is no other fuel used either during the start up or co-fired. There is provision for diesel storage on site, however 1) management has no intention to use diesel for electricity generation as liquid fuels are very costly and PP cannot sell merchant power in competition to other plants if project activity uses diesel. 2) The diesel fuel storage is provision to meet regulatory requirement of 'Electricity License for Generation Licensee' from EMA to the project activity. As per, pg. 10, para. 10, PP is requirement to maintain 90 days of fuel reserve 'on site'. This is in line with the energy security concerns of the country and to be used only in case of emergencies. PP has also made a provision to monitoring diesel used and its energy content (NCV). If in some emergency, PP has to use more than 1% of this fuel (other than NG), the emission reduction will not be claimed in that monitoring period.
The geographical/ physical boundaries of the baseline grid can be clearly identified and information pertaining to the grid and estimating baseline emissions is publicly available.	In this case the baseline grid is Singapore grid and the information pertaining to the grid and estimating baseline emission is publicly made available by the NEA on its web site[10].
Natural gas is sufficiently available in the region or country, e.g. future natural gas based power capacity additions, comparable in size to the project activity, are not constrained by the use of Natural Gas in the project activity.	All of the natural gas used for this project activity will be imported[11] at upcoming LNG terminal. So the project activity will not divert NG from existing users in the country and will not constrain future capacity addition. Further discussion on this aspect is given below this Table.

Gas availability, utilization and Import in country

[10] cms.nea.gov.sg/NEADownload.aspx?res_sid=20120420366305500749
This page directly downloads the file from NEA web site. If link does not work please go to link (Information on Emission Factors (For CDM projects in Singapore) on web page
http://app2.nea.gov.sg/clean_development_mechanism.aspx

[11] EMA, Singapore Energy Statistics, 2011, page no. 10; Pg. 12-13 for total NG consumption by sectors

The spirit of emphasizing "sufficient availability" of NG in the methodology as an applicability criterion is:

(a) to ensure that NG from other users are not diverted and
(b) to ensure future power generation facilities of comparable size are not deprived due to NG being taken up by the project activity [Ref: footnote No. 2 of the AM0029, Version 3]

The points (a) and (b) above are borne out by the clarification [Ref: F-CDM-AM-Clar_Resp_ver 01.1 - AM_CLA_0091] issued by EB in response to a DOE query. In the response, EB also clearly mentions how the applicability condition pertaining to availability is to be implemented. In EB's view, a project activity to demonstrate that it meets the applicability condition will need to do so by resorting to appropriate monitoring. The relevant excerpt from EB's clarification– "*the monitoring should show that satisfying the project activity's demand for natural gas will not lead to shortages in supplies of the gas to other projects within the country*".

In other similar examples, recently registered projects from China in the applicable methodology AM0029, have shown 'LNG import agreements from other countries like Malaysia' (Project reference No.s 1381, 1343, 1344) in support of the NG availability. Thus, NG availability in the project activity region alone is not the applicability of methodology here.

The Singapore Government is working on energy mix diversification strategy which includes diverse sources as well as fuels. Singapore had started with natural gas transports from Malaysia through the first transnational natural gas pipeline built in East Asia. About 80% of Singapore's electricity demand[12] is generated from Natural Gas. Three main import pipelines serve the Natural Gas system:

- 150 million standard cubic feet per day from Malaysia
- 325 million standard cubic feet per day from Northeast Indonesia
- 350 million standard cubic feet per day from Southwest Indonesia

Gas consumption in Singapore: Among the various sectors, the consumption of the industrial-related sector was the highest, accounting for 79.9% of total gas consumption in Singapore as of 2009, followed by the commerce & services-related sector (8.7%), households (6.9%) and the transport-related sector (1.6%). As of 2009, a total of 3,595.4 ktoe of electricity was generated within the electricity generation sector in Singapore. Electricity generators consumed 1,253.6 ktoe of petroleum products, 6,133.5 ktoe of natural gas and 563.6 ktoe of other energy products (such as biogas, municipal solid waste and solar) to produce 3,496.5 ktoe of electricity. Auto producers consumed 559.4 ktoe of natural gas and 0.7 ktoe of other energy products to produce 98.9 ktoe of electricity, primarily for their own consumption.

Considering future gas demand mainly driven by the electricity generation capacity addition, the Government has started construction of a LNG terminal[13]. This will have capacity of 6 million ton per annum –MTPA in two phase of 3 MTPA each in 2013 and 2018 and its development has started and is expected to be commissioned in mid 2013 (EMA – Integrated summary on proposed Singapore LNG terminal project. This capacity of LNG terminal is designed by considering the projects which are under development (including the project activity power plant) and future capacity planned[14]).

The PP would like to further clarify that the project activity is commissioned now (unit 1 on 15/01/2014 and unit 2 on 06/02/2014). There are some units under construction and planned commissioning dates as

[12] About 80% electricity is generated from natural gas during 2006-2010; EMA, Singapore Energy Statistics, 2011, page no. 14

[13] http://www.lowcarbonsg.com/2011/10/31/singapores-strategies-to-meet-its-energy-challenge-amid-an-uncertain-global-energy-future/

[14] 'Base case demand for LNG – Integrated Summary on Proposed Singapore LNG Project by EMA, pg. 11

available on the Schedule A to Licence on Electricity Market Authority, Singapore web site (https://www.ema.gov.sg/page/115/id:129/#generation).

Sr. No.	**Generator / company**	**Capacity planned**	**Expected commissioning date**
1	Tuas Power unit 5	405.9 MW	01/04/2014
2	SembcorpCogenPte Ltd Unit 3	400 MW	Q1 2014
3	SembcorpCogenPte Ltd Unit 4	500 MW	31/12/2014
4	Shell Eastern Petroleum Pte. Ltd.	67.8 MW	April 2015
5	Tembusu Multi-Utility Complex Unit 2	32.5 MW	April 2014
6	Tembusu Multi-Utility Complex Unit 3	32.5 MW	July 2017
7	SRC Cogen Unit 1	42 MW	Q1 2015
8	SRC Cogen Unit 2	42 MW	Q2 2015

Thus, it can be confirmed from above data on the planned capacity addition as well monitoring provision of source of the gas to be used in the project activity that gas will not be diverted from existing users and the future capacity addition will not be constrained.

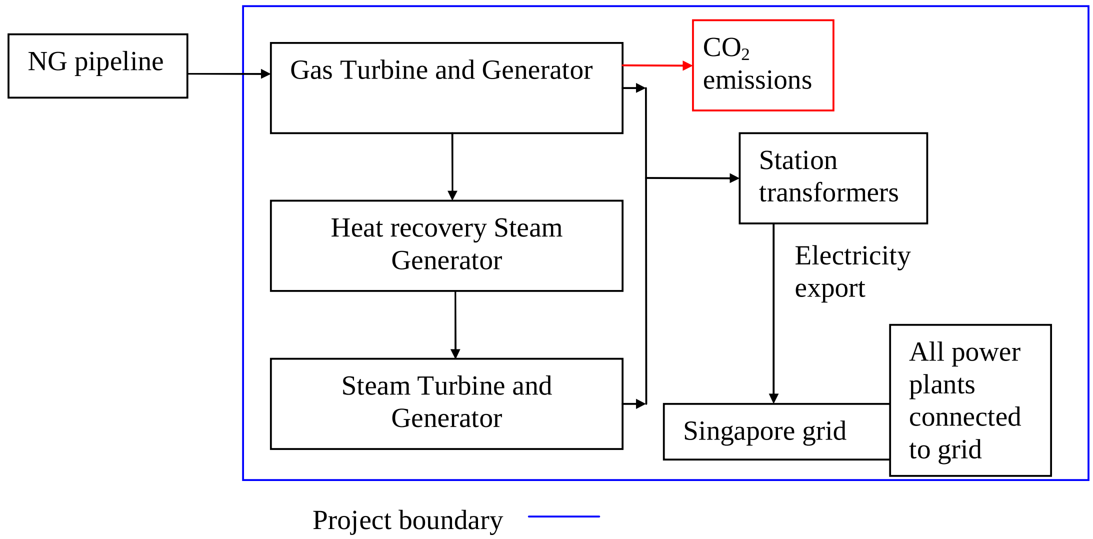
~~Thus, the project activity plant will not divert NG from existing users and also will not constrain the future capacity addition.~~

Thus, all the applicability conditions are met and this methodology is used here.

B.3. Project boundary

According to AM0029, the spatial extent of the project boundary includes the project site and all power plants connected physically to the baseline grid as defined in “Tool to calculate the emission factor for an electricity system.” According to the Tool to calculate the emission factor for an electricity system, for the baseline emission factor, the spatial extent of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to.

Since the CDM project is connected to the national grid, it is also preferred to take the Singapore grid as project boundary. Thus the project boundary comprises the project site and all power plants connected physically to the Singapore grid. The specific components and facilities included in the project boundary are (1) Gas Turbines - two numbers; (2) Heat recovery steam generators – two numbers; (3) steam turbine generator – two numbers; (4) two Power transformers; (5) Auxiliary equipments of Gas Turbines and Generators, HRSGs and Steam Turbines and Generators; meters (gas, electricity) and gas supply pipelines.



Summary of gases and sources included in the project boundary are discussed in the table below.

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Power Generation in baseline	CO_2	Included	Main emission source
		CH_4	Excluded	Excluded for simplification. This is conservative
		N_2O	Excluded	Excluded for simplification. This is conservative
Project scenario	On-site fuel combustion due to the project activity	CO_2	Included	Main emission source
		CH_4	Excluded	Excluded for simplification. This is a minor emission source.
		N_2O	Excluded	Excluded for simplification. This is a minor emission source.

B.4. Establishment and description of baseline scenario

Baseline scenario identification as per the requirements of AM0029 leads us to the following assessment at the start of the project activity.

