

REDUCTION OF GHG EMISSIONS IN PROPYLENE OXIDE PRODUCTION AT MTP HPPO MANUFACTURING CO., LTD.

Document Prepared By (South Pole Carbon Asset Management Ltd.)

Project Title	Reduction of GHG Emissions in Propylene Oxide Production at MTP HPPO Manufacturing Co., Ltd.
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Table of Contents

1	Project Details.....	3
1.1	Summary Description of the Project.....	3
1.2	Sectoral Scope and Project Type	3
1.3	Project Proponent.....	3
1.4	Other Entities Involved in the Project.....	3
1.5	Project Start Date	4
1.6	Project Crediting Period.....	4
1.7	Project Scale and Estimated GHG Emission Reductions or Removals	4
1.8	Description of the Project Activity	5
1.9	Project Location	5
1.10	Conditions Prior to Project Initiation	6
1.11	Compliance with Laws, Statutes and Other Regulatory Frameworks	6
1.12	Ownership and Other Programs	6
1.12.1	Right of Use.....	6
1.12.2	Emissions Trading Programs and Other Binding Limits.....	6
1.12.3	Other Forms of Environmental Credit.....	7
1.12.4	Participation under Other GHG Programs.....	7
1.12.5	Projects Rejected by Other GHG Programs	7
1.13	Additional Information Relevant to the Project	7
2	Application of Methodology	7
2.1	Title and Reference of Methodology	7
2.2	Applicability of Methodology.....	8
2.3	Project Boundary	8
2.4	Baseline Scenario.....	12
2.5	Additionality	12
2.6	Methodology Deviations.....	17
3	Quantification of GHG Emission Reductions and Removals	17
3.1	Baseline Emissions	17
3.2	Project Emissions.....	19
3.3	Leakage.....	23
3.4	Net GHG Emission Reductions and Removals	23
4	Monitoring.....	24
4.1	Data and Parameters Available at Validation	24
4.2	Data and Parameters Monitored.....	27
4.3	Monitoring Plan	32
5	Environmental Impact	33
6	Stakeholder Comments.....	34
	APPENDIX 1: Grid Emission Factor Computation.....	37

1 PROJECT DETAILS

1.1 Summary Description of the Project

The project involves a new process installation at a production facility of Propylene Oxide (PO) at MTP HPPO Manufacturing Co., Ltd, a joint venture between The Siam Cement Public Co., Ltd and The Dow Chemical Company, which is Hydrogen Peroxide-based Propylene Oxide (HPPO) technology instead of the conventional Chlorohydrin process. The conventional Chlorohydrin process is one of the typical processes in the Propylene Oxide industry that involves hydrochlorination process. In the Chlorohydrin process, Propylene (C_3H_6) is combined to hypochlorous acid to form a Chlorohydrin intermediate which is subsequently dechlorohydrinated to PO and leads to the formation of salts. While in the HPPO process, Propylene and Hydrogen peroxide is combined to produce PO.

The HPPO technology will be able to reduce GHG emissions and waste generation during PO synthesis compared to the Chlorohydrin process. GHG emissions and waste generation reductions are owing to usage of lesser GHG intensive reagents and reduced process energy requirements in the HPPO technology. The project activity is expected to prevent 239,356 tCO₂ emissions in a year and a total of 2,393,569 tCO₂ for a period of 10 years.

The new plant will be located within the Asia Industrial Estates (AIE) site near Map Ta Phut, Rayong, Thailand.

1.2 Sectoral Scope and Project Type

The project activity falls under the category 5, chemical industry. The project is a single project activity and not a grouped project.

1.3 Project Proponent

Organization name	MTP HPPO Manufacturing Co.,Ltd.
Contact person	Mr. Jirasak Singmaneechai
Title	Managing Director
Address	15th Floor, White Group Building II, 75 Soi Rubia, Sukumvit 42 Road, Prakanong, Klongtoey, Bangkok, Thailand.
Telephone	+662 365 7000
Email	Sjirasak@dow.com

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon (Thailand) Co., Ltd.
Role in the project	Consultant
Contact person	Mr. Patrick Buergi

Title	Director
Address	2/22 Iyara Building, 6 th Floor, Chan Road, Kwang Thungwatdon, Bangkok, Thailand - 10120
Telephone	-
Email	p.buerger@southpolecarbon.com

1.5 Project Start Date

The project start is 04 October 2011 that has been taken as the actual commissioning date of the new HPPO technology at MTP HPPO Manufacturing Co.,Ltd.

1.6 Project Crediting Period

The project crediting period is 10 years fixed starting from 04 October 2011 up to 03 October 2021.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

The project activity is a normal project activity with emission reductions of 239,356 tCO₂/year.

Project Scale	
Project	X
Large project	

Years	Estimated GHG emission reductions or removals (tCO ₂ e)
2011 (Oct - Dec)	58,363
2012	239,356
2013	239,356
2014	239,356
2015	239,356
2016	239,356
2017	239,356
2018	239,356
2019	239,356
2020	239,356
2021 (Jan – Oct)	180,993
Total estimated ERs	2,393,569
Total number of crediting years	10
Average annual ERs	239,356

1.8 Description of the Project Activity

The project is a Greenfield installation to produce Propylene Oxide (PO) using innovative Hydrogen Peroxide to Propylene Oxide (HPPO) technology. As compared to the conventional processes based on Chlorohydrin technology, the HPPO technology reduces overall energy consumption, thus resulting in significant emission reductions. Furthermore, the HPPO technology diminishes the wastewater volume also significantly, and decreases the infrastructure requirements and physical footprint by using simpler raw material and avoiding co-products. The new HPPO production facility has a production capacity of 390 kilotons per annum of PO.

As per methodology, there are 2 (two) classes of emissions that are considered in the proposed project activity, they are up-stream emissions and on-site process emissions. Up-stream emissions will relate to type of reagents used in the chemical reaction in the baseline and project activities while the on-site emissions includes emission sources located within the PO production facility and include emissions associated with the synthesis of the PO as well as emissions associated with by-product and waste treatment. Both emissions will be considered in the project activity and baseline.

The project activity lifetime is 30 years based on technology provider confirmation.

1.9 Project Location

The project activity is located at 10 Moo 2, Asia Industrial Estate, Banchang, Rayong, Thailand (<http://www.dow.com/thailand/about/locations.htm>). The coordinate of the production facility are:

Latitude: 12.7342 (12° 44' 03" N); Longitude 101.0485 (101° 02' 54" E)

[Source: <http://earthexplorer.usgs.gov/>]

The project location is also shown in the following figure.



1.10 Conditions Prior to Project Initiation

This is a Greenfield project activity by MTP HPPO Manufacturing Co., Ltd.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The project is under the compliance of the relevant local laws and regulations and is not prohibited by any of the national/state level sectoral policies. Further, the consent to operate the plant and No Objection Certificate has been received from Pollution Control Board of Thailand, which is the required statutory authority.

1.12 Ownership and Other Programs

1.12.1 Right of Use

Proof of ownership of the production facility will be submitted as evidence.

1.12.2 Emissions Trading Programs and Other Binding Limits

Project proponent of the project activity that reduce GHG emission from implementing the new HPPO technology is not part of any emission trading program nor part of jurisdiction or sector in which binding limits are established on GHG emissions. Thus, the GHG emission reductions generated by the project will not be used for compliance with an emissions trading program or to meet binding limits on GHG emissions.

1.12.3 Other Forms of Environmental Credit

The project proponent intends to claim credits only for the period after the commissioning of the project activity and its subsequent generation. The VCS crediting period starts from 04 October 2011 up to 03 October 2021, during this period any other form of environmental credit has not been claimed by the project proponent.

1.12.4 Participation under Other GHG Programs

The project activity has not been registered nor sought registration under any other GHG programs as this project activity is using the new proposed methodology.

1.12.5 Projects Rejected by Other GHG Programs

The project activity has not been rejected under any other GHG programs as this project activity is using the new proposed methodology.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

The project eligibility criteria are not applicable as the project activity is not a grouped project.

Leakage Management

As per new proposed methodology, no leakage will be occurred from the project activity.

Commercially Sensitive Information

No commercially sensitive information has been excluded from the public version of the project description.

Further Information

Not applicable as relevant legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and/or temporal information have been defined in other relevant sections.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

Title of methodology - VM0023: Reduction of GHG Emissions in Propylene Oxide Production

Version: 01

Tools applied

Tool for the demonstration and assessment of additionality, Version 7.0;

Tool to calculate the emission factor for an electricity system, Version 4.0;

“Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”, Version 2.

2.2 Applicability of Methodology

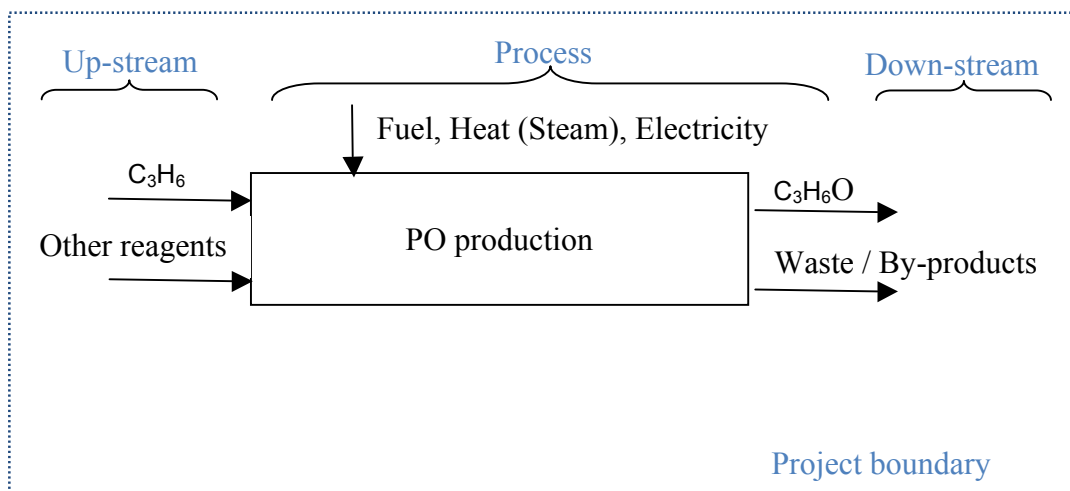
The methodology chosen is applicable to the proposed project due to the following reasons:

Table 1 Applicability conditions of the project activity

No.	Applicability conditions	Justification
1.	The methodology is limited to greenfield projects (i.e., new PO production facilities) wherein PO is the only output.	The project activity is a Greenfield facility and produces PO as its only output.
2.	The PO production process must not produce any co-products. There may be by-products produced in the PO production process, due to the selectivity of catalysts.	The project activity produces no co-products but there are some by-products emitted.
3.	The PO production process must not create more than 10% (in mass terms) by-product, relative to PO output.	The project activity produces no significant by-products
4.	The methodology is applicable only to projects where the project activity is the implementation of the HPPO process and where implementation of the CHPO-chlor-alkali process is identified as the baseline scenario.	The project activity employs the HPPO technology and it is identified that the baseline scenario of this project activity is Chlorohydrin-Chlor-Alkali process.
5.	The project may be located in any geographic region of the world.	The project activity takes place in a production facility owned by MTP HPPO Manufacturing Co., Ltd., which is located in Thailand.
6.	The applicability conditions of the tools referenced in this methodology also apply.	The applicability conditions of the applied tools are met.

