“Biogas recovery and utilization in a tapioca starch factory”
(Implementing Entity: Pacific Consultants CO., Ltd.)

1. Overview of the proposed JCM Project

<table>
<thead>
<tr>
<th>Study partners</th>
<th>Climate Consulting, LLC.</th>
<th>JCM methodology development, support for site visits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biotrix Asia Company Ltd.</td>
<td>Technology evaluation, outline design, construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>schedule and cost estimation, effluent stream analysis</td>
</tr>
<tr>
<td></td>
<td>KPN Tapioca Factory Co.,</td>
<td>Economic/financial assessment and plan formulation,</td>
</tr>
<tr>
<td></td>
<td>Ltd.</td>
<td>providing information of the plant for JCM project</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project site</th>
<th>Lao PDR</th>
</tr>
</thead>
</table>

| Description of project | The aim of this project is to replace fossil fuels (coal) and non-renewable biomass fuel (logged timber) through anaerobic treatment of effluent in an anaerobic fermentation digester, to generate and recover biogas and use it as boiler fuel, at the tapioca starch factory of KPN Tapioca Factory Co. Ltd. (hereafter KPN) located near Pakse City (20 km from city center), Champasak Province, Lao People's Democratic Republic. This project will reduce greenhouse gas (GHG) emissions, by avoiding CO$_2$ emissions associated with the combustion of fossil fuels and non-renewable biomass and by recovering CH$_4$ from an open lagoon. |

<table>
<thead>
<tr>
<th>Expected project implementer</th>
<th>Japan</th>
<th>Pacific Consultants Co., Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host country</td>
<td>KPN Tapioca Factory Co., Ltd.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial investment</th>
<th>203 million Japanese yen</th>
<th>Date of groundbreaking</th>
<th>Not yet decided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual maintenance cost</td>
<td>4.5 million Japanese yen</td>
<td>Construction period</td>
<td>9-12 months</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Willingness to investment</th>
<th>High intention on introducing a system</th>
<th>Date of project commencement</th>
<th>Not yet decided</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Financial plan of project</th>
<th>The initial investment is to be funded at the project start and time of equipment installation by KPN’s own capital and borrowing from a local bank, and after completion of the installation and launch of operations, the JCM equipment subsidy is expected to be applied. Anticipated lenders include the Bank of Lao PDR to which KPN has applied for funding, but if it becomes possible to obtain financing from a bank backed by Thai capital that has branches in Laos, it could become a lending candidate. If financing from domestic banks is difficult to obtain, other options may be considered, including a combination of self-financing and borrowing secured by company assets.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CO$_2$ emission reductions</th>
<th>71,235 (tCO$_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= Annual emission reductions 4,749 (tCO$_2$/year) × Statutory useful life of the system 15 (years)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GHG emission reductions</th>
<th>28,110 (tCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= Annual emission reductions 1,874 (tCO$_2$e/year) × Statutory useful life of the system 15 (years)</td>
</tr>
</tbody>
</table>
2. Target Project of the Study

(1) Outline of the Project

- **Purpose of the project**

  The aim of this project is to replace fossil fuels (coal) and non-renewable biomass fuel (logged timber) through anaerobic treatment of effluent in an anaerobic fermentation digester, to generate and recover biogas and use it as boiler fuel, at the tapioca starch factory of KPN Tapioca Factory Co. Ltd. (hereafter KPN) located near Pakse City (20 km from city center), Champasak Province, Lao People's Democratic Republic. This project will reduce greenhouse gas (GHG) emissions, by avoiding CO₂ emissions associated with the combustion of fossil fuels and non-renewable biomass and by recovering CH₄ from an open lagoon.

- **GHG emission reduction effect**

  KPN obtains a large volume of logged timber at low cost from sources that include agricultural expansion and infrastructure development in the region around its factory, and uses the heat from combustion in boilers for the process of drying tapioca starch. However, the Lao government is gradually tightening rules regarding the procurement and use of wood as fuel, so it is expected that the company will eventually have to use high-priced coal or other fossil fuels. Therefore, if biogas recovery and utilization can be achieved through this project, it will be possible to achieve a reduction in GHG emissions originating from the combustion of fossil fuels.