1. Identify plausible baseline scenarios

Alternatives to be analysed should include, inter alia:

The purpose of the project activity is to generate electricity and deliver it to the Singapore Grid to cater to the base load power requirement of the grid. The project activity plant is expected to operate at 72% annual PLF i.e. 6,307 hours/ year. As per the other baseline methodology, ACM0013, Version 05.0.0 "base load is defined as a load factor of more than 3,000 hours per year". Thus, the project activity is considered base load and baseline alternatives providing base load services are considered similar.

a) **The project activity i.e. 800 MW NG based Combined Cycle power plant with an efficiency of 58.16%[15] and with a lifetime of 30 years and not implemented as a CDM project activity.**

[15] Siemens F-class advanced turbines have this efficiency - http://www.siemens.com/about/en/businesses/energy/energy_service.htm

The purpose of the project activity is to generate electricity from the Natural Gas and deliver it to the Singapore Grid to meet the base load power requirement of the grid. This alternative is in compliance with all the applicable legal and regulatory guidelines. Hence this option can be a part of the baseline scenario.

b) Power generation using Natural Gas as the fuel but with different alternative technologies.

The different possible technologies that are available with the stakeholders in the grid to generate power using natural gas as the fuel include;

b.1) Power generation using Combustion Turbine with an installed capacity of 800 MW with an efficiency of 39.8%[16] using Open cycle mode of operation with a lifetime of 30 years.

This alternative generates electricity using Natural Gas as the fuel and can cater to the base load demand of the grid but has lower system efficiency compared to the project activity. In 2011, out of total licensed power generation capacity, only 3% was that from open cycle technology[17]. As the option has lower system efficiency in comparison with the power generation using Combined Cycle mode of operation, it is not a realistic and credible alternative. Therefore this alternative cannot be a part of the baseline scenario.

b.2) Power generation using Gas Turbine in Cogeneration mode of operation.

This alternative generates both steam and electricity from Natural Gas, though the thermal efficiency is very high in this mode of operation (63%)[18] the electrical efficiency is low in comparison with the Combined Cycle Mode of Operation (50%)[7]. The Cogeneration mode of operation is mainly used to provide electricity and steam for industrial facility and the project activity's purpose is to deliver the power to the grid. Hence this option does not deliver the similar services comparable to the project activity. Hence, this is also not a credible and realistic alternative and therefore this alternative cannot be a part of the baseline scenarios.

c) Power generation using energy sources other than Natural Gas

The various alternative energy sources that can generate power other than natural gas include:
Singapore Energy Sector overview:
Energy Management Authority (EMA), a statutory board under the Ministry of Trade and Industry, Singapore, in its annual report 2010-11 has given a brief overview of the Singapore energy sector as below:

Fuel mix electricity for generation (EMA, Annual Report 2010/1011. Pg. 18):

Fuel Type	Fuel Oil (%)	Natural Gas (%)	Others (%)
2006	12	78	10
2007	18	79	3
2008	15	80	5
2009	15	81	4

This link shows rounded off value 56%. However, heat balance diagram from Siemens for project activity shows efficiency 58.16%, so same is chosen for conservativeness
[16] Open cycle efficiency taken from Siemens gas turbine SGT5-4000F brochure, pg. 3
[17] Energy Market Authority, Annual Report 2010/1011. Pg. 20
[18] http://www.netl.doe.gov/publications/proceedings/01/carbon_seq/2B1.pdf (p. 3)

2010	17	77	6

As can be seen from the figure above, about 80% of the electricity generated in Singapore is from natural gas. The share of fuel oils in this fuel mix has been between 12-18% in the last five years.

Another source shows similar statistics from 2003[19]

Total	2003	2004	2005	2006	2007	2008	2009	2010
Petroleum Products	35.1%	27.2%	22.0%	18.9%	17.8%	15.4%	15.4%	18.7%
Natural Gas	62.1%	70.2%	75.6%	78.7%	80.0%	82.1%	82.1%	78.7%
Others	2.8%	2.6%	2.4%	2.4%	2.2%	2.5%	2.5%	2.6%

This shows that there are very few power plants existing using other energy sources than petroleum products (fuel oils) and natural gas and also less opportunity to use other fuels. However, as required by the procedure to establish baseline, a discussion on other alternatives is also presented as follows.

c.1) Power generation using wind as the energy source.
Power generation from wind does not meet the base load requirement for the grid on a continuous basis as wind is seasonal in nature and the capacity utilization factor is very low. Due to the high uncertainty of wind it is not a credible and realistic option for such high capacity comparable to the project activity. Also as per Energy Market Authority, Singapore, due to limitations in land, Singapore cannot replicate other countries' application of wind power[20] in terms of large wind farms. To generate reasonably efficient power from wind turbines, the average wind speed needs to be above 5m/s (metres per second). Singapore does not have abundant winds except in the coastal areas and offshore islands; the average wind speed is usually lower than 3.3m/s. So power generation from wind in Singapore is not a plausible scenario.

c.2) Power generation using Hydro as the energy source (lifetime 35 years)
As per Country energy information Singapore, it is not having hydro[21] potential. As per this report which was published in 2006, the electricity production from hydro is 0%. As per Singapore Energy statistics-2011, there is no mention of hydro power for the electricity generation. From above discussion, it is clear that power generation from Hydro power is not a realistic scenario.

c.3) Power generation using fuel oil

As per above statistics between 2006-2012, only 17-18% of the electricity generation is from the fuel oil in Singapore.

In 2001, 71% of the electricity was generated from fuel oil and 26% from natural gas – this has changed significantly to 15% fuel oil and 81% natural gas in 2009[22]. As a small city-state with no significant indigenous energy resources, Singapore is dependent on fossil fuel imports to meet her energy needs[23].

[19] Singapore Energy Statistics 2011, pg. 14 (http://www.ema.gov.sg/media/files/publications/SES2011.pdf)
[20] http://www.ema.gov.sg/page/35/id:68/
[21] http://www.energyrecipes.org/reports/genericData/Asia/061129%20RECIPES%20country%20info%20Singapore.pdf
[22] http://app.nccs.gov.sg/page.aspx?pageid=83
[23] EMA, Energising our nation, Singapore Energy Statistics, 2011 (Page No. 7)

Thus, no new fuel oil based power plants have been commissioned in last 10 years. Thus, this alternative is not considered realistic and not discussed further.

c.4) Power generation using Nuclear Fuel

In 2010, around 79% of Singapore's electricity was generated from natural gas, and another 19% from petroleum products such as fuel oil and diesel. The remaining 3% was generated through renewable sources such as biogas, municipal solid waste and solar. There is no mention of electricity generation from nuclear power. As per one of the press releases[24] in 2011 "The Government is conducting a study into the possible use of nuclear energy here, and will release its initial findings next year." Government is also thinking that Malaysia, Indonesia and Singapore could work together and build an offshore nuclear power plant on an island somewhere. From the above discussion it is clear that till now in Singapore electricity generation from nuclear energy has not taken place. This is not a plausible baseline scenario.

c.5) Power generation with thermal power plants using coal and/ or lignite as the energy source

The coal used for the power production in Singapore is imported from countries like Indonesia, Malaysia etc. For example Tuas Power company who is installing new coal and biomass based plant at Jurong island has signed a contract with Indonesia's PT Bayan Resources[25] to supply Sub-bituminous coal over the next 15 years.

In a media release by the 'Energy Market Authority – Government of Singapore' on 25/09/2008 has said that "the Government has decided not to use coal for power generation on a large scale, until the demand for LNG stabilises. We will not allow any entry of coal to adversely affect and jeopardise the viability of the LNG project."

Thus, large scale coal based power plant was not considered as a baseline alternative. A precedence of approval for 160 MW coal based power plant in Singapore exists, hence this unit size was chosen as appropriate for the baseline alternative.

Also, supercritical power plant has minimum size requirement of 660 MW due to technical design of boilers that can operate on supercritical conditions. Thus, supercritical power plants cannot have sizes lower than 660 MW for single unit size. Thus, due to this limitation, this was not considered as realistic scenario in Singapore where large scale coal based power plants are not allowed by Government decision as discussed earlier. Thus, the size of coal/ lignite based power plant equivalent to the project activity is unprecedented in Singapore. However, as per baseline methodology AM0029, several smaller plants may be a reasonable alternative to the project activity. Thus, five units of 160 MW each using subcritical technology (equivalent to Tuas Power's coal based power plant) is a realistic scenario.

As for lignite, due to its spontaneous combustion property, it cannot be transported over long distance or stored for longer durations[26]. Thus, this alternative cannot be a practical for the project activity as Singapore does not have lignite reserves and fuel will need to be imported from other countries.

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[24] http://cjcpig.wordpress.com/2011/11/08/singapore-looking-into-importing-electricity-and-possibility-of-nuclear-energy/

[25] Report on "The Use of Coal in Singapore" July 19, 2011. http://www.lowcarbonsg.com/2011/07/19/the-use-of-coal-in-singapore/

[26] http://www.geology.ar.gov/energy/lignite.htm
and Book "Geology of Coal Fires: Case Studies from Around the World", by Glenn B. Stracher, pg. 58 (copy submitted to DOE)

Thus, coal can be chosen to use in either sub-critical / super critical power plant. Thus, this is a realistic scenario and is considered for further analysis.

- These alternatives need not consist solely of power plants of the same capacity, load factor and operational characteristics (i.e. several smaller plants, or the share of a larger plant may be a reasonable alternative to the project activity), however they should deliver similar services (e.g. peak Vs. base load power).

- Note further that the baseline scenario candidates identified may not be available to project participants, but could be other stakeholders within the grid boundary (e.g. other companies investing in power capacity expansions)

- All relevant power plant technologies that have recently been constructed or are under construction or are being planned (e.g. documented in official power expansion plans) should be included as plausible alternatives.