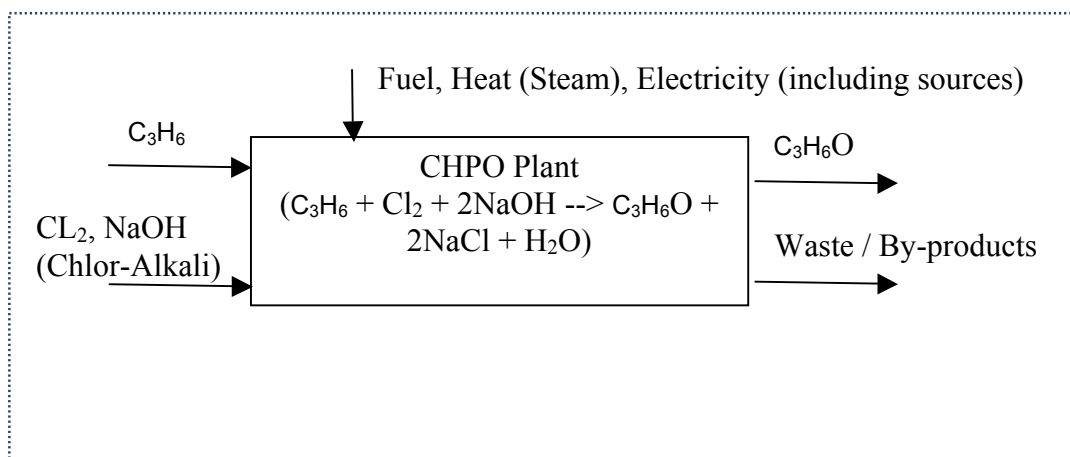
2.3 Project Boundary

The spatial extent of the project boundary encompasses PO manufacturing plant from reagents admission to the treatment of by-products and waste from process.

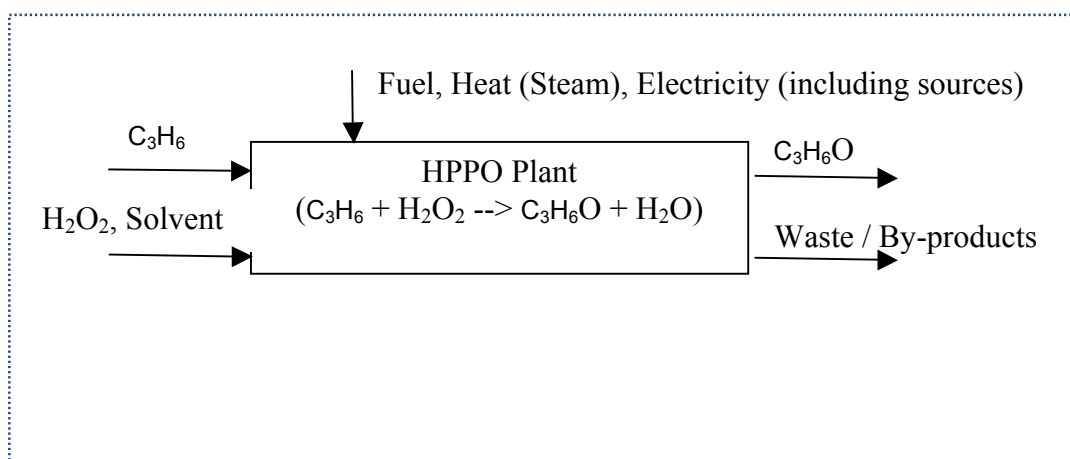


The project boundary encompasses also the project electricity system(s) and Heat/steam generation system that the PO plant is connected to. The spatial extent of the project electricity system consists of the power plants that are physically connected through transmission and distribution lines to the project activity and that can be dispatched without significant transmission constraints. The project is connected to the Glow grid which in turn is connected to the national grid. Therefore, the national grid is considered as the ultimate connected grid. The spatial extent for the heat (steam) system is similar, including the heat/steam generating systems that are physically connected to the project activity and that can be displaced without significant constraints. The heat (steam) requirements of the project are met by the steam extracted from the cogeneration plants of Glow grid. As the emissions get accounted in the electricity component therefore to avoid double counting and applying conservative principle the emission factor for steam has been considered as zero. The fuel requirement is for incineration purpose. Natural gas is being used as the fuel.

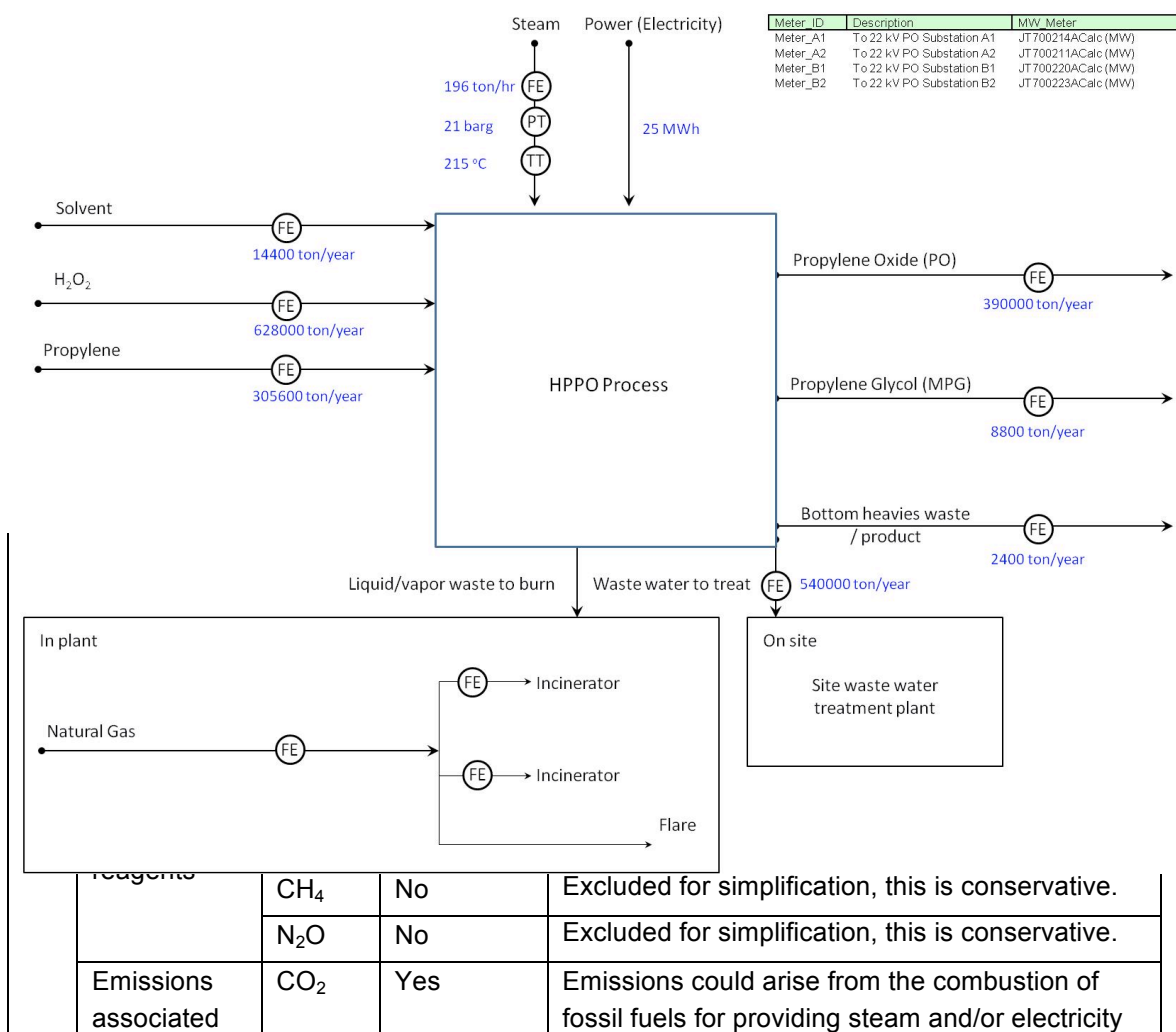
For the CHPO-chlor-alkali process (baseline scenario), the spatial extent of the project boundary is defined as follows:



For the HPPO process (proposed project activity) the geographic project boundary encompasses:



The block flow diagram clearly depicting the reagents, waste streams along with mass and energy balance is as follows:



Source		Gas	Included?	Justification/Explanation
	with steam and electricity requirements of the production process			to the PO production facility
		CH ₄	No	Excluded for simplification, this is conservative.
		N ₂ O	No	Excluded for simplification, this is conservative.
	Emissions associated with treatment of waste produced by the production process	CO ₂	No	Emissions could arise from the incineration of waste. This source has been excluded for conservativeness and simplification.
		CH ₄	No	Excluded for simplification, this is conservative.
		N ₂ O	No	Excluded for simplification, this is conservative.
Project	Emissions associated with the production of project reagents	CO ₂	Yes	The emissions associated with H ₂ O ₂ production and solvent (make-up) have been accounted for as these reagents are generally not found naturally and are produced in an industrial facility. The emissions associated with C ₃ H ₆ have, however, not been accounted for as its usage would be essentially the same as in the baseline activity.
		CH ₄	No	Excluded for simplification, this is conservative.
		N ₂ O	No	Excluded for simplification, this is conservative.
	Emissions associated with steam and electricity requirements of the process	CO ₂	Yes	Emissions could arise from the combustion of fossil fuels for providing steam and/or electricity to the PO production facility
		CH ₄	No	Excluded for simplification, this is conservative.
		N ₂ O	No	Excluded for simplification, this is conservative.
	Emissions associated with treatment of waste produced by the	CO ₂	Yes	Emissions could arise from the incineration of waste (e.g., low boils, waste gas, etc.). For simplification this source has been excluded as the waste generation is lesser in quantity and carbon intensity as compared to baseline. Also assuming that the fossil fuel consumed in the incinerator is the same as in the baseline.