These conditions give scope for inclusion of coal as a possible baseline alternative given Tuas Power[27,28] has started construction of a 160 MW coal based power plant.

d. Import of electricity from connected grids, including the possibility of new interconnections.
Singapore Government is seriously considering electricity imports as a medium term option. Electricity imports allow countries like Singapore to access new energy options that may be unavailable or not economically feasible. EMA held a public consultation exercise from Jan-Mar 2012, on the regulatory framework to govern electricity imports to Singapore[29].

The paper noted:
"To further diversify our energy mix, we are considering importing electricity. This will allow us to tap into new energy options that may be unavailable or economically infeasible in Singapore such as coal and other renewable sources like Hydro and geothermal".

The initial plan is to import about 600 MW of electricity.

In another report[30], EMA noted "*In particular, the power generation industry could consider options such such as coal and electricity imports. Coal is expected to remain relatively cheap and can be sourced from from different countries. The import of electricity through long-distance high-voltage cables is another option, which will free up valuable land in Singapore. It could also allow us to tap on the significant renewable energy potential, such as hydro-electricity or geothermal power, in our region. ~~However, adequate safeguards will have to be put in place to ensure the integrity and stability of our power system~~*". However, the electricity import project will likely take around 4-5 years to develop and implement, and the importer could start selling electricity to Singapore from 2017/2018. As this project

[27] EMA media release 'Government approves new biomass-coal multi-utilities complex on Jurong Island 25 September 2008 - http://www.ema.gov.sg/news/view/18
[28] Tuas Power secures coal supplies, 16 February 11 – http://www.sgprocessindustries.com/SingleNews.aspx?DirID=114&rec_code=699984&title=Tuas+Power+secures+coal+supplies
[29] Regulatory Framework for Electricity Imports, Consultation Paper, 12 December 2011 (http://www.ema.gov.sg/media/com_consultations/attachments/4ee55a713fe04-EMA-_Consultation_Paper_on_Elect_Import_Framework__final_12_Dec_11.pdf)
[30] STATEMENT OF OPPORTUNITIES for the Singapore energy industry 2010 (http://www.ema.gov.sg/media/files/publications/soo/EMA_SOO_2010_web-2.pdf)

will take four years more than planned commissioning of the project activity (2014), this option is not considered further.

~~Thus, this is considered as a plausible alternative.~~

From the above discussion it is evident that the plausible baseline scenarios identified include:

a) The project activity i.e. '800 MW NG based Combined Cycle power plant with an efficiency of 58.16% and with a lifetime of 30 years' not implemented as a CDM project activity**.**
b) Power generation using coal as the energy source
~~c) Import of electricity from connected grids, including the possibility of new interconnections~~

Based on the investment analysis presented in the following section B.5, table below summarizes the levelized cost of electricity generation for identified alternatives.

Sr. No.	**Baseline Scenario**	**Levelized Cost of generation (S$/ MWh)**
(a)	Project activity implemented without the CDM	171.28
(b)	Power generation using coal as the energy source	138.94
~~(c)~~	~~Cost of electricity imported from other countries~~[31]	~~150~~

Thus, the economically attractive baseline scenario as identified by the investment analysis using the levelized cost of electricity generation (in S$/ MWh) as the financial indicator is the alternative i.e. (b) Power generation using coal as the energy source.

As the sensitivity analysis result in following Section B.5 is conclusive that under no scenario, the project activity without CDM is financially attractive compared to the alternative 'Power generation using coal as the energy source'. Thus, this is chosen as the baseline.

B.5. Demonstration of additionality

The PP has continued steps from Section B.4 as per the additionality tool to demonstrate Additionality.

2. Identify the economically most attractive baseline scenario alternative.

Sub Step -1: Benchmark Investment Analysis

As per Additionality tool selected in Section B.1 above, Sub-step 2b, option III "Identify the financial/economic indicator, such as IRR, most suitable for the project type and decision context".

The project activity plant will sell electricity from in the open market/ merchant basis. So it will have to compete with existing suppliers/ future capacity addition using low cost options like coal (one plant already under construction and other phase under planning). Thus, open market sale happened on bid basis based on per unit cost of electricity. Thus, levelised cost of electricity generation (LCOE) is the most important parameter in the decision making context. If the LCOE of project activity is higher than the other power projects in competition, then PP will not be able to sell electricity and hence will not achieve annual capacity utilization projected. Also, the electricity sale rate is not fixed and hence calculation of other financial indicators like IRR will not give realistic revenue projections.

~~[31] Estimate from Power Market Analyst contracted by PP – based on the National Energy Market of Singapore, Monthly Trading Report, Dec. 2010~~

The levelized cost for the alternative (a) i.e. implementing the project activity without the consideration of CDM revenue is calculated by the following assumptions:

Techno Economic parameters 800 MW NG based power plant			**References**
Installed Capacity	800	MW	EPC contract and Mandate letter available at investment decision (pg.17) [Mandate letter, pg. 18 mentions equity = 378+127; pg. 1 mentions 670 debt]
Total Investment[32]	1,175	Million S$	
Debt: Equity	57%:43%	ratio	
Interest rate	Linked to SIBOR [33] (refer 'debt' worksheet in the financial calculations)		
Loan repayment	17	year	Mandate letter, pg. 54 (2 years moratorium – during construction phase)
O&M Costs including Insurance	4	% of capital cost	IEA ETSAP - Technology Brief E02 – April 2010; pg. 3
Capacity utilization of plant	72	%	Calculated from 30 years estimated export in financial analysis
Net Station Heat Rate	6,190	kJ/kWh	Heat balance diagram of plant from EPC offer
Natural gas NCV	52.67	MMBTU/ton	Estimate in financial closure model
Landed cost of natural gas	21.29	S$/MMBTU	
Book Depreciation Rate (Straight Line Method basis)			
annual depreciation	3.0	%	Straight line method (90/30) 10% is considered salvage value
Book Depreciation up to (% of asset value)	90	%	
Useful life of plant	30	Years	Refer discussion below this table
Annual gas requirement	841,806,000	m^3	Calculated from electricity generation, gas NCV and plant heat rate

Useful plant life: In line with the guidance of EB guideline EB 50 Annex 15, first two options are not applicable as (a) manufacturer of GTs did not specify any technical life (b) expert opinion is not taken by PP. Thus, based on option 'c' default value of "Gas turbines, above 50 MW capacity = 200,000 hours". Considering 72% capacity utilization as per PP's financial analysis at investment decision, the useful life of plant is = 200,000/(24* 365* 72%) = 31.7 years.

The PP had estimated 30 year life at investment decision and for the financial analysis submitted for bank loan approvals. This value being close to the default recommended in the above referred guidance a life of 30 years is considered here.

The levelized cost of electricity generation using Natural gas as the energy source calculated using the above values comes out to be S$ 171.28/ MWh[34].

[32] The project cost does not include land as land is on lease and thus total cost is used for depreciation and salvage value calculation (and land cost is not depreciated)

[33] SIBOR - Association of Banks in Singapore and Swap Offer Rates

[34] Detailed spread sheet based model is submitted to DOE for validation and an extract of the P&L sheet and levelised cost calculation is given in Annex 1

The assumptions considered for calculating the levelized cost of generation for the alternative (b) i.e. power generation using coal as the energy source are described in the table below. Most other assumptions are kept same as the above alternative (a) for better comparison.

Techno Economic parameters for power generation using coal as the energy source		
Installed Capacity	800 MW	kept same as project activity plant for comparison
Total Investment	2,461.4 million S$	IEA ETSAP – Technology Brief E01-April 2010 on Coal fired Power - capital cost ~ 2000-2500 USD/kW. Highest range is used for calculation here (USD 2500/kW).
O&M Costs	4% of capital cost	IEA ETSAP - Technology Brief E01 – April 2010; pg. 1[35]
Net station heat rate	9196.64 kJ/kWh	India CERC-(Terms-and-Conditions-of-Tariff)-Regulations-2009; pg. 46[36]
NCV of coal	25.8 TJ/Gg	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 2, Ch 1, pg. 1.18; for other bituminous coal
Landed price of coal	80 S$/ton	EMA - Integrated summary report for SLNG Terminal, pg. 17 mentions US$65/ton - highest among scenarios[37]
Annual coal price escalation	9.48%	Calculated from coal price index [38] between June 2001 to Jun 2011 (10 years before investment decision)
All other assumptions are same as NG based power plant for comparison and conservativeness in financial analysis		

The levelized cost of electricity generation using Coal as the energy source calculated using the above values comes out to be S$ 138.94 /MWh

Thus, the economically attractive baseline scenario as identified by the investment analysis using the levelized cost of electricity generation (in S$/ MWh) as the financial indicator is the alternative (b) which is power generation using coal as the energy source.

Further, in line with the requirement of the methodology, the benchmark analysis is done as below.
The financial indicator chosen is equity IRR as this is most common variable used by the investors for new investments. This is the first power project of the PP in Singapore and hence equity IRR was considered as the preferred financial indicator to study financial viability at the investment decision[39]. The benchmark chosen is 'default expected return on equity' given by Guidelines on the assessment of investment analysis (Version 05, EB 62, Annex 5). As per the Guidance 12 of the EB 62, Annex 5, 'Required/ expected returns on equity are appropriate benchmarks for an equity IRR.' Also, in line with the Guidance 13 of the earlier referred Guidelines, as the project activity (a new natural gas based power

[35] http://www.iea-etsap.org/web/E-TechDS/PDF/E01-coal-fired-power-GS-AD-gct.pdf
[36] Lowest (so conservative) heat rate applicable for imported coal - so taken for any international site
[37] 1 USD = 1.2307 SGD; source: http://www.exchangerates.org.uk/USD-SGD-06_06_2011-exchange-rate-history.html
[38] Evidence submitted to DOE – web page from http://www.indexmundi.com
[39] The statement is supported by a public reference to the PP's presentation to the investors where equity IRR from the financial analysis was highlighted.

plant) can be developed by any other entity, the benchmark is taken based on parameters standards in the market. As the para 15 of the same Guidelines, the cost of equity is determined by the first option given i.e. (a) selecting the values provided in Appendix A. The project activity being 'Energy Industries' is categorised in Group 1. The referred guidance has given expected default RoE as 10.5% for Singapore. This being real terms RoE, inflation (5.20%[40]) is added to get nominal RoE. Thus, the benchmark is 15.70%.

The project activity does not have a firm PPA for the sale of electricity and will sell electricity in open market on merchant basis. The revenues for the financial analysis here consider details energy market scenarios in future and as per different tariffs are considered for 'peak' 'off peak' and 'shoulder' periods (as tariff varies during these periods in day/ year) for vesting contracts, retail and uncontracted spot sale in energy market is considered. Few recent electricity trading reports available publicly are shared with the DOE and confirm different tariffs for these periods. Also, the tariffs and escalation used thereon is same as that used by the lenders for the loan approval[41]. Following are the types of electricity sale contracts and revenue sources.

- **The Peak, Offpeak & Shoulder prices**

The peak period captures those hours with the highest demand in the year. The off-peak period captures the 2,745 hours with the lowest demand in the year. The shoulder period defines hours between the peak and off-peak periods and represents the intermediate 3,150 hours in the year. In order to model peak and off-peak periods in higher granularity, non-shoulder segments represent a smaller number of hourly observations.

- **Vesting Contract:**

The Vesting Contract is a contract between a generation licensee and SP Services , which make up the vesting contract regime in Singapore. Under this regime, a generation licensee must enter into a vesting contract if so directed by the EMA, for the purpose of mitigating or preventing the misuse of market power by a generation licensee. In some circumstances, vesting contracts have been entered into as a result of such a direction. In other circumstances, a generation licensee such as IPC, has elected to enter into a Vesting Contract to limit its exposure to volatility in the electricity pool.
The Vesting Contract is a financial contract for differences. The contract does not establish any right to the physical supply of electricity. Difference payments are calculated for each half hour on the basis of the difference between the Hedge Price and the VCRP for the relevant half hour, multiplied by the applicable Hedge Quantity (in MW) for that half hour.

The Issuer makes the difference payment where the Hedge Price exceeds the VCRP. IPC makes the difference payment where the VCRP exceeds the Hedge Price.

The Vesting Contract is applicable to three types of Hedge Quantities:

- Balancing Vesting Quantity: allocated under the existing scheme for electricity generated from PNG and other fuel (which may include LNG);
- LNG Vesting Quantity: allocated under the LNG Vesting Scheme for electricity generated from LNG; and
- Tender Vesting Quantity: allocated under the Tender Vesting Scheme pursuant to a tender process. The fuel type may vary.

IPC is entitled to vesting quantities under the Balancing Vesting Scheme and the LNG Vesting Scheme. However, IPC may tender for a tender vesting quantity at a later date.

- **Retail Contract:**

[40] http://www.singstat.gov.sg/stats/keyind.html
[41] confirmation from the financial closure excel sheet model is done by the DOE

Under the National Electricity Market of Singapore, consumers are grouped into two categories according to their annual consumption - contestable and non-contestable. Contestable consumers are mainly single premise users with consumption of at least 10,000 kWh per month and multi-tenanted buildings that have successfully attained contestability status via an en bloc exercise of obtaining 100% consensus from tenants.

The retailers purchase electricity directly from the wholesale market and sell it to the contestable customers. All retailers in Singapore have related companies with generation licences and invariably enter into bilateral contracts with their parent generation company to hedge its position. The retailers enter into various types of contracts with a tenor of 6 months to 3 years with contestable customer

- **Uncontracted Revenue:**

Singapore is a merchant market and the generator has to bid in the market to sell electricity. The uncontracted revenue means the revenue generated by the company by selling electricity in the wholesale market other than revenue arising out Vesting contract and Retail contracts.

For this project activity, an independent consultant was appointed for study of power and fuel price as well as future projections for study of project profitability[42]. The draft report[43] was available before the investment decision and same was used for the demonstration is additionality.

The equity IRR for the project activity is 13.74%[44] and is below the benchmark. Thus, the project activity is not financial viable without CDM.

Sensitivity Analysis: Further a sensitivity analysis is performed on both the alternatives to vary important parameters in line with Guidance 20 of the EB 62, Annex 5. The justification on the selected range of sensitivity parameters is also presented in the Section B.5 and it is concluded that the actual plant performance is within this sensitivity range.

S.N	Parameter varied	**Levelized Cost of generation (S$/ kWh)**			
		Project activity without CDM		**Power generation using coal**	
		+10%	-10%	+10%	-10%
1	Heat rate	203.58	142.06	149.17	128.71
2	Plant load factor	169.69	173.22	135.61	143.01
3	Fuel cost	186.66	155.90	149.17	128.71
4	Project cost	173.03	169.53	142.60	135.28
5	O&M cost	172.21	170.35	140.89	136.99

It can be seen that the LCOE of coal is lower than that of NG for all the scenarios studied above.

Sensitivity analysis for equity IRR:

S.N	Parameter varied	Equity IRR		
		+10%	-10%	Benchmark
0	Base case	13.74		
1	Plant load factor	15.80	11.57	

[42] An agreement signed by PP and Lenders on 24/04/2010 is shared with the DOE

[43] "Power and fuel market analysis to support the financing of GMR's CCGT project in Singapore" by IPA Energy + Water Economics Limited, London. This evidence is shared with the DOE.

[44] Detailed financial model submitted to the DOE

2	Fuel cost	13.63	13.87	15.70%
3	Project cost	12.91	14.71	

Heat rate is not subjected to the sensitivity analysis as by natural degradation during life of plant and on account of lower than optimal load operations[45], the fuel consumption will go up and hence IRR will increase. Since, the heat rate cannot increase for a gas turbine technology after it is installed once, the heat rate reduction will not be realistic.

The sensitivity on tariff is not done since in Singapore, the electricity prices are determinate based on fuel cost and not fuel cost (cost in generating electricity and delivering to consumers). Thus, the tariff will not change independent of the fuel cost. The non fuel cost component has not changed in past few years[46]. The sensitivity on fuel cost is already covered in the analysis above.

Though the equity IRR crosses benchmark with +10% change in the plant load factor, this situation is unlikely. The latest EMA report[47] uses annual average expected utilization factor of the plant as 72.8%. Further, pg. 37 of the report confirms this value being 'the actual historic capacity factor for the previous 12 months'. The project activity uses 72% as base case PLF considered for the loan applications, also consistent with the EMA report and hence this 10% changes is not considered realistic. As can be seen from the analysis above, the equity IRR does not cross benchmark in any realistic variation in the parameters studied and sensitivity analysis is conclusive that project activity is financial not viable without CDM.

Impact of CDM:

The equity IRR changes to 15.14% and alleviates the investment barrier after considering CDM revenue.

Step 2: Common Practice Analysis

As per the 'Guidelines on Common Practice Analysis' (Version 02.0, EB 69, Annex 8, common practice analysis requires the following step-by-step analysis.

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

Considering 800 MW project here, the applicable range will be from 400 MW to – 1200 MW.

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;
(b) The projects apply the same measure as the proposed project activity;
(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;
(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;

[45] EMA report 'Review of the vesting contract parameters for 2013 and 2014 – Draft report' pg. 19 (pg. 23 of pdf file); refer Table 10 for impact of load factor on heat rate, at 72% annual load factor of project activity, the heat rate will be from 104-105% of the design heat rate
[46] Responses to FAQ from EMA, Singapore - http://www.ifaq.gov.sg/ema/apps/fcd_faqmain.aspx
[47] EMA, Review of the vesting contract parameters for 2013 and 2014 – draft report, pg. 1 (pg. 5 of pdf file)

(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.

Going by the above conditions, the commercially operating combined cycle power plants and their licensed capacities are as below[48]:

S.N.	Plant/ company name	Capacity (MW)
1	Power Seraya	1,472
2	Senoko Power	1,945
3	Tuas Power Generation	1,470
4	Sembcorp Cogen	785
5	Keppel Merlimau Cogen	500

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}.

Out of the five plants in Step 2, most of the old capacity of Power Seraya was fuel oil fired. Also, the new 740 MW was web hosted for global stakeholder comments under CDM validation.

Tuas Power: Few references show that at least 1,200 MW capacity had started construction in mid 1990s[49] and these plants were based on oil fired steam sets[50] and these are not considered for comparison here. Though the official Tuas Power website shows generation capacity of 2670 MW, the difference could be under construction or sold to other industrial/ dedicated customers[51].

From the remaining 1,470 MW CCGT capacity, first two units of 367.5 MW capacity had started construction in October, 1999. This difference of more than 10 years before the project activity start date can have significant difference from capital cost, Government policy shifts, competitive tariff policy etc. and two units are not considered here. The remaining two CCGTs construction had started in October 2001. Thus, only this 735 MW is considered in the analysis here and the capacity is within the capacity range of analysis here.

Senoko Power: the company website[52] shows following factsheet in the 'Media' section:

[48] Source shared with the DOE
[49] http://www.yokogawa.com/iab/suc/power/pwr-suc-tua-002en.htm
[50] http://www.tuaspower.com.sg/about-us/milestones.html
[51] http://www.tuaspower.com.sg/ourbusiness/index.html
[52] http://www.senokoenergy.com.sg/

Owners	Lion Power Consortium
Facilities	1976: 3 units of 120megawatt (MW) generating plants under Stage I Development. 1979: 3 units of 250MW generating plants under Stage II Development. 1983: 2 units of 250MW generating plants under Stage III Development. 1990/91: 4 sets of 130MW gas turbines. These were converted into two blocks of 850MW combined cycle plants (CCPs), each with a generation capacity of 425MW in 1996/97. 1992-96: 5 units of 250MW generating plants were converted to dual-fuel gas/oil firing capability. 2001/02: 1 unit of 360MW CCP. 2004/05: 2 units of 360MW CCP.
Current Capacity	500MW thermal steam plants 1,945MW combined-cycle plants (CCPs) 190MW open-cycle gas turbines (PPGT)
Full Licensed Capacity	3,300MW

There is no documented evidence available that the last added capacity of 720 MW in 2004/ 05 was ever considered for CDM. Thus, this capacity is considered for analysis here.