Source		Gas	Included?	Justification/Explanation
	production process	CH ₄	No	Excluded for simplification, this is conservative.
		N ₂ O	No	Excluded for simplification, this is conservative.

2.4 Baseline Scenario

In the absence of the project, there are several realistic and credible baseline scenario of PO production technology that could be identified as following steps referred to the methodology:

Step 1: Identification of plausible alternative scenarios

The plausible alternative scenarios to the project activity are as follows:

P1: The project activity without carbon revenues;

P2: A PO production facility with comparable capacity using a CHPO process (CHPO-lime or CHPO-chlor-alkali processes);

P3: A PO production facility with comparable capacity using any other commercially available technology.

As the project activity produces PO as its only output therefore other processes wherein co-products are getting produced for e.g., CHP, POSM, POTBA are not considered as likely alternatives. Further the CHPO-lime option has been not considered owing to conservative reasons. The lime process has higher cost of production as can be seen from the Nexant report, section 2.3, table 4.4 and table 4.5. So only Chlorohydrin-Chloro-Alkali is being considered as a likely alternative. Furthermore, currently there is no other commercially available technology so option P3 is eliminated.

Therefore the likely realistic and credible alternatives to the project activity are:

P1: The project activity; and

P2: A plant with the same capacity using the Chlorohydrin process (Chloro-Alkali).

Step 2: Consistency with mandatory applicable laws and regulations:

There is no restriction to either of the alternatives. As a consequence the two shortlisted alternatives and therefore are inclusive and being analysed in the barrier analysis.

Step 3: Barrier analysis

Please refer the following section

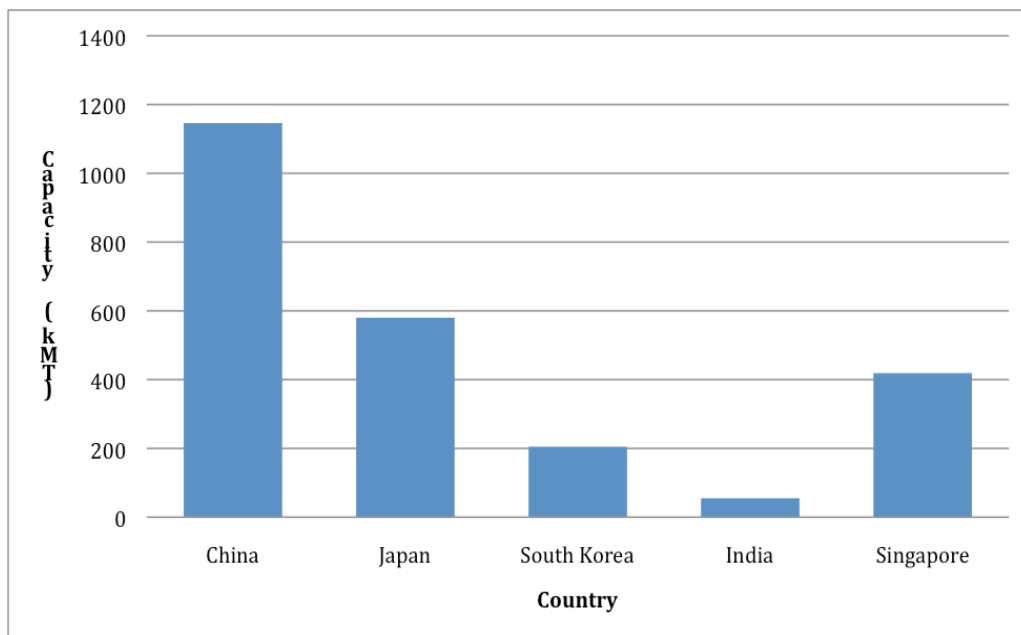
2.5 Additionality

The following steps are used to demonstrate the additionality of the project according to the "Tool for the demonstration and assessment of additionality", Version 7.0.

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

The project activity is first-of-its-kind and involves feedstock as well as technology switch. The *Guidelines on additionality of first-of-its-kind project activities, Version 02.0* has been followed, to demonstrate that the project is a 'first-of-its-kind'.

Applicable geographical area: The project is implemented in Thailand. As prior to the project activity there has been no PO production in Thailand, therefore a larger area comprising of the Asia Pacific region has been considered as the applicable geographical area. Within the Asia Pacific region, Japan, Singapore and China are main producers of PO, together representing over 85% of total capacity. The remaining portions of the total capacity are produced by PO plants in South Korea and India. The POSM and chlorohydrin processes dominate the PO production within Asia Pacific with the POSM route contributing about half of the regions total capacity. As POSM also results in co-products therefore it is not considered as an alternative.

Asia Pacific Propylene Oxide Capacity, by country, 2007

The project is first of its kind in the region as is evident from the table on Asia Pacific PO capacity indicated in the Nexant report on Propylene Oxide¹. The prevalence of Chlorohydrin process is also on account for it requiring the lowest capital among the various other technologies².

The crediting period is therefore restricted to fixed 10 years.

¹ Table 5.5, Asia Pacific Propylene Oxide Capacity, 2007, pp 96, Chemsystems PERP Program Report Propylene Oxide 07/08-6, November 2008, Nexant

² Comparison of PO technologies, pp 25, PEP Review 2009-4, Propylene Oxide by the BASF-DOW HPPO Process, December 2009, SRI Consulting

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations**Sub-step 1a. Define alternatives to the project activity:**

Please refer previous section 2.4, step 1.

Sub-step 1b. Enforcement of applicable laws and regulations:

Please refer previous section 2.4, step 2.

Step 2. Investment Analysis

Investment analysis was not performed for this project activity.

Step 3. Barrier Analysis

Although the project has been proven as first-of-its-kind, nevertheless the following barrier was also considered:

1) Technological barriers;

- "The particular technology used in the proposed project activity is not available in the relevant region".

The Chlorohydrin process is the most conventional technology for PO production and has been employed since around 1910³. Over the years, continuous improvements have been made to the Chlorohydrin process but the formulate principles have always been the same: the process starts with production of propylene chlorohydrin and ends with product purification. The technology continues to be the most predominant technology for PO market, with Dow being the main PO producer employing this process. Taking this into account, an analysis on the existence of this technological barrier is done based on the market penetration of different PO production technologies within the following 3 different regions as follows: (1) geographic locations of Dow's PO plants around the globe, (2) in the Host country (Thailand), and (3) World PO market as a whole.

(1) Dow is a major player in the PO market (holding over 25% of total market share). The company has in total 5 PO plants around the globe, with total nameplate capacity of 2,045 kilotons per annum of PO. Chlorohydrin process represents the status quo system that is most widely practiced process to produce PO, with 4 out of 5 existing Dow plants (with a totalling capacity of 1,895 kT) producing PO with chlorohydrin technology. Relative to total production capacity, the Chlorohydrin technology is the dominating production process in Dow, holding a share of an approximate 93%. Only in 2001 that Dow has initiated a laboratory study on HPPO technology when it acquired its hydrogen peroxide technology through the purchase of EniChem's polyurethane business. The development of such technology on a commercial basis began in 2003 when Dow and BASF began their joint research program. The collaboration

³ Shao-Hwa Wang, 2003, *Propylene Oxide*, SRI Consulting, report no. 2H., page 2-8

allowed the companies to start examining each other's processes and in 2008, together they have announced the start-up of their first HPPO plant in Antwerp, Belgium. Dow's ownership of 150 kTpa capacity of this HPPO plant constitutes 7% technological share of its total production capacity.

List of PO plants owned by Dow

Location	Capacity (kT/year)	Technology
Freeport (USA)	725	CHPO
Stade (Germany)	590	CHPO
Plaquemine (USA)	330	CHPO
Aratu (Brazil)	250	CHPO
Antwerp (Belgium)	150 ⁴	HPPO
Total	2,045	

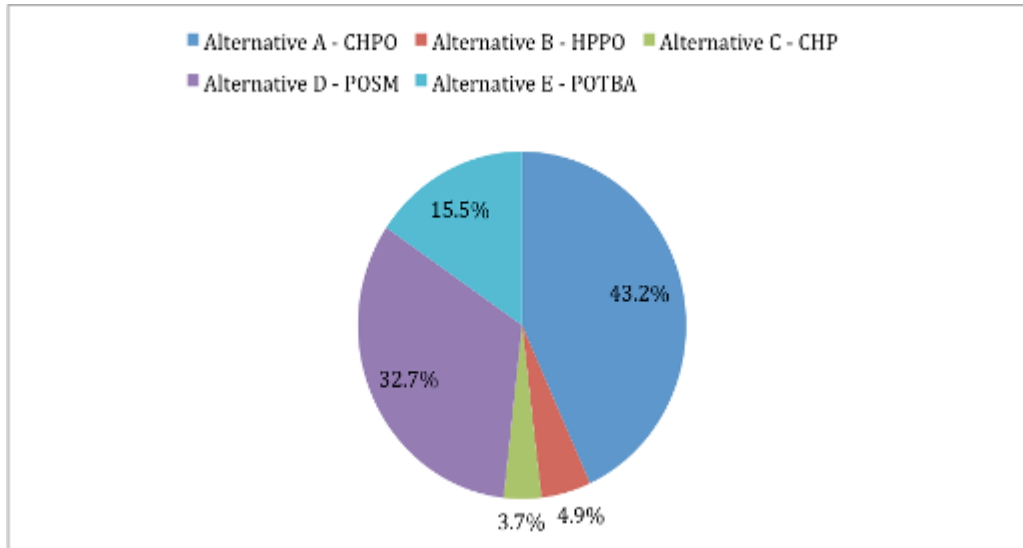
(2) Within the Asia Pacific region, Japan, Singapore and China are main producers of PO, together representing over 85% of total capacity and none of them are through HPPO route. The remaining portions of the total capacity are produced by PO plants in South Korea and India. Currently, PO is not produced in Thailand. PO is imported and consumed in Thailand for the production of Polyols.