Thus N_{all} = 4 (excluding Power Seraya for being in the CDM pipeline) and

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}
Further, plant 4 and 5 being co-generation plants, are considered as different technologies as they do not deliver the same services, given that the Project Activity will be providing electricity only.

N_{diff} = 2 (both co-generation units).

Step 5: Calculate factor F = 1 - N_{diff}/N_{all} *representing the share of plants using technology similar to the technology used in the proposed project activity in all plants that deliver the same output or capacity as the proposed project activity.*

The factor F, based on inferences drawn from Step 3 works out to [1 – 2/ 4]; F = 0.5

As per para 10 of this guidance, '*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.*'

For this specific project, we calculated F above as 0.5, which is greater than 0.2.

But,

N_{all} - N_{diff} = 4 – 2 = 2, which is NOT greater than 3.

Therefore, since the project does not meet condition number (b), the plant can be shown as not a common practice.

Prior Consideration of the CDM:
As per the 'Guidelines on the demonstration and assessment of prior consideration of the CDM' Ver. 04, EB 62, Annex 13, para 2, PP had sent the prior consideration to the UNFCCC within six months of the starting date.

SN	Date	Project implementation Step	CDM registration efforts	Evidence
1	07/06/2011	Draft report from Energy consultant for fuel and electricity sale price estimation	-	"Power and fuel market analysis to support the financing of GMR's CCGT project in Singapore"[53]
2	14/06/2011	Decision by Board of Directors	Board considered CDM for the viability of project	Minutes of the meeting of Board of Directors
3	24/08/2011	Communication from EPC contractor for change in project specifications	-	Communications with Siemens AG
4	08/12/2011	Approval of change to EPC design	**CDM starting date**	Letter from PP to EPC contractor
5	09/03/2012	-	CDM prior consideration sent to UNFCCC and NCDMA	CDM web site[54] and F-CDM-Form
6	19/07/2012	-	Public Notice inviting for Local stakeholders meeting	Notice given in Strait Times
7	26/07/2012	-	Local stakeholders' meeting	Minutes of the meeting
9	12/09/2012	-	PDD web hosted for global stakeholder comments	CDM website, validation link[55]
10	24/04/2013	-	Letter of Approval from Singapore DNA	Copy of LoA
11	~~0~~15/01/2014 06/02/2014	~~Expected~~ commissioning ~~of the project activity plant~~date – Unit 1 Commissioning Unit 2	-	~~EPC schedule~~EMA website[56] (Refer - Schedule A to Licence)

Thus, the project activity is additional.

B.6. Emission reductions
B.6.1. Explanation of methodological choices

[53] Report prepared by IPA Energy + Water Economics Limited, London
[54] https://cdm.unfccc.int/Projects/PriorCDM/notifications
[55] https://cdm.unfccc.int/Projects/Validation/DB/830F72JOW1JARKR2OGB582IYL3TZP7/view.html
[56] https://www.ema.gov.sg/page/69/id:129/

According to the approved methodology AM0029

Project emissions
The project activity is on-site combustion of natural gas to generate electricity. The CO_2 emissions from electricity generation (PEy) are calculated as follows:

$$PE_y = \sum_f FC_{f,y} * COEF_{f,y} \quad (1)$$

Where:

$FC_{f,y}$: = Is the total volume of natural gas or other fuel 'f' combusted in the project plant or other start up fuel (m^3 or similar) in year(s) y

$COEF_{f,y}$: = Is the CO_2 emission coefficient (tCO_2/m^3 or similar) in year(s) for each fuel and is obtained as:

$$COEF_{f,y} = \Sigma NCV_y * EF_{CO2f,f,y} * OXID_f \quad (1a)$$

Where:

$NCV_{f,y}$: = Is the net calorific value (energy content) per volume unit of natural gas in year *y* (GJ/m^3) as determined from the fuel supplier, wherever possible, otherwise from local or national data

$EF_{CO2,f,y}$: = Is the CO_2 emission factor per unit of energy of natural gas in year *y* (tCO_2/GJ) as determined from the fuel supplier, wherever possible, otherwise from local or national data

$OXID_f$: = Is the oxidation factor of natural gas

Baseline emissions
Baseline emissions are calculated by multiplying the electricity generated in the project plant ($EG_{PJ,y}$) with a baseline CO_2 emission factor ($EF_{BL,CO2,y}$), as follows:

$$BE_y = EG_{PJ,y} \cdot EF_{BL,CO2,y} \quad (2)$$

According to the approved methodology AM0029 version 03, project participants shall use for $EF_{BL,CO2,y}$ the lowest emission factor among the following three options:

For the first crediting period:

Option 1 The build margin, calculated according to "Tool to calculate emission factor for an electricity system"; and

Option 2 The combined margin, calculated according to "Tool to calculate emission factor for an electricity system", using a 50/50 OM/BM weight;

Option 3 The emission factor of the technology (and fuel) identified as the most likely baseline scenario under "Identification of the baseline scenario" above, and calculated as follows:

$$EF_{BL,CO2}(tco2/Mwh) = \frac{COEF_{BL}}{\eta_{BL}} * 3.6GJ/MWh \quad (3)$$

Where:

$COEF_{BL}$: = The fuel emission coefficient (tCO2e/GJ), based on national average fuel data, if available, otherwise IPCC defaults can be used

η_{BL} : = The energy efficiency of the technology, as estimated in the baseline scenario analysis above

Leakages

As per the approved methodology AM0029, leakage emissions are calculated as follows:

$$LE_y = LE_{CH4,y} + LE_{LNG,CO2,y} \quad (4)$$

Where:

LE_{y} :	=	Leakage emissions during the year *y* in tCO_2e
$LE_{CH4,y}$:	=	Leakage emissions due to fugitive upstream CH_4 emissions in the year *y* in t CO_2e
$LE_{LNG,CO2,y}$:	=	Leakage emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year *y* in t CO_2e

Fugitive methane emissions

According to the approved methodology AM0029, the fugitive methane emissions are calculated as follows:

$$LE_{CH4,y} = \left[FC_y \cdot NCV_y \cdot EF_{NG,upstream,CH4} - EG_{PJ,y} \cdot EF_{BL,upstream,CH4}\right] \cdot GWP_{CH4} \quad \textbf{(5)}$$

Where:

$LE_{CH4,y}$:	=	Leakage emissions due to fugitive upstream CH_4 emissions in the year *y* in t CO_2e
FC_{y} :	=	Quantity of natural gas combusted in the project plant during the year *y* in m³
$NCV_{NG,y}$:	=	Average net calorific value of the natural gas combusted during the year *y* in GJ/m³
$EF_{NG,upstream,CH4}$:	=	Emission factor for upstream fugitive methane emissions of natural gas from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, in t CH_4 per GJ fuel supplied to final consumers
$EG_{PJ,y}$:	=	Electricity generation in the project plant during the year in MWh
$EF_{BL,upstream,CH4}$:	=	Emission factor for upstream fugitive methane emissions occurring in the absence of the project activity in t CH4 per MWh electricity generation in the project plant, as defined below
GWP_{CH4} :	=	Global warming potential of methane valid for the relevant commitment period

$LE_{LNG,CO2,y} = FC_y$ x $EF_{CO2,upstream,LNG}$

$LE_{LNG,CO2,y}$	= Leakage emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in t CO_2e
FC_y	= Quantity of natural gas combusted in the project plant during the year *y* in m^3
$EF_{CO2,upstream,LNG}$	= Emission factor for upstream CO_2 emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system

The default value mentioned in the baseline methodology 6 tCO_2/TJ will be used for this parameter in the project activity.

Emission Reductions

$ER_y = BE_y – PE_y – LE_y$ **(6)**

Where:

ERy:	=	Emissions reductions in year y (t CO_2e)
BEy:	=	Emissions in the baseline scenario in year y (t CO_2e)
PEy:	=	Emissions in the project scenario in year y (t CO_2e)
LEy:	=	Leakage in year y (t CO_2e)

No credits are claimed for activities during the project construction activity.

B.6.2. Data and parameters fixed ex ante

Data / Parameter	$EF_{electricity.y}$
Unit	tCO_2/MWh
Description	The combined margin emission factor of Singapore national grid
Source of data	NEA's 'Information on emission factors (for CDM projects in Singapore)', published 20/04/2012
Value(s) applied	0.4846
Choice of data or Measurement methods and procedures	Calculated as the weighted average of the build margin emission factor and operating margin emission factor (with 50/50 weights to OM and BM)
Purpose of data	Calculation of baseline emissions
Additional comment	BM 0.4578 OM 0.5114

Data / Parameter	$EF_{BM,y}$
Unit	tCO_2/MWh
Description	The Build Margin emission factor of Singapore national grid
Source of data	NEA's 'Information on emission factors (for CDM projects in Singapore)', published 20/04/2012
Value(s) applied	0.4578
Choice of data or Measurement methods and procedures	The value is taken from the NEA's 'Information on emission factors (for CDM projects in Singapore)', published 20/04/2012
Purpose of data	Calculation of baseline emissions
Additional comment	The value is used only for estimate now and will be monitored ex-post throughout the crediting period

Data / Parameter	$EF_{OM,y}$
Unit	tCO_2/MWh
Description	The Operating Margin emission factor of Southern grid
Source of data	NEA's 'Information on emission factors (for CDM projects in Singapore)', published 20/04/2012
Value(s) applied	0.5114
Choice of data or Measurement methods and procedures	The value is taken from the NEA's 'Information on emission factors (for CDM projects in Singapore)', published 20/04/2012
Purpose of data	Calculation of baseline emissions
Additional comment	The yearly Operating Margin emission factor of Singapore grid is as follows. An average of these values is used 2009: 0.5042; 2010: 0.5154; 2011: 0.5146