(3) The same conclusion can be reached even when the 'World' is considered as a region for analysis. Even with more than one supplier of the technology⁵, the popularisation of HPPO technology is still at an initial stage. Figure below reveals that in 2008, the capacity share of the HPPO technology is still only at 4.9% of the World's PO production capacity.

World Propylene Oxide Capacity Share by Technology, 2008

⁴ The plant has a total capacity of 300 kT per annum but 50% of its production is owned by BASF, hence only 150 can only be attributed to Dow

⁵ Evonik Degussa, a subsidiary of Evonik Industries AG (Degussa) together with Uhde GmbH, have also developed a HPPO process (similar to one developed by TDCC and BASF); referred to as the Degussa-Uhde HPPO process.



Based on analyses provided above, it can be concluded that being among the first few plants to conceptualise the HPPO technology for PO production in the World (as well as the first in Thailand), the project proponent was taking a significant risk in the investment of the project activity. Thus, with reference to the “Guidelines for Objective Demonstration and Assessment of Barriers”, version 1, the HPPO technology can be seen as being marginal as it represents less than 10%⁶ in the PO industry. Such barrier is not applicable for CHPO process, where its 43.2% share of the World’s PO production capacity represents a majority and is an indication that the Chlorohydrin process is the prevailing practice in the PO industry.

Owing to the above stated barriers the conventional CHPO technology would be the likely alternative and thus only realistic and credible baseline scenario to the proposed project activity.

The registration of the VCS project activity will alleviate the barriers that prevent the proposed project activity from occurring in the absence of the VCS: it will provide additional revenues for the project, which are needed to mitigate the additional risks raised by the identified barriers. In other words, VCS revenues provide an incentive to develop this new and un-experienced technology in Asia and more particularly in Thailand.

Step 4. Common Practice Analysis

Taking into account the market penetration rate of HPPO technology in 3 different scales of region (World, Asia Pacific and Thailand), the Project can be considered as the ‘first of its kind’. It is therefore not necessary to conduct a common practice analysis. In conclusion, the proposed project activity is additional

It is thus concluded that the realistic baseline scenario will be a plant with the same capacity using the CHPO-Chloro-Alkali process.

⁶ EB 50 report, Annex 13, Guidelines for objective demonstration and assessment of barriers, Version 01, page 2. An example stated in paragraph 6 (guideline 3) in the Guidelines: “*The existence of a technological barrier for high pressure steam technology is confirmed by showing evidence that the use of this technology in the considered sector is marginal e.g. below 10%*”

2.6 Methodology Deviations

Not applicable as there are no methodology deviations.

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

Baseline emissions for the chosen baseline scenario are calculated as follows:

$$BE_y = BE_{Upstream,y} + BE_{Process,y} \quad (1)$$

Where:

BE_y Baseline emission in year y (tCO₂)

$BE_{Upstream,y}$ Emissions associated with the baseline reagents required for the production of PO in year y (tCO₂)

$BE_{Process,y}$ Emissions due to energy usage (heat and electricity) for transforming the baseline reagents into the final product (PO) and also for waste and by-product treatment in year y (tCO₂)

Up-stream emissions ($BE_{Upstream,y}$):

The up-stream emissions are on account of the various reagents used in the process. The reagents used in the baseline (CHPO-Chlor-Alkali process) are C₃H₆, Cl₂ and NaOH. The emissions associated with C₃H₆ has however not been accounted as its usage would be essentially the same as in the project activity. The emissions associated with Chlor-Alkali production have been accounted as these are generally not found naturally and are to be produced in an industrial facility.

The emissions associated with Chlor-Alkali production are calculated as follows:

$$BE_{Upstream,y} = be_{Chlor-Alkali,y} \times PO_y \quad (2)$$

Where:

$be_{Chlor-Alkali,y}$ Quantity of CO₂ that would be emitted from Chlor-Alkali production per unit of PO in year y (tonnes)

PO_y Quantity of PO produced in year y (tonnes)

The Chlor-Alkali process involves the electrolysis of aqueous sodium chloride (brine) in a membrane cell. The CO₂ emissions associated with Chlor-Alkali production are calculated as follows:

$$be_{Chlor-Alkali,y} = \left(\frac{71}{58} \right) \times ec_{Chlor-Alkali,y} \times EF_{EL,y} \quad (3)$$

Where:

$ec_{Chlor-Alkali, y}$	Energy consumption per ton of Cl_2 production in year y (MWh/t Cl_2)
$EF_{EL, y}$	Emission factor for electricity generation in year y (tCO ₂ /MWh)
71/58	Ratio between the molecular weights of Cl_2 and C_3H_6O (mass units/mass units)

Process emissions ($BE_{Process, y}$):

The process emissions would arise due to energy usage (heat, electricity etc.) for transforming the reagents into the final product and also from waste treatment.

The emissions associated with energy usage will be calculated as follows:

$$BE_{Process, y} = BE_{Heat, y} + BE_{Elec, y} + BE_{Waste, y} \quad (4)$$

Where:

$BE_{Heat, y}$	Emissions due to thermal energy (heat/steam) for transforming the baseline reagents into the final product (PO) and also for waste treatment in year y (tCO ₂)
$BE_{Elec, y}$	Emissions due to electrical energy for transforming the baseline reagents into the final product (PO) and also for waste treatment in year y (tCO ₂)
$BE_{Waste, y}$	Emissions due to treatment of waste products in year y (tCO ₂)

The CO₂ emissions from thermal energy (heat/steam) will be calculated as follows:

$$BE_{Heat, y} = SSC_{CHPO} \times PO_y \times EF_{Steam, y} \quad (5)$$

Where:

SSC_{CHPO}	Specific thermal energy consumption ratio in the PO production through CHPO process (TJ/ton of PO).
$EF_{Steam, y}$	Emission factor for thermal energy generation in year y (tCO ₂ /TJ)

The emission factor for thermal energy generation would be calculated as follows:

$$EF_{Steam, y} = EF_{CO_2, i, y} / \eta_{Boiler, y} \quad (6)$$

Where:

$EF_{CO_2, i, y}$	Weighted average CO ₂ emission factor of fuel type i in year y (tCO ₂ /TJ).
$\eta_{Boiler, y}$	Efficiency of the steam generating system

The CO₂ emissions from electrical energy will be calculated as follows:

$$BE_{Elec, y} = SEC_{CHPO} \times PO_y \times EF_{EL, y} \quad (7)$$

Where:

SEC_{CHPO} Specific electrical energy consumption ratio in the PO production through CHPO process (MWh/tonne of PO).

$EF_{El,y}$ Emission factor for electricity generation in year y (tCO₂/MWh)

The specific energy consumption ratios (thermal/electrical) will be sourced from independent third party reports.

The CO₂ emissions from waste treatment will be calculated as follows:

$$BE_{Waste,y} = \left(\frac{44}{12} \right) \times (CA_{Waste,Baseline}) + FC_{i,Baseline} \times COEF_i \quad (8)$$

Where:

$CA_{Waste,Baseline}$ Carbon amount in the waste stream derived from the carbon amount in the Propylene feed, PO and by-products in the baseline (tonnes).

$44/12$ Ratio between the molecular weights of CO₂ and Carbon (mass units/mass units)

$FC_{i,Baseline}$ Quantity of fuel type i combusted in the incinerator in the baseline (mass or volume unit/year)

$COEF_i$ CO₂ emission coefficient of fuel type i (tCO₂/mass or volume unit)

The “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” should be referred to calculate the CO₂ emission coefficient.

The carbon amount in the waste stream and fuel combusted in the incinerator could be presented in terms of PO output.

For simplification and as a conservative approach, the emissions linked to waste and by-products will be neglected.

3.2 Project Emissions

Project emissions are calculated as follows:

$$PE_y = PE_{Upstream,y} + PE_{Process,y} \quad (9)$$

Where:

PE_y Project emissions in the year y, (tCO₂)

$PE_{Upstream,y}$ Emissions associated with the project reagents for the production of PO in year y (tCO₂)

$PE_{Process,y}$ Emissions due to energy usage (heat, electricity etc.) for transforming the project reagents into the final product (PO) and also for waste treatment in

year y (tCO₂)

Up-stream emissions ($PE_{Upstream,y}$):

The upstream emissions are based on the various reagents used in the PO production process. The reagents used in the project scenario (HPPO process) are C₃H₆ and H₂O₂. However, the emissions associated with C₃H₆ are not accounted for as its usage would be essentially the same as in the baseline activity. The emissions associated with H₂O₂ production have been included as this compound is generally not found naturally and is produced in an industrial facility. Further, since the reaction is carried out in solvents⁷, the emissions associated with the make-up solvent are considered as well.

The upstream emissions are calculated as follows:

$$PE_{Upstream,y} = PE_{Upstream,H_2O_2,y} + PE_{Upstream,Solvent,y} \quad (10)$$

The emissions associated with H₂O₂ production are calculated as follows:

$$PE_{Upstream,H_2O_2,y} = \left(\frac{34}{58} \right) \times pe_{HP} \times PO_y \quad (11)$$

Where:

pe_{HP}	Quantity of CO ₂ that would be emitted per tonne of H ₂ O ₂ (tCO ₂ /tH ₂ O ₂)
PO_y	Quantity of PO produced in year y (tonnes)
34/58	Ratio between the molecular weights of H ₂ O ₂ and C ₃ H ₆ O (mass units/mass units)

The emissions associated with make-up solvent are calculated as follows:

$$PE_{Upstream,Solvent,y} = pe_{Sol} \times sol_y \times PO_y \quad (12)$$

Where:

pe_{Sol}	Quantity of CO ₂ that is emitted per tonne of solvent (tCO ₂ /tonne of solvent)
sol_y	Quantity of solvent required per tonne of PO in year y (tonnes)
PO_y	Quantity of PO produced in year y (tonnes)

⁷ Typically solvents of polar nature are used, such as alcohols, ketones, ethers, etc.

Note that sol_y , as found in equation 12 above, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, " $sol_y \times PO_y$ " is represented by Sol_y in equation 12 above, the value of which is monitored.

Process emissions ($PE_{Process,y}$):

The process emissions arise from the energy usage (eg, heat and electricity) required for transforming the reagents into the final product, and for by-product and waste treatment.

The process emissions are calculated as follows:

$$PE_{Process,y} = PE_{Heat,y} + PE_{Elec,y} + PE_{Waste,y} \quad (13)$$

Where:

$PE_{Heat,y}$ Emissions due to thermal energy (heat/steam) for transforming the project reagents into the final product in year y (tCO₂)

$PE_{Elec,y}$ Emissions due to electrical energy for transforming the project reagents into the final product in year y (tCO₂)

$PE_{Waste,y}$ Emissions due to treatment of waste products in year y (tCO₂)

The CO₂ emissions from thermal energy (heat/steam) are calculated as follows:

$$PE_{Heat,y} = SSC_{HPPO,y} \times PO_y \times EF_{Steam,y} \quad (14)$$

Where:

$SSC_{HPPO,y}$ Specific thermal energy consumption ratio in PO production through the HPPO process in year y (TJ/tonne of PO)

$EF_{Steam,y}$ Emission factor for thermal energy generation in year y (tCO₂/TJ)

Note that $SSC_{HPPO,y}$, as found in equation 14 above, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, " $SSC_{HPPO,y} \times PO_y$ " is represented by SC_{HPPO} in equation 14 above, the value of which is monitored.

The emission factor for thermal energy generation is the same as calculated for the baseline emissions.

The CO₂ emissions from electrical energy are calculated as follows:

$$PE_{El,y} = SEC_{HPPO,y} \times PO_y \times EF_{El,y} \quad (15)$$

Where:

$SEC_{HPPO,y}$ Specific electrical energy consumption ratio in PO production through the HPPO process in year y (MWh/tonne of PO)

$EF_{El,y}$ Emission factor for electricity generation in year y (tCO₂/MWh)

Note that SEC_{HPPO} , as found in equation 15 above, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, “ $SEC_{HPPO} \times PO_y$ ” is represented by EC_{HPPO} in equation 15 above, the value of which is monitored.

The emission factor for electricity generation is the same as calculated for the baseline emissions.

The CO₂ emissions from waste treatment are calculated as follows:

$$PE_{Waste,y} = \left(\frac{44}{12} \right) \times (CA_{Waste,y}) + FC_{i,y} \times COEF_{i,y} \quad (16)$$

Where:

$CA_{Waste,y}$ Carbon amount in the waste stream derived from the carbon amount in the propylene feed, solvent, PO and by-products in year y (tonnes)

$44/12$ Ratio between the molecular weights of CO₂ and carbon (mass units/mass units)

$FC_{i,y}$ Quantity of fuel type i combusted in the incinerator in year y (mass or volume unit/year)

$COEF_{i,y}$ CO₂ emission coefficient of fuel type i in year y (tCO₂/mass or volume unit)

The CDM Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion must be used to calculate the CO₂ emission coefficient.

The carbon amount in the waste stream must be calculated as follows:

$$CA_{Waste,y} = CA_{Propylene,y} + CA_{Solvent,y} - (CA_{PO,y} + CA_{Byproducts,y}) \quad (17)$$

Where:

$CA_{Propylene,y}$ Carbon amount in the propylene feed in year y (tonnes)

$CA_{Solvent, y}$ Carbon amount in the solvent used in year y (tonnes)

$CA_{PO, y}$ Carbon amount in PO produced in year y (tonnes)

$CA_{Byproducts, y}$ Carbon amount in the by-products in year y (tonnes)

The total amount of carbon in a particular product is a function of the respective carbon fraction and the quantity of the product, expressed as follows:

$$CA_{x,y} = ca_{x,y} \times Q_{x,y} \quad (18)$$

Where:

$CA_{x, y}$ Carbon amount in the product x in year y (tonnes)

$ca_{x, y}$ Carbon fraction in the product x in year y (mass units/mass units)

$Q_{x, y}$ Quantity of the product x in year y (tonnes)

x propylene, solvent, PO, by-product, waste

3.3 Leakage

No leakage emissions are considered. The main emissions potentially giving rise to leakage in the context of the project are emissions arising due to construction of the PO production facility and transportation of reagents. These emissions sources are excluded as these would be higher in the baseline scenario as compared to project scenario.

3.4 Net GHG Emission Reductions and Removals

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (17)$$

Where:

ER_y Emission reductions in year y (tCO₂e/yr)

BE_y Baseline emissions in year y (tCO₂/yr)

PE_y Project emissions in year y (tCO₂e/yr)

LE_y Leakage emissions in year y (tCO₂e/yr)

Estimation of baseline, project, and leakage emissions including net emissions reductions from the proposed project activity is shown in Table 2.

Table 2 Estimated emission reductions

Years	Estimated baseline emissions or removals	Estimated project emissions or removals	Estimated leakage emissions	Estimated net GHG emission reductions or removals

	(tCO ₂ e)	(tCO ₂ e)	(tCO ₂ e)	(tCO ₂ e)
2011 (Oct - Dec)	135,812	77,448	0	58,363
2012	556,982	317,625	0	239,356
2013	556,982	317,625	0	239,356
2014	556,982	317,625	0	239,356
2015	556,982	317,625	0	239,356
2016	556,982	317,625	0	239,356
2017	556,982	317,625	0	239,356
2018	556,982	317,625	0	239,356
2019	556,982	317,625	0	239,356
2020	556,982	317,625	0	239,356
2021 (Jan - Oct)	421,170	240,177	0	180,993
Total	5,569,823	3,176,254	0	2,393,569

4 MONITORING

4.1 Data and Parameters Available at Validation

Following are data and parameters available at validation:

Data / Parameter	$eC_{Chlor-Alkali, y}$
Data unit	MWh/tCl ₂
Description	Energy consumption per tonne of Cl ₂ production in year y.
Source of data	Independent third party report from a recognized, credible source which must be reviewed by an appropriately qualified, independent organization or appropriate peer review group, or be published by a government agency.
Value applied	2.2
Justification of choice of data or description of measurement methods and procedures applied	The membrane cell process is the preferred process for new PO production facilities. Thus, it is assumed that production of chlor-alkali in the baseline PO production facility is through the membrane cell process ⁸ .
Purpose of Data	Calculation of baseline emissions
Comments	-

⁸ <http://www.miga.org/documents/ChlorAlkali.pdf>

Data / Parameter	SSC_{CHPO}
Data unit	TJ/ton of PO
Description	Specific thermal energy consumption ratio in PO production through the CHPO-chlor-alkali process.
Source of data	Independent third party report
Value applied	0.003864
Justification of choice of data or description of measurement methods and procedures applied	Steam consumption is converted conservatively into energy terms using enthalpy values and accounting for any condensate return
Purpose of Data	Calculation of baseline emissions
Comments	Nexant report on HPPO, Table 4.3 and 4.5 This parameter is not considered in both baseline scenario and is conservative since baseline thermal energy consumption is higher as compared to project.

Data / Parameter	SEC_{CHPO}
Data unit	MWh/ton of PO
Description	Specific electrical energy consumption ratio in PO production through the CHPO-chlor-alkali process.
Source of data	Independent third party report
Value applied	0.100
Justification of choice of data or description of measurement methods and procedures applied	Electrical energy required per ton of the PO in the CHPO process excluding the chlor-alkali production
Purpose of Data	Calculation of baseline emissions
Comments	Nexant report on HPPO, Table 4.5

Data / Parameter	pe_{HP}
Data unit	tCO ₂ / tH ₂ O ₂
Description	Quantity of CO ₂ that would be emitted per ton of H ₂ O ₂
Source of data	Independent third party report
Value applied	0.533
Justification of choice of data or description of measurement methods and procedures applied	Amount of CO ₂ expected to be released per ton of the H ₂ O ₂ production based on Life Cycle Assessment (LCA) study

Purpose of Data	Calculation of baseline emissions
Comments	Sourced from certified environmental product declaration (EPD) for hydrogen peroxide

Data / Parameter	pe_{Sol}
Data unit	tCO ₂ /tonne of solvent
Description	Quantity of CO ₂ emitted per tonne of solvent
Source of data	Table 3.12, Chapter 3: Chemical Industry Emissions, IPCC 2006 report
Value applied	0.310
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$ca_{Waste, Baseline}$
Data unit	tC/ ton of PO
Description	Carbon amount in the waste stream combusted in the incinerator in the baseline per ton of PO
Source of data	-
Value applied	-
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	Excluded for simplification

Data / Parameter	$fc_{i,baseline}$
Data unit	Ratio
Description	Quantity of fossil fuel combusted in the incinerator in the baseline per ton of PO production
Source of data	-
Value applied	-
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions

Comments	Excluded for simplification
Data / Parameter	$EF_{EL,y}$
Data unit	tCO ₂ /MWh
Description	Emission factor for electricity generation in year y
Source of data	Electricity Generating Authority of Thailand (EGAT)
Value applied	0.5113
Justification of choice of data or description of measurement methods and procedures applied	The emission factor is calculated according to the latest 'Tool to calculate the emission factor for an electricity system' Version 4.0 provided by Thailand Greenhouse Gas Management Organization (Public Organization): TGO.
Purpose of Data	Calculation of baseline and project emissions
Comments	Although the emission factor provided by the Thai DNA refers to version 2.2.1 of the tool. However the changes from version 2.2.1 to version 4.0 of the tool do not impact the computation in the context of Thailand.

4.2 Data and Parameters Monitored

Following are data and parameters monitored during the monitoring period:

Data / Parameter	PO_y
Data unit	tonnes
Description	Quantity of PO produced in year y
Source of data	Plant records
Description of measurement methods and procedures to be applied	Flow-rate meters and cross-check with stock verification records.
Frequency of monitoring/recording	Continuous monitoring, integrated daily and at least monthly recordings
Value applied	390,000
Monitoring equipment	Vortex meter
QA/QC procedures to be applied	Accuracy: +/- 0.15% of reading. Meters should be calibrated regularly according to manufacturer's guidelines. Cross-checking with production stock inventory.
Purpose of data	Calculation of baseline and project emissions
Calculation method	Not applicable
Comments	Meter series: FT431118

Data / Parameter	Sol_y
Data unit	Tonnes
Description	Quantity of make-up solvent used in year y.
Source of data	PO production facility records.
Description of measurement methods and procedures to be applied	Flow-rate meters, mass meters, cross-check with stock verification records.
Frequency of monitoring/recording	Data monitoring is continuous and aggregate recording must be performed at least monthly.
Value applied	14400
Monitoring equipment	Vortex meter
QA/QC procedures to be applied	Accuracy: +/- 0.15% of reading. Meters must be calibrated regularly according to manufacturer's guidelines or national standards, and cross-checked with stock inventory.
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	Note that sol_y , as found in equation 12, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, " $sol_y \times PO_y$ " is represented by Sol_y in equation 12, the value of which is monitored in accordance with the procedures described above.