Data / Parameter	$EF_{CO2,NG,y}$
Unit	$kgCO_2e/TJ$
Description	Emission Factor of Natural Gas
Source of data	Table 1.4, Chapter 1, Volume 2, 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	56,100
Choice of data or Measurement methods and procedures	In absence of country specific data; IPCC default value used as recommended in methodology.
Purpose of data	Calculation of project emissions
Additional comment	--

Data / Parameter	$OXID_{NG}$
Unit	Unit less factor
Description	Oxidation Factor of NG
Source of data	Table 1.4, Chapter 1, Volume 2, 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1
Choice of data or Measurement methods and procedures	In absence of country specific data; IPCC default value used as recommended in methodology.
Purpose of data	Calculation of project emissions
Additional comment	This value is used for estimation and will be monitored ex-post throughout the crediting period

Data / Parameter	$EF_{NG, Upstream,CH4}$
Unit	t CH_4/PJ
Description	Emission factor for upstream fugitive methane emissions of natural gas from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, in tCH_4 per GJ fuel supplied to final consumers.
Source of data	Table 2, page 9 of the approved methodology AM0029, version 03
Value(s) applied	296
Choice of data or Measurement methods and procedures	In absence of the country specific data, default value given in the methodology for the world average is used.
Purpose of data	Calculation of leakage emissions
Additional comment	--

Data / Parameter	$EF_{CO2,upstream,LNG}$
Unit	tCO_2/TJ
Description	Emission factor for upstream CO_2 emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system
Source of data	default value as per baseline methodology AM0029, Version 03, pg. 10
Value(s) applied	6
Choice of data or Measurement methods and procedures	In absence of country specific data, default value used as recommended in methodology is used.
Purpose of data	Calculation of leakage emissions
Additional comment	--

Data / Parameter	$EF_{BL, Upstream,CH4}$
Unit	t CH_4/MWh
Description	Emission factor for upstream fugitive methane emissions occurring in the absence of the project activity in terms of ton of methane per MWh
Source of data	The value is taken from the NEA's 'Information on emission factors (for CDM projects in Singapore)', published 20/04/2012
Value(s) applied	0.00228
Choice of data or Measurement methods and procedures	Wherever necessary default values suggested in the approved methodology AM0029 are used in the formula above to arrive at the above value.
Purpose of data	Calculation of leakage emissions
Additional comment	-

Data / Parameter	$EF_{CO2,FF,y}$
Unit	kgCO_2e/TJ
Description	Emission Factor of diesel
Source of data	Table 1.4, Chapter 1, Volume 2, 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	74,100
Choice of data or Measurement methods and procedures	In absence of country specific data; IPCC default value used as recommended in methodology.
Purpose of data	Calculation of project emissions
Additional comment	--

B.6.3. Ex ante calculation of emission reductions

1. Calculation of baseline emissions

As per the NEA's 'Information on emission factors (for CDM projects in Singapore)', the latest (2011) build margin was 0.4578 tCO_2/MWh.

The three year average operating margin is:

Year	2009	2010	2011	Average
Simple OM (tCO_2/MWh)	0.5042	0.5154	0.5146	0.5114

Thus, combined margin is 0.4846 tCO_2/MWh.

For option 3, the technology and fuel of the baseline scenario will also require financial analysis (outside the scope of this study). However, as discussed above, the subcritical coal based power plant is most likely the baseline and its emission factor will always be higher than Singapore's build margin reported above (as this is based on the last built NG based CCGT/s). Hence, option 3 is not being calculated here.

Thus, $EB_{BLCO2,y} = 0.4578\ tCO_2/MWh$

Project activity plant has 800 MW installed capacity, 771 MW net available after 3.6% auxiliary requirement and taking annual 72% capacity utilization, the plant is expected to export

$EG_{GEN,}y$ = 800 x 24 x 365 x 72% = 5,045,760 MWh

$EG_{PJ,}y$ = 5,045,760 x (1-3.6%) = 4,865,010.44 MWh

BEy = 4,865,010.44 x 0.4578
= **2,227,202** $\mathbf{tCO_2}$

2. Calculation of Project Emissions (PE_y)

Calculated as per equation number-2 of AM 0029 as contained in part A (Procedure followed for estimating emissions in the project scenario) of section B.6.1 "Explanation of Methodological Choices". The value of project emissions is **1,752,964** $\mathbf{tCO_2e}$**.**

Values of sub-variables:
Volume of fuel combusted in project plant ($FC_{f,y}$) : 829,408,155 m^3
Based on the above, the estimated annual project emissions (PE_y) will be
= 829,408,155 m^3 x 9,000 kcal/m^3 x 56.1 tCO_2/TJ *(4.186 kJ/kcal x 10^{-9} kJ/TJ) = 1,752,964 tCO_2.

The Sub-variables are calculated as follows:
Calculation of CO_2 Emission Co-efficient of natural gas ($COEF_{f,y}$)
CO_2 Emission Co-efficient of natural gas is calculated as per equation number-2a of AM0029 Values of sub-variables:
1) Net Calorific Value of gas (NCV_y)[57]: 9,000 kcal/m^3
2) CO_2 emission factor ($EF_{CO2,f,y}$): 56.1 t CO_2/TJ
3) Oxidation factor of gas ($OXID_f$): 1

$COEF_{NG,y}$ = 9,000 kcal/m^3 x 4.186 x 10^{-9} x 56.1 (t CO_2 / TJ) x 1 = **0.0021 t** $\mathbf{CO_2}$**/SCM**

3) Calculation of Leakages (LE_y)

$LE_y = LE_{CH4,y} + LE_{LNG,CO2,y}$

$LE_{CH4,y}$ is ~~C~~calculated as:

$EF_{NG,upstream,CH4}$ is 296 tCH_4/PJ as per AM0029 (pg. 9, value is default for the world, excluding USA/ Canada and Europe.

Applying values in the above equation we get LE = **-** 47,466 tCO_2.

This is a negative number and means that upstream emissions of fuel used in the country are higher than that of NG required for the project activity. As per AM0029, pg. 10 'Where total net leakage effects are negative (LEy < 0), project participants should assume LEy = 0.'

[57] This value is taken from source (http://www.gailonline.com/final_site/energyconversionmatrix.html). As quantity of gas will vary in line with its NCV, this assumption will not impact emission reduction estimate. The quantity and NCV will be monitored anyway in the crediting period.

Thus, this factor is set at zero for further calculation.

$LE_{LNG,CO2,y} = FC_y \times EF_{CO2,upstream,LNG}$

$= 829,408,155 \times 9,000 \times 4.186 \times 10^{-9}$
$= 187,483\ tCO_2$

$LE_y = LE_{CH4,y} + LE_{LNG,CO2,y}$
$= 0 + 187,483$
$= 187,483\ tCO_2$

4. Emissions Reduction (ER_y)

= BEy – PEy – Ly
= 2,227,202 - 1,752,964 – 187,483
= ~~474,238~~**286,755** **tCO_2**

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 ($t\ CO_2e$)
2014	2,227,202	1,752,964	187,483~~0~~	286,755~~474,238~~
2015	2,227,202	1,752,964	187,483~~0~~	286,755~~474,238~~
2016	2,227,202	1,752,964	187,483~~0~~	286,755~~474,238~~
2017	2,227,202	1,752,964	187,483~~0~~	286,755~~474,238~~
2018	2,227,202	1,752,964	187,483~~0~~	286,755~~474,238~~
2019	2,227,202	1,752,964	187,483~~0~~	286,755~~474,238~~
2020	2,227,202	1,752,964	187,483~~0~~	286,755~~474,238~~
Total	**15,590,412**	**12,270,745**	187,483~~0~~	**2,007,288~~3,319,667~~**
Total number of crediting years	**7**			
Annual average over the crediting period	**2,227,202**	**1,752,964**	**187,483~~0~~**	**286,755~~474,238~~**

B.7. Monitoring plan
B.7.1. Data and parameters to be monitored

Data / Parameter	$EG_{Export,y}$
Unit	MWh
Description	New electricity exported by the project plant in year y
Source of data	Data measured and recorded from energy meters installed in the plant and in substation.
Value(s) applied	4,865,010.44
Measurement methods and procedures	As per plant records – there are two transmission lines (capable of export to grid and import from grid). Each of the two lines have separate main and check meter. These meters can monitor the total export and total import from grid. The net export used here will be calculated from 'export – import' Meter type: Accuracy: 0.2s Recording frequency: continuous measurement, monthly recording Calibration frequency: annual Responsible entity: plant head
Monitoring frequency	Monthly
QA/QC procedures	Meters will be calibrated as per the standard procedures and documents for the same will be maintained throughout. Cross check by recipient of sales.
Purpose of data	Calculation of baseline and project emission.
Additional comment	--

Data / Parameter	$FC_{NG,y}$
Unit	m^3
Description	Quantity of NG consumed in the project activity in year y
Source of data	Continuous monitoring will be done at project boundary
Value(s) applied	829,408,155
Measurement methods and procedures	The total fuel consumption will be monitored both at project end for billing and measured in standard cubic meters/Energy flow in accordance with Gas Supply Agreement. Meter type: ultrasonic gas flow meter Accuracy: ±0.1% of MV (linearity) Recording frequency: continuous monitoring with monthly recording Calibration frequency: once in six months Responsible entity: plant head
Monitoring frequency	Daily
QA/QC procedures	Natural gas supply metering to the project will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The fuel consumption will be cross checked at project end (PP's gas flow meter at the gas skid/ receiving station) for cross verification.
Purpose of data	Calculation of Project emission.
Additional comment	--