Data / Parameter	$EF_{CO_2, i, y}$		
Data unit	tCO ₂ /TJ		
Description	Weighted average CO ₂ emission factor of fossil fuel used during year y		
Source of data	IPCC default value		
Description of measurement methods and procedures to be applied	Onsite observation		
Frequency of monitoring/recording	Annually		
Value applied	Type	tCO ₂ /TJ	
	Natural gas	56.1	
Monitoring equipment	-		
QA/QC procedures to be applied	-		
Purpose of data	Calculation of baseline and project emissions		
Calculation method	-		

Comments	International publicly available data
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Data / Parameter	$\eta_{Boiler,y}$
Data unit	%
Description	Efficiency of the steam generating system
Source of data	-
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	-
Value applied	-
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline and project emissions
Calculation method	-
Comments	This parameter is not considered in both baseline and project scenario and is conservative since baseline energy consumption is higher as compared to project. Source: Nexant report on HPPO, Table 4.3 & 4.5

Data / Parameter	$SC_{HPPO,y}$
Data unit	TJ
Description	Thermal energy consumption in the PO production through HPPO process in year y
Source of data	Plant records
Description of measurement methods and procedures to be applied	Steam consumption would be converted conservatively into energy terms using enthalpy values and accounting for any condensate return.
Frequency of monitoring/recording	Calculated
Value applied	1,460.106
Monitoring equipment	Data shall be taken from the meters calibrated regularly according to manufacturer's guidelines.
QA/QC procedures to be applied	Cross-checking with thermal energy purchase receipt from the thermal supplier
Purpose of data	Calculation of project emissions
Calculation method	The respective enthalpies should be determined based on the mass (or volume) flows, the temperatures and, in case of superheated steam, the pressure. Steam tables or appropriate

	thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure.
Comments	This parameter is not considered in both baseline and project scenario and is conservative since baseline thermal energy consumption is higher as compared to project. Source: Nexant report on HPPO, Table 4.3 & 4.5

Data / Parameter	$EC_{HPPO, y}$
Data unit	MWh
Description	Electrical energy consumption in the PO production through HPPO process in year y
Source of data	Plant records
Description of measurement methods and procedures to be applied	Electrical consumption to be monitored continuously and the average specific electrical energy consumption to be calculated based on PO production
Frequency of monitoring/recording	Continuous monitoring, integrated daily and at least monthly recordings
Value applied	200000
Monitoring equipment	Electricity meters
QA/QC procedures to be applied	Meters should be calibrated regularly according to manufacturer's guidelines.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	Meter series: X14000334N, X14000335N, X14000336N, X14000337N

Data / Parameter	$Q_{Propylene, y}$
Data unit	Tonnes
Description	Quantity of propylene used in year y.
Source of data	PO production facility records
Description of measurement methods and procedures to be applied	Flow-rate meters, mass meters, cross-check with stock verification records.
Frequency of monitoring/recording	Data monitoring is continuous and aggregate recording must be performed at least monthly
Value applied	305600
Monitoring equipment	Mass flow meters

QA/QC procedures to be applied	Accuracy: +/- 0.15% of reading. Meters must be calibrated regularly according to manufacturer's guidelines or national standards, and cross-checked with stock inventory
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$Q_{By-product,y}$
Data unit	Tonnes
Description	Quantity of by-product produced in year y.
Source of data	PO production facility records
Description of measurement methods and procedures to be applied	Flow-rate meters, mass meters, cross-check with stock verification records.
Frequency of monitoring/recording	Data monitoring is continuous and aggregate recording must be performed at least monthly
Value applied	8800
Monitoring equipment	Vortex flow meter
QA/QC procedures to be applied	Accuracy: +/- 0.5% of reading. Meters must be calibrated regularly according to manufacturer's guidelines or national standards, and cross-checked with stock inventory.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$FC_{i,y}$
Data unit	Mass or volume units
Description	Quantity of NG combusted in the incinerator during the year y
Source of data	NG supplied by PTT
Description of measurement methods and procedures to be applied	Measured through turbine meter
Frequency of monitoring/recording	-
Value applied	4800000 Nm ³
Monitoring equipment	Turbine meter
QA/QC procedures to be applied	Accuracy: +/- 1% of reading. The meter belongs to PTT and installed on PTT skid
Purpose of data	Calculation of project emissions

Calculation method	-
Comments	-

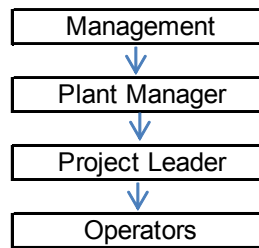
Data / Parameter	$COEF_{i,y}$
Data unit	tCO ₂ /t of Natural gas
Description	CO ₂ emission coefficient of Natural gas
Source of data	IPCC
Description of measurement methods and procedures to be applied	Publicly available national data
Frequency of monitoring/recording	As per the "Tool to calculate project or leakage CO ₂ emissions from fossil fuel combustion", Version 2
Value applied	2.6928
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	Based on option B, equation 4 of the tool. NCV = 48.0 TJ/Gg (IPCC 2006, Energy volume: Overview, Table 1.2) EF = 56.1 Tons/TJ (IPCC 2006, Energy volume: Overview, Table 1.4)
Comments	Conversion of volume units to energy units: 1 Nm ³ = 0.0433 GJ (http://agnatural.pt/documentos/ver/natural-gas-conversion-pocketbook_fec0aeed1d2e6a84b27445ef096963a7eebab0a2.pdf)

4.3 Monitoring Plan

Monitoring Management

The required monitoring equipment will be installed and monitoring procedures will be followed as mentioned in section 4.2. The data will be recorded on a continuous basis or as indicated in section 4.2 and recorded in the logs. The data will be kept in both soft and hard copy format and proper data backups will be maintained. The calibration of monitoring equipment will be done on regular intervals at site, based on master equipments traceable to industry/national standards.

All the staff will be trained by the company on how to operate the plant as well as monitor the required data under the VCS methodology. General outline of operation and management of the project activity is as followed:



Quality assurance and quality control

The project leader will monitor the overall plant's performance, ensuring proper and timely calibration (in accordance with the manufacturer specifications or national standard) of systems, data acquisition and storage. Erroneous data or uncertainties found in measurement of the monitoring devices for the project (i.e. flow rate, electricity meters, etc.) will be included in the quality assurance and quality control procedures for individual monitoring parameters as per Section 4.2 under this VCS PD.

Data storage and filling

All monitoring data will be stored in logs and in electronic format as excel sheets. Primary source of data for emission reduction calculation shall be derived from the electronic system while in case of emergency or data error, support monitoring data from the log book shall be used instead. The monitoring records shall be archived for a period of the crediting period plus two years.

Emergency procedure

The project activity is not expected to result in any emergency that can result in substantial emissions.

However, since unexpected emergency situations might affect the completeness or accuracy of monitored data. Apart from general provisions described topic above and below of this section 4.3, the operator shall also take measures to avoid data loss and inaccuracies under such circumstances. Following an emergency situation, the staff responsible for operation and monitoring of the plant shall be made aware of any event from the previous day or previous shift and plan to promptly rectify the situation. In case of problems with any equipment or machines, immediate action shall be taken to restore regular operation of such affected devices.

Uncertainty in data

Some uncertainties may result due to malfunction of meters, calibration issues and wrong data collection (gaps in manual log sheets, human errors by plant operators). The operator is expected to put best efforts to prevent such errors, however regular internal audits shall rectify any such uncertainty in the monitored data.

5 ENVIRONMENTAL IMPACT

According to the Thai regulation, for this proposed VCS project activity, an Environmental Impact Assessment (EIA) is required, and such a report shall be approved by the Office of Environmental Policy and Planning (OEPP) and National Environmental Board (NEB).

The following assessment procedure has to be followed:

Environmental assessment procedure

1. Collection of relevant data from various sources such as site visits by a surveyor to the proposed project area, interviews with various stakeholders identified by the project and collection of primary and secondary data from government records on agro-forestry, agriculture and agriculture related industries.
2. A desktop review and compilation of this data followed.
3. Environmental aspects (project activities that had potential to impact the environment) of the project were then identified. E.g. Emissions of flue gas from stack fossil fuel emissions from transportation of biomass, generation of effluent from the water treatment plant etc.
4. The environmental aspects were then prioritised based on their potential to have adverse impacts on the project environment and its stakeholders.
5. An environmental management plan was then formulated, to best control / manage / mitigate these impacts. The primary aim of the environmental management plan was to ensure that regulatory standards were met and that there exists appropriate monitoring procedures for collection of the relevant data.

In accordance, none of the environmental impacts identified are considered significant by project stakeholders, and the report has been approved by Thai government. Hence, all identified environmental aspects of the project activity will be monitored and mitigated/controlled as applicable.

6 STAKEHOLDER COMMENTS

A stakeholder consultation was conducted before the implementation of the proposed VCS project activity on the 3rd of February 2010 as part of the EIA. The invitation letter was sent out as well as announcement made publicly. In addition, the project also organized several following up group consultation in order to make sure that most of relevant stakeholders had expressed their opinion and concern on the project. The results of such public hearings were positive.

Invitation letter

เรื่อง ขอเข้าพบสนทนากลุ่ม เพื่อรับฟังความคิดเห็นในขั้นตอนการประเมินผลกระทบ และจัดทำรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมและสุขภาพ

เขียน นายกเทศมนตรีตำบลบ้านฉาง

สิ่งที่ส่งมาด้วย ประเด็นการสนทนากลุ่มย่อย

ตามที่ บริษัท ยูไนเต็ค แอนนาลิสต์ แอนด์ เอ็นจิเนียริง คอนซัลแตนท์ จำกัด ซึ่งเป็นหนึ่งในกลุ่มบริษัทที่ปรึกษาที่ได้รับรางวัลจากกลุ่มบริษัท ดาว ในประเทศไทย และ กลุ่มบริษัท โซลเวย์ ให้เป็นที่ปรึกษาในการดำเนินการประเมินผลกระทบต่อสุขภาพ โครงการก่อสร้างและขยายโรงงานอุตสาหกรรมปิโตรเคมี ในพื้นที่นิคมอุตสาหกรรมเอเซีย อำเภอบ้านฉาง จังหวัดระยอง ซึ่งได้ดำเนินการจัดประชุมรับฟังความคิดเห็นในเวทีกำหนดขอบเขตและแนวทางการประเมินผลกระทบด้านสิ่งแวดล้อมและสุขภาพโดยสาธารณะ (Public Scoping) ของโครงการ เมื่อวันที่ 3 กุมภาพันธ์ 2553 แล้วนั้น

ในการนี้ บริษัท ยูไนเต็ค แอนนาลิสต์ แอนด์ เอ็นจิเนียริง คอนซัลแตนท์ จำกัด ขอเข้าพบสนทนากลุ่ม เพื่อรวบรวมข้อมูลการจัดการอนามัยสิ่งแวดล้อม และการจัดการด้านสาธารณสุข รวมทั้ง นำเสนอการประเมินผลกระทบสิ่งแวดล้อมและสุขภาพ และมาตรการป้องกัน แก้ไขผลกระทบสิ่งแวดล้อมและสุขภาพของโครงการ (รายละเอียดดังสิ่งที่ส่งมาด้วย) จึงขอเชิญ ในวันที่ 15 มีนาคม 2553 เวลา 13.30 – 15.30 น. ณ เทศบาลตำบลบ้านฉาง ทั้งนี้ขอความอนุเคราะห์ในการเชิญผู้แทนของสาธารณสุขและสิ่งแวดล้อม และผู้แทนฝ่ายป้องกันและบรรเทาสาธารณภัยของเทศบาลฯ เข้าร่วมประชุม ตามวันและเวลาดังกล่าว เพื่อร่วมแสดงความคิดเห็นและข้อเสนอแนะที่จะเป็นประโยชน์สำหรับให้บริษัทฯ ได้นำมาปรับปรุงแนวทางการประเมินผลกระทบด้านสุขภาพให้ครอบคลุมประเด็นวิกฤตกังวลให้มากที่สุด พร้อมทั้ง ขออนุเคราะห์ห้องประชุมของเทศบาลตำบลบ้านฉาง เป็นสถานที่จัดสนทนากลุ่มในครั้งนี้ ซึ่งคาดว่าจะมีผู้เข้าร่วมประชุมประมาณ 8-10 คน

จึงเรียนมาเพื่อโปรดพิจารณา และขอขอบคุณมา ณ โอกาสนี้

ขอแสดงความนับถือ
นางสาวณัฐพร สิงขประสิทธิ์
(นางสาวณัฐพร สิงขประสิทธิ์)
ผู้จัดการโครงการ

ศิริพร จันทิมา
ส.ค. 53

ผู้ประสานงาน นางสาวอริยา อุบัวทอง
ฝ่ายศึกษาและจัดการสิ่งแวดล้อม
โทร. 02-7632828 ต่อ 2903 โทรสาร 02-7632839

Public announcement (in 4 areas)



Stakeholder consultation



Registration form

ใบลงทะเบียน

การประชุมสหภาพเพื่อรับผิดชอบต่อสังคมและการพัฒนาที่ยั่งยืนของประเทศไทย
โครงการส่งเสริมและพัฒนาผู้ประกอบการรายย่อยในเขตภาคเหนือตอนบน
ให้พื้นที่พัฒนาผู้ประกอบการรายย่อย อำเภอแม่จาง และพัฒนาผู้ประกอบการรายย่อย อำเภอเมือง จันทบุรี

วันที่ ที่ สหกรณ์ พ.ศ. 2553 เวลา น.

ณ จัดตั้งโดย

ลำดับที่	ชื่อ-นามสกุล	ตำแหน่ง/หน่วยงาน	เบอร์ติดต่อ/Email address	ลายเซ็น

APPENDIX 1: GRID EMISSION FACTOR COMPUTATION

Calculation of the grid emission factor of Thailand

The grid emission factor has been calculated using the “**Tool to calculate the emission factor for an electricity system**” – version 02.2.1, Annex-19, EB63.

The data employed in this study was based on the latest data available at the time of PDD submission for validation to the DOE. The data has been taken from the publicly available data published by the Thai DNA on the emission factor of electricity system in Thailand published on 30 December 2011⁹.

The “**Tool to calculate the emission factor for an electricity system**” states procedures to determine the following parameters to estimate baseline grid emission factor:

Parameter	SI Unit	Description
$EF_{grid,CM,y}$	tCO ₂ /MWh	Combined margin CO ₂ emission factor for the project electricity system in year y
$EF_{grid,BM,y}$	tCO ₂ /MWh	Build margin CO ₂ emission factor for the project electricity system in year y
$EF_{grid,OM,y}$	tCO ₂ /MWh	Operating margin CO ₂ emission factor for the project electricity system in year y

As per the “**Tool to calculate the emission factor for an electricity system**” project participants shall apply the following steps:

STEP 1. Identify the relevant electric power system.

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

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

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

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

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

Step 1: Identifying the relevant electric power system

The Thai DNA has published the delineation of connected electricity system. The electricity transmission system of Thailand is considered as a single system since the transmission lines are networked throughout the country and owned by the Electricity Generating Authority of Thailand (EGAT). EGAT is the authority that controls electricity generation and distribution in Thailand, whereas the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) are the authorities that supply the electricity to the users in Bangkok and provinces, respectively.

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

Only grid connected power plants are included in the calculation, as per Option I of the “Tool to calculate the emission factor for an electricity system” version 02.2.1.

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

⁹ http://www.tgo.or.th/index.php?option=com_content&view=article&id=349:thailand-grid-emission-2010-report&catid=62:tgo-research&Itemid=29

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

- 1) Simple OM
- 2) Simple adjusted OM
- 3) Dispatch data analysis OM
- 4) Average OM

According to Thailand's data, the simple OM method (Ex ante Option) is the most appropriate method. This method requires the latest 3 years data including quantity of electricity generated; fuel types used and fuel consumption of each fuel type. This study used data obtained in the year 2008-2010 due to the following reasons:

- In Thailand, the generated electricity that is transferred to the national grid is the only available data. Thus, it is not possible to obtain off-grid electricity generation data.
- Low-cost/must-run (LC/MR) power plants include hydro and renewable power plants. The quantity of electricity generated by these power plants is not included in the calculation because it is less than 50% of total grid generation.

Year	LC/MR, MWh	Total grid, MWh	LC/MR share
2006	9,961.12	139,421.94	7.14%
2007	10,382.64	144,364.39	7.19%
2008	9,115.86	145,232.00	6.28%
2009	9,106.39	145,300.19	6.27%
2010	7,587.23	160,190.96	4.74%
			6.32%

LC/MR – Low-cost/must run

Low cost/must run resources constitute an average of 6.32 % of total generation which is less than 50%. On this basis, Option (a), the Simple OM has been selected.

Step 4: Calculate the operating margin emission factor according to the selected method

The simple OM emission factor is calculated as the generation-weighted average CO₂ emissions per unit net electricity generation (tCO₂/MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units.

The simple OM may be calculated by one of the following two options:

Option A: Based on the net electricity generation and a CO₂ emission factor of each power unit; or

Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

Option B is selected to calculate OM emission factor due to the following reasons:

- a) The necessary data for option A is not available such as data of net electricity generation of each power plant/unit serving the system;
- b) Only nuclear and renewable power generation are considered as low-cost/must-run power sources and the quantity of electricity supplied to the grid by these sources is known; and
- c) Off-grid power plants are not included in the calculation.

The Operating Margin emission factor is calculated by using Simple OM, Option B as per the following equation:

$$EF_{grid,OMsimple,y} = \frac{\sum_i (FC_{i,y} \times NCV_{i,y} \times EF_{CO_2,i,y})}{EG_y}$$

Where:

$EF_{grid,OMsimple,y}$ = Simple operating margin CO2 emission factor in year y (tCO2/MWh)
 $FC_{i,y}$ = Amount of fossil fuel type i consumed in the project electricity system in year y (mass or volume unit)
 $NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type i in year y (GJ/mass or volume unit)
 $EF_{CO_2,i,y}$ = CO2 emission factor of fossil fuel type i in year y (tCO2/GJ)
 EG_y = Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must-run power plants/units, in year y (MWh)
i = All fossil fuel types combusted in power sources in the project electricity system in year y
y = The relevant year as per the data vintage chosen in Step 3

The values of CO2 emission from combustion of fossil fuel (per unit of fossil fuel) are shown in Table 1. Net Calorific Value (NCV) is obtained from data provided by the Department of Alternative Energy Development and Efficiency, Ministry of Energy. The CO2 Emission Factor of fossil fuel follows IPCC default values as specified in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Table 1. Net Calorific Value and CO2 emission per unit of each type of fossil fuel

Fuel type	Unit	NCV ¹⁰ (MJ/unit)	CO2 emissions ¹¹ (tCO2/TJ)	CO2 emissions (kgCO2/Unit)
Natural gas	scf	1.02	54.30	0.0554
Lignite	ton	10,470.00	90.90	951.7230
Bituminous	ton	26,370.00	89.50	2,360.1150
Bunker	liter	39.77	75.50	3.0026
Diesel	liter	36.42	72.60	2.6441

The quantity of electricity generated and delivered to the national grid can be obtained from the Electricity Report 2008 – 2010 published by the Electricity Generating Authority of Thailand as shown in Table 2. Data are categorized by electricity generation system, type of power plant and quantity of electricity generated by LC/MR and Non LC/MR power plants. Type of power plant includes the power plant of the Electricity Generating Authority of Thailand, Independent Power Producers (IPPs) and Small Power Producers (SPPs).

Quantity and type of fossil fuel consumed in electricity generation are also obtained from the Electricity Report 2008 – 2010 published by the Electricity Generating Authority of Thailand as shown in Table 3.

VSPP power plants use renewable energy including biogas, biomass, hydro, wind and solar energy and are considered as low-cost/must-run power plants. However, a VSPP power plant is non-firm and can supply only a small quantity of electricity to the grid compared to other power plants. In 2010, the amount of electricity that VSPP power plants sold to the

¹⁰ Electric Power in Thailand 2008/ Department of Alternative Energy Development and Efficiency, Ministry of Energy

¹¹ IPCC default values at the lower limit as provide in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Provincial Electricity Authority was 1,155.1 GWh¹² (0.72% of the total electricity generated in 2010). Thus, this study does not include electricity generated by VSPP in the calculation of total electricity in the national grid. The total amount of electricity exported to the national grid (only Non LC/MR) in the years 2008 – 2010 was 424,913.67 GWh.