Data / Parameter	**$NCV_{NG,y}$**
Unit	GJ/m^3
Description	Net Calorific Value of Natural Gas
Source of data	Invoice from the gas supplier
Value(s) applied	0.0377
Measurement methods and procedures	The calorific value of the gas would be based on the measurement readings recorded by Gas Chromatograph located at the PP plant boundary. Suppliers' analysis/ report will be used to monitor this value.
Monitoring frequency	--
QA/QC procedures	Gas Chromatograph will be subject to regular (in accordance with guidelines of the OEM) maintenance and testing to ensure accuracy. GC may not be available on project site and within project boundary. Thus, PP will not have control on its calibration frequency.
Purpose of data	Calculation of Project emission.
Additional comment	--

Data / Parameter	**$COEF_{NG,y}$**
Unit	tCO_2/m^3
Description	CO_2 emission coefficient
Source of data	Calculated under project activity
Value(s) applied	0.0021
Measurement methods and procedures	calculated CO_2 Emission Co-efficient of natural gas is calculated as per equation number-2a of AM0029 Values of sub-variables: 1) Net Calorific Value of gas (NCV_y): 9,000 kcal/ m^3 2) CO_2 emission factor ($EF_{CO2,f,y}$): 0.0561 t CO_2/GJ 3) Oxidation factor of gas ($OXID_f$): 1
Monitoring frequency	Annual
QA/QC procedures	Not applicable as it is a calculated value and also in line with the monitoring methodology AM0029
Purpose of data	Calculation of Project emission.
Additional comment	--

Data / Parameter	$EF_{CO2,NG,y}$
Unit	$kgCO_2e/TJ$
Description	Emission Factor of Natural Gas
Source of data	Table 1.4, Chapter 1, Volume 2, 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	56,100
Measurement methods and procedures	In absence of country specific data; IPCC default value used as recommended in methodology.
Monitoring frequency	--
QA/QC procedures	Not Required as the default value from IPCC Guidelines for National Greenhouse Gas Inventories Table 1.4, Chapter 1, Volume 2, 2006 is used.
Purpose of data	Calculation of Project emission.
Additional comment	If IPCC publishes another version of this report, the same will be used.

Data / Parameter	$OXID_{NG}$
Unit	Unit less factor
Description	Oxidation Factor of NG
Source of data	Latest available version of IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1
Measurement methods and procedures	In absence of country specific data; IPCC default value used as recommended in methodology.
Monitoring frequency	Annual
QA/QC procedures	Not required as this is default value published by IPCC and latest available report (IPCC Guidelines for National Greenhouse Gas Inventories) will be referred.
Purpose of data	Calculation of Project emission.
Additional comment	This value is used for estimation and will be monitored ex-post throughout the crediting period.

Data / Parameter	**PEy**
Unit	tCO_2
Description	Project emission due to combustion of fuel
Source of data	Calculated under project activity
Value(s) applied	1,752,964
Measurement methods and procedures	Please refer to Section B.6.3 of the PDD for step wise calculation procedure
Monitoring frequency	--
QA/QC procedures	Not applicable as it is a calculated value
Purpose of data	Calculation of Project emission.
Additional comment	This value will be calculated ex-post in the monitoring period.

Data / Parameter	**$EF_{BL,CO2,y}$**
Unit	tCO_2/MWh
Description	Baseline CO_2 emission factor
Source of data	The value is taken from the NEA's 'Information on emission factors (for CDM projects in Singapore)', published 20/04/2012
Value(s) applied	0.4578
Measurement methods and procedures	Calculated as per monitoring methodology AM0029 As the option 1 - build margin is chosen, this parameter will monitored ex-post and based on latest available database published from the National Environment Agency (www.nea.gov.sg), Singapore
Monitoring frequency	Annual
QA/QC procedures	No QA/QC is required.
Purpose of data	Calculation of baseline emission.
Additional comment	This value will be monitored ex-post as required by the monitoring methodology AM0029.

Data / Parameter	**$FC_{FF,y}$**
Unit	Ton OR m^3
Description	Quantity of fossil fuel (diesel) consumed in the project activity in year y
Source of data	Continuous monitoring will be done at project boundary
Value(s) applied	0
Measurement methods and procedures	The total fuel consumption will be monitored if used for start up/ auxiliary Meter type: mass flow meter Accuracy: ±1% Recording frequency: continuous monitoring with daily recording Calibration frequency: once in six months Responsible entity: plant head
Monitoring frequency	Continuous monitoring with monthly recording
QA/QC procedures	Fossil fuel metering to the project will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. This will also be cross checked with the purchase invoice/ receipts
Purpose of data	Calculation of Project emission
Additional comment	--

Data / Parameter	**$NCV_{FF,y}$**
Unit	GJ/m^3
Description	Net Calorific Value of fossil fuel
Source of data	Invoice from the fossil fuel supplier
Value(s) applied	--
Measurement methods and procedures	Suppliers' analysis/ report will be used to monitor this value.
Monitoring frequency	--
QA/QC procedures	NCV measurement equipment may not be available on project site and within project boundary. Thus, PP will not have control on its calibration frequency and QC.
Purpose of data	Calculation of Project emission.
Additional comment	--

Data / Parameter	**Source of gas for project activity**
Unit	-
Description	This parameter is monitored to establish that gas is used from imported LNG from the new SLNG terminal and not diverted from existing users in the host country
Source of data	Gas supply invoices
Value(s) applied	-
Measurement methods and procedures	-
Monitoring frequency	Once in monitoring period
QA/QC procedures	-
Purpose of data	Demonstration of compliance to applicability condition on abundance availability of gas
Additional comment	--

B.7.2. Sampling plan

Not applicable for project activity. The project activity will monitor all the data and will not use sampling.

B.7.3. Other elements of monitoring plan

The project activity is operated and managed by the PP. The individual plants record data related to their respective project activity. The natural gas based power project abides and will abide by all regulatory and statutory requirements as prescribed under the state and central laws and regulations.

A CDM project team will be placed at the plant site immediately after start of crediting period. The project team has been entrusted with the responsibility of storing, recording the data related to the project activity. The project team is also responsible for calculation of actual creditable emission reduction in the most transparent and relevant manner. Installed meters are calibrated according to the maintenance schedule programmed at the start of the operation and recalibrated according the plants performance requirement.

All the monitoring data will be stored, recorded and kept under safe custody of the Plant Manager at the plant site for a period of crediting period or the last issuance whoever later + 2 years. The data will be

achieved in both hard copies and electronic format (excel sheets). Also, any change within the project boundary, such as change in spare and or equipments will be recorded and any change in the emission reduction due to such alteration will also be studied and recorded.

Monitoring of net electricity supplied to the grid

There are two transmission lines and each line has one main (by PP) and one check meter (by power purchaser). These meters will read both total export and import of electricity. The net export will be calculated from readings of these meters (total export – total import).

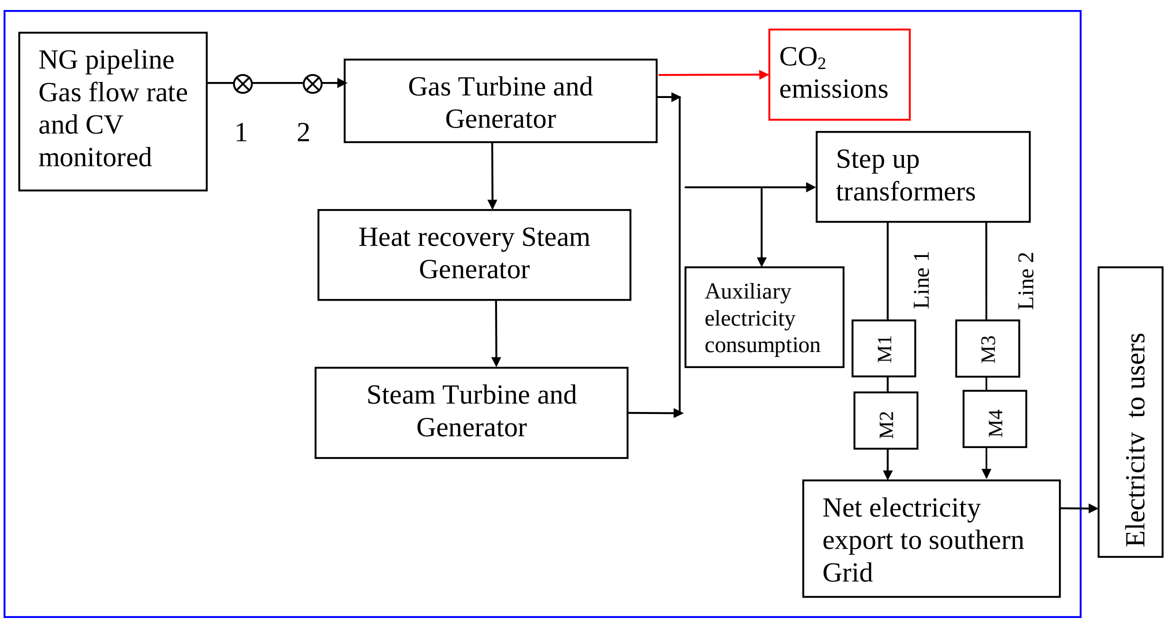
Emergency plan:

The electricity meter (the main meter owned by PP) will be calibrated annually. In case, both the meters have shown error more than the limit prescribed in the class, both the meters will be taken for the calibration and correction will be applied to the electricity generation recorded by the main meter.

Monitoring of gas consumed in the project activity and NCV

Gas consumed is measured by PP owned fuel flow meter reading at project boundary. There are two such Gas Fuel flow meters designated as Main and Check meters. Piping arrangement is provided in such a way, that both main and check meter are always in service or any one of them can be in service. This provision is to take care of pulling out one of the meter for calibration or maintenance purpose. The responsibility for calibration of the Gas fuel flow meter lies with the PP as stipulated in the Singapore Gas Metering code. Fuel Flow meter can measure the gas quantity both in terms of energy flow and/or volumetric flow. Gas supplier has only gas supply terminal with motorised isolation valves near project boundary. Necessary metering and status signals are transmitted to the gas transporter through the remote terminal unit located in the project boundary.