Table 2. Quantity of electricity generated and delivered to the national grid¹³

Generation System	Grid Generation (GWh)			
2010	EGAT	IPP	SPP	Total
Total	78,517.70	67,775.98	13,897.27	160,190.96
Non LC/MR	73,185.41	67,775.98	11,642.33	152,603.73
LC/MR	5,332.30	0.00	2,254.94	7,587.23
Thermal	27,289.03	15,408.42	2,162.89	44,860.34
Combined cycle	38,338.71	52,367.56	8,655.76	99,362.04
Gas turbine	276.30	0.00	823.67	1,099.97
Diesel engine	3.98	0.00	0.00	3.98
Hydro power	5,325.20	0.00	23.64	5,348.84
Renewable energy	7.10	0.00	2,231.30	2,238.40
Import	7,277.39	0.00	0.00	7,277.39

2009	EGAT	IPP	SPP	Total
Total	66,488.10	64,840.72	13,971.37	145,300.19
Non LC/MR	59,541.66	64,840.72	11,811.42	136,193.80
LC/MR	6,946.44	0.00	2,159.95	9,106.39
Thermal	23,463.69	12,388.03	2,225.63	38,077.35
Combined cycle	33,164.46	52,452.69	8,752.19	94,369.35
Gas turbine	309.63	0.00	833.60	1,143.23
Diesel engine	1.44	0.00	0.00	1.44
Hydro power	6,941.74	0.00	23.97	6,965.71
Renewable energy	4.70	0.00	2,135.98	2,140.68
Import	2,602.43	0.00	0.00	2,602.43

2008	EGAT	IPP	SPP	Total
Total	63,719.02	67,420.14	14,092.83	145,232.00
Non LC/MR	56,791.19	67,420.14	11,904.81	136,116.14
LC/MR	6,927.83	0.00	2,188.03	9,115.86
Thermal	26,778.89	14,398.34	1,996.83	43,174.06
Combined cycle	26,449.20	53,021.80	9,029.90	88,500.90
Gas turbine	659.33	0.00	878.07	1,537.41
Diesel engine	2.30	0.00	0.00	2.30
Hydro power	6,926.02	0.00	28.77	6,954.79
Renewable energy	1.81	0.00	2,159.26	2,161.07
Import	2,901.47	0.00	0.00	2,901.47

Table 3. Amount of fossil fuel consumed by power plants¹⁴

2010	EGAT	IPP	SPP	Total
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¹² Provincial Electricity Authority: PEA

¹³ Electricity Report 2008-2010/Electricity Generating Authority of Thailand

¹⁴ Electricity report 2008 – 2010/ Electricity Generating Authority of Thailand

Natural Gas	scf	430,662,249,446	491,131,955,423	151,290,468,150	1,073,084,673,019
Lignite	tonnes	16,043,174	0	0	16,043,174
Bituminous	tonnes	0	3,646,898	1,855,262	5,502,160
Bunker	liter	140,084,467	87,347,782	5,797,497	233,229,746
Diesel	liter	11,865,427	10,853,795	1,307,336	24,026,558

2009		EGAT	IPP	SPP	Total
Natural Gas	scf	369,146,214,392	459,228,417,361	140,550,086,056	968,924,717,809
Lignite	tonnes	15,818,265	0	0	15,818,265
Bituminous	tonnes	0	3,645,721	1,840,527	5,486,248
Bunker	liter	111,039,065	38,180,874	8,797,506	158,017,445
Diesel	liter	12,140,891		1,685,046	13,825,937

2008		EGAT	IPP	SPP	Total
Natural Gas	scf	340,739,529,461	490,866,999,785	145,410,364,035	977,016,893,281
Lignite	tonnes	16,407,465	0	0	16,407,465
Bituminous	tonnes	0	3,711,791	1,866,776	5,578,567
Bunker	liter	247,441,682	93,212,260	9,555,452	350,209,394
Diesel	liter	6,792,039	43,698,832	1,451,087	51,941,958

Table 4. CO2 emission from electricity generation in the years 2008 – 2010

Fuel type	Fuel Consumption		CO2 Emission	
	Unit	Volume		
2010		Total	kgCO2/unit	tCO2
Natural Gas	scf	1,073,084,673,019	0.0554	59,433,868
Lignite	tonnes	16,043,174	951.7230	15,268,658
Bituminous	tonnes	5,502,160	2,360.1150	12,985,730
Bunker	liter	233,229,746	3.0026	700,304
Diesel	liter	24,026,558	2.6441	63,528
2009		Total	kgCO2/unit	tCO2
Natural Gas	scf	968,924,717,809	0.0554	53,664,864
Lignite	tonnes	15,818,265	951.7230	15,054,607
Bituminous	tonnes	5,486,248	2,360.1150	12,948,176
Bunker	liter	158,017,445	3.0026	474,469
Diesel	liter	13,825,937	2.6441	36,557
2008		Total	kgCO2/unit	tCO2
Natural Gas	scf	977,016,893,281	0.0554	54,113,058
Lignite	tonnes	16,407,465	951.7230	15,615,362
Bituminous	tonnes	5,578,567	2,360.1150	13,166,060
Bunker	liter	350,209,394	3.0026	1,051,551
Diesel	liter	51,941,958	2.6441	137,339

Table 5. Operating Margin Emissions Factor (ex-ante option)

Year	Total emissions	Grid generation- non LCMR	OM
	tCO2	GWh	tCO2/MWh
2010	88,452,088	152,603.73	0.5796

2009	82,178,673	136,193.80	0.6034
2008	84,083,369	136,116.14	0.6177
			0.5994

Step 5: Calculate the build margin (BM) emission factor

Option 1 has been selected as per the “Tool to calculate the emission factor for an electricity system”.

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

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

- Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently (SET5-units) and determine their annual electricity generation (AEGSET-5-units, in MWh);
- Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEGtotal, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEGtotal (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) (SET≥20%) and determine their annual electricity generation (AEGSET-≥20%, in MWh);
- From SET5-units and SET≥20% select the set of power units that comprises the larger annual electricity generation (SET sample);

Identify the date when the power units in SET sample started to supply electricity to the grid. If none of the power units in SET sample started to supply electricity to the grid more than 10 years ago, then use SET sample to calculate the build margin. In this case ignore steps (d), (e) and (f).

The steps (d), (e) and (f) are ignored as they are not considered relevant as none of the power units started to supply electricity more than 10 years ago.

As the set of power units that comprises the larger annual generation must be used, according to Thailand's data, the first option can generate less electricity than the second option, thus this study uses the quantity of electricity generation of the second option as listed in Table 6. Fuel consumptions of these power plants are shown in Table 7.

Table 6: Electricity generation by the most recently built power plants¹⁵

	Power Plant	Commercial Operation Date	Grid Generation (KWh)
			32,934,252,047
1	North Bangkok Power Plant (Unit 01)	19-Nov-10	1,584,220,065
2	Bangpakong Power Plant (Unit 05)	16-Sep-09	4,643,224,142

¹⁵ Electricity report 2010/ Electricity Generating Authority of Thailand

3	Phu Kieaw Bio Power Project 2	15-Sep-09	79,461,380
4	Dan Chang Bio Power Project 2	15-Sep-09	76,753,860
5	South Bangkok Power Plant (Unit 03)	01-Mar-09	4,431,921,700
6	Chana Power Plant (Unit 01)	15-Jul-08	5,090,016,200
7	Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	1-Jun-08	7,124,721,800
8	Gulf Power Generation Co., Ltd. (Unit 1&2)	1-Mar-08	9,903,932,900
	Percentage of 2010 grid generation		20.56%

Table 7. Fuel Consumption of the most recently built power plants¹⁶

2010 Emission	Unit	Fuel consumption	kgCO ₂ /Unit	tCO ₂
Natural Gas	scf	251,512,881,819	0.0554	13,930,292
Lignite	tonnes	0	951.7230	0
Bituminous	tonnes	0	2,360.1150	0
Bunker	liter	0	3.0026	0
Diesel	liter	1,179,772	2.6441	3,119
Total				13,933,411.90

The build margin emissions factor is the generation-weighted average emission factor (tCO₂/MWh) of all power units *m* during the most recent year *y* for which electricity generation data is available, calculated as follows:

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

Where:

$EF_{grid,BM,y}$ = Build margin CO₂ emission factor in year *y* (tCO₂/MWh)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)

$EF_{EL,m,y}$ = CO₂ emission factor of power unit *m* in year *y* (tCO₂/MWh)

m = Power units included in the build margin

y = Most recent historical year for which electricity generation data is available

Table 8. Calculation of Build Margin Emission Factor (from table 6 and 7 above)

Year	CO ₂ emissions (tCO ₂)	Electricity generation (GWh)	BM (tCO ₂ /MWh)
2010	13,933,411.90	32,934,252,047	0.4231

Step 6 : Calculate the combined margin emissions factor

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times W_{OM} + EF_{grid,BM,y} \times W_{BM}$$

$EF_{grid,BM,y}$ = Build margin CO₂ emission factor in year *y* (tCO₂/MWh)

$EF_{grid,OM,y}$ = Operating margin CO₂ emission factor in year *y* (tCO₂/MWh)

W_{OM} = Weighting of operating margin emissions factor (%)

W_{BM} = Weighting of build margin emissions factor (%)

¹⁶ Electricity report 2010/ Electricity Generating Authority of Thailand

The following default values should be used for w_{OM} and w_{BM} :

- Wind and solar power generation project activities: $w_{OM} = 0.75$ and $w_{BM} = 0.25$ (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;
- All other projects: $w_{OM} = 0.5$ and $w_{BM} = 0.5$ for the first crediting period, and $w_{OM} = 0.25$ and $w_{BM} = 0.75$ for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.

Table 9: Weighting of operating and build margin for general CDM project:

Project type	w_{OM}	w_{BM}
General project	0.5	0.5

Table 10: Combined margin emission factor

Project type	Emission factor (tCO ₂ /MWh)		
	$EF_{grid,OM}$	$EF_{grid,BM}$	$EF_{grid,CM}$
General project	0.5994	0.4231	0.5113