The net calorific value of natural gas consumed would be provided by PP. This is done on continuous basis using a Gas Chromatograph. The weighted average of NCV will be taken from the invoice from gas supplier for each billing period.



Project boundary

1 – gas supplier's gas flow and NCV monitoring
2 – PP's gas flow and

Line -1
M1- Main meter (owned by PP)
M2 – Check meter of APTRANSCO
Line 2

As the project activity registration may not coincide with the JMR date (both monitoring period start and the end),

(1) the net electricity export for this period will be monitored from the main meter readings (Automatic/manual record daily by the PP's team).

OR (2) the monitoring period will be taken from the subsequent JMR date after the registration date.

Similarly for the gas consumed and NCV readings, JMR will be done in accordance with the Gas Supply Agreement with the Gas Supplier.

Monitoring of diesel (back up fuel)
PP has installed 04 number of Storage tanks of capacity 25000 m^3 each at site to store back up fuel i.e. Diesel. The diesel fuel storage is provision to meet regulatory requirement of 'Electricity License for Generation Licensee' from EMA to the project activity. As per, pg. 10, para. 10, PP is requirement to maintain 90 days of fuel reserve 'on site'. This is in line with the energy security concerns of the country and to be used only in case of emergencies.

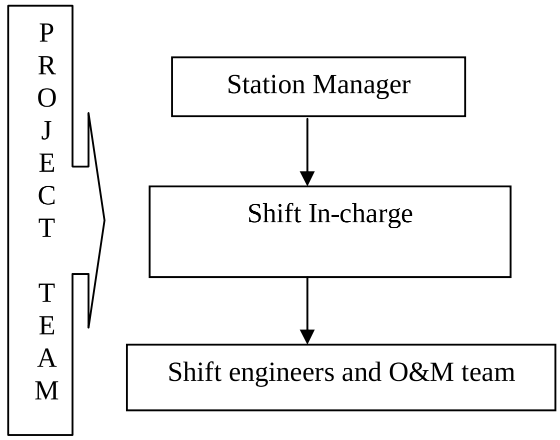
PP has also made a provision to monitoring diesel used and its energy content (NCV). If in some emergency, PP has to use more than 1% of this fuel (other than NG), the emission reduction will not be claimed in that monitoring period.

INTERNAL AUDIT AND PERFORMANCE REVIEWS

Monitoring team will be responsible for the annual performance reviews. The monthly invoices from recipient will be cross checked with the monthly export data. Any non-conformity if observed will be corrected.

The energy meter calibration due dates will be informed to the O&M team. In the review meeting, if the calibrations are found to be not done on due date, the meters will calibrated immediately and the correction factor will be applied to the monitored values.

Designation	**Responsibilities**
Plant Manager and Operation Manager	• Registration • Project Execution
CDM coordinator	• Operation • Verification of data • Inspection of data whenever necessary to independently check the authenticity of data and take corrective actions • Storage/ Achieving of data • Internal audit of monitored data and GHG reduction calculation
Shift in-charge & engineers, supported by operators	• Operation, Monitoring and Verification of Data • Data Recording • Storage of data
Operation and Maintenance team/ Contractor	• Operation and Maintenance • Storage of data • Data Recording • Data Collection • Archiving of data



SECTION C. Duration and crediting period
C.1. Duration of project activity
C.1.1. Start date of project activity

08/12/2011
On this date, approval to the EPC contractor was given for implementation of the project activity plant.

C.1.2. Expected operational lifetime of project activity

30 years 0 months

C.2. Crediting period of project activity
C.2.1. Type of crediting period

Renewable crediting period is chosen

C.2.2. Start date of crediting period

01/01/2014 (expected plant operations start) or the date of CDM project activity registration, whichever is later.

C.2.3. Length of crediting period

7 years 0 months (twice renewable)

SECTION D. Environmental impacts
D.1. Analysis of environmental impacts

An environmental impacts study was done by Environmental Resources Management (S) Pte. Ltd. (ERM)[58] in Oct. 2010 and a report 'Construction Impacts of the Power Plant' is available with PP. As the project site is coming up on an established industrial island, no impact on residential areas is expected. The impact assessment and mitigation plan where impact is categorized significant is summarised in following Section D.2.

[58] www.erm.com

D.2. Environmental impact assessment

1) Impacts during construction phase of the power plant

Activity/ source of impact / hazard	Mitigation / enhancement measures	Impact significance
Site clearing, earthworks, general construction activities, lay down areas of construction equipment	• Prepare an erosion control management plan using qualified professional • Drainage control, maintenance of natural drainage system will be observed • Schedule site clearing and earthworks outside peaks of rainfall • Install sedimentation tank to settle solids prior to discharge to public storm water drains • Drip collection devices for temporary fuel tanks on sealed areas with a bundled closure • Spent lubrication oils shall be disposed appropriately • Provide necessary sanitation facilities to workers	negligible
Pumping potentially contaminated groundwater / surface water into storm water drains	• Prepares an earth control management plan that is submitted to Public Utilities Board • Design and install appropriate treatment measures for pumped water from excavation sites • Treat groundwater to allowable limits before discharging into storm water drains/ canal/ river • Slit and sediment accumulated behind silt fence inside cut-off drain should be cleaned weekly	negligible
Environmentally hazardous material storage, use and handling	• Refuelling, fuel loading – unloading, lube oil change, waste storage and disposal to be managed appropriately • Onsite spill response and clean-up process will be in place, include workers' training • Waste management plan, off-site waste disposal will be planned and implemented • Hazardous materials handling and storage procedures will be prepared and followed • All temporary fuel storage tanks will be bunded • Refuelling areas will be hard surfaced and provision will be made for collection of spills	negligible
Construction dust, vehicular and construction equipment exhaust emissions (diesel powered machinery)	• Wet suppression of exposed soil and areas • During material excavation/ deposit – minimum drop heights • Windbreaks/ sheet covering for stockpiled material and spoils that are being transported • Provision for vehicle wash facility as necessary • Provision for vehicle speed restriction as necessary • Housekeeping – road sweeping, washing • Diesel powered construction equipments and vehicles to be maintained to minimize tail pipe emissions	negligible
Construction equipment and vehicles – noise	• Monitor noise during construction at boundaries • Good site practice will be followed to minimize noise at	negligible

	source • Only well maintained service equipments will be used • Silencers/ mufflers will be put on equipments • Temporary noise barriers will be constructed in areas of high noise • Simultaneous noisy activities will be avoided	
Construction traffic/ transport operations	• Traffic Management Plan will be developed • Adherence to speed limits will be observed • Detailed route planning will be carried out • Police escort will be requested for oversized loads • Measures will be undertaken to repair affected roads • Parking for construction workers will be controlled	negligible

2) Impacts during power plant operations

The project activity will abide by all air, water, pollution control regulations and is not expected to have any significant impact.

The plant is not expected to have any trans-boundary impacts.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

The PP identified nearby industries on Jurong Island, local residents in Singapore, representatives of local government authorities from electricity distribution, pollution control departments etc as possible stakeholders for the project activity plant. An invitation to all stakeholders was given by news paper (The Straits Times) advertisement on 19/07/2012. A total of 19 people attended the meeting held at Jurong Safra hotel (near project location).

The stakeholder process was followed as per following agenda

- Welcome address
- Presentation of the CDM – Kyoto Protocol and role of stakeholders
- Discussion and articulation of concerns
- Summary by meeting Chairman
- Vote of thanks

The discussions took place in English and minutes of the meeting along with attendance were recorded.

E.2. Summary of comments received

S.N.	Name of stakeholder and query	Reply from PP
1	Mr. Thirumalavan Is this a pure NG project with no other fuel?	This is a pure natural gas project.
2	Mr. Thirumalavan The fuel is NG of LNG? If its LNG, where will be re-gasification done?	The fuel used at plant is NG. The Singapore LNG Terminal will receive LNG and do gasification and send it to plant in pipeline.
3	Mr. Thirumalavan Is this is more efficient gas turbine?	Yes, this plant will use F class GTs from Siemens.

Some more points related to CDM process and CER prices were also discussed by Mr. Ng Koon Siang and Teo Jian Long.

E.3. Report on consideration of comments received

There were no comments that required follow up action from the PP.

SECTION F. Approval and authorization

PP has yet to get the letter of approval from the Host Country DNA.

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Appendix 1: Contact information of project participants

Organization name	PacificLight Power Pte. Ltd.
Street/P.O. Box	Lot 01962A PT MK34, Seraya Place, Jurong Island
Building	--
City	Jurong Island
State/Region	Jurong Island
Postcode	627867
Country	Singapore
Telephone	+65 6603 8999
Fax	+ 65 6896 8805
E-mail	shivaprasad.lokanath@pacificlight.com.sg
Website	www.gmrgroup.in
Contact person	-
Title	-
Salutation	Mr.
Last name	Lokanath
Middle name	-
First name	Shivaprasad
Department	-
Mobile	-
Direct fax	+ 65 6896 8805
Direct tel.	+65 6603 8999
Personal e-mail	shivaprasad.lokanath@pacificlight.com.sg

Appendix 2: Affirmation regarding public funding

There is no public funding involved in the project activity.

Appendix 3: Applicability of selected methodology

The applicability of the selected methodology is justified in Section B.2.

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

The ex ante calculation of emission reductions are based on the methodological choices explained in section B.6.1

Appendix 5: Further background information on monitoring plan

All the information regarding the monitoring plan has been included in the PDD Section B.7.3

Appendix 6: Summary of post registration changes

Not Applicable as project activity is not registered yet.

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History of the document

Version	Date	Nature of revision
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	EB 66 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).
03	EB 25, Annex 15 26 July 2006	
02	EB 14, Annex 06b 14 June 2004	
01	EB 05, Paragraph 12 03 August 2002	Initial adoption.
Decision Class: Regulatory **Document Type:** Form **Business Function:** Registration		