  As part of its production process, KPN discharges organic effluent with high COD concentrations. The company currently treats the effluent under natural conditions in an existing open lagoon, but by installing a biogas generation and recovery system and utilizing the resulting methane gas (CH₄) as fuel in the boilers, it will be possible to substitute all of the fuel that is being used in boilers.

- **Scale and performance of equipment to be installed**

  A Biotrix Flexible Liner Reactor (FLR) type of system will be installed as the biogas generation and recovery system. This method has advantages that improve operation and control compared to typical covered-lagoon anaerobic fermentation systems. A FLR system is designed and built with a high density polyethylene (HDPE) sheet covering the top of the digester that stores biogas, and the sheet will expand or contract depending on the amount of biogas generated.

  The biogas generation and recovery system consists of a digester (90 m x 65 m x 10 m lagoon covered by a HDPE sheet), dosing station, mixing tank, primary pump, effluent pump, sludge pump, gas blower, boiler, control system, H₂S scrubber, biogas cyclone, and flare system. The biogas recovered from the digester is utilized as fuel in the biogas boilers.

- **Implementation site**

  KPN has been producing tapioca starch at the implementation site since 2010. Cassava provides the raw material for tapioca, but harvest volumes are low during the months of July to October each year, which coincides with the rainy season, and since starch content is also low, the factory closes during that period. Meanwhile, peak production is from November to June, which is the dry season.

  KPN procures cassava raw material from sources including the company’s own fields and from farmers in the region, and produces about 50–60 t of tapioca starch per day. Due to increasing domestic and foreign demand for tapioca starch and an increase in farmers in the region growing cassava, it is expected that there will be an adequate
supply of cassava in the future, and the firm plans to expand daily production to 150 t per day within two years.

(2) Background of the Project

- **Motivation of Japan’s expected representative partners**
  
  As a consulting firm, Pacific Consultants aims to contribute to the promotion of a JCM initiative of the Japanese government by having this project registered as a JCM project and implementing the project with the support of JCM equipment subsidy project funds. Also, by implementing this project as an entity on the Japanese side of an international consortium for JCM equipment subsidized projects, we aim to further accumulate and enhance knowhow about project development overseas.

- **Motivation of local project implementation entity**
  
  Since its establishment, KPN has been interested in biogas recovery and utilization, but did not proceed due to concerns about inadequate cassava availability, and due to the large initial investment required for biogas recovery/utilization systems. However, as there has been a rapid increase in cassava harvests in the region, the firm decided that production volumes could be increased, and decided to apply to financial institutions to finance the capital investment.

  Also, KPN currently operates it boiler using wood fuel arising from sources such as land development in the region, but the firm is aware that it will become more difficult in the future to obtain low-cost wood fuel. In addition, if production volume increases above current levels, the firm expects that the thermal energy available from wood fuel will be insufficient, and believes that it will be necessary to shift from wood to alternative fuels. Therefore, the firm is now seriously considering installing a biogas generation/recovery system, and reviewing the potential to utilize the JCM equipment subsidy program.

- **Needs of the project in the host country**
  
  Among tapioca starch factories in Laos, although one factory implements biogas recovery and utilization as a CDM project, it has not been proceeded in other tapioca starch factories and food processing factories.

  In Laos where its fossil fuel resources are heavily dependent on imports, and obtaining domestic wood fuel is strictly restricted, needs for an energy self-sufficient biogas project is considered to be high. Also, in Laos where the most of energy comes from hydroelectric power which emission factor is zero, it can be possible to develop CO2 zero emission projects by replacing fossil fuel use to biogas use. By making this project as CO2 zero emission model factory, the ripple effect to other tapioca starch factories and food processing factories can be expected.

- **Consistency with Host Country’s Relevant Regulations and Policies**
  
  Laos formulated a renewable energy development strategy in 2011. It promotes the use of renewable energy and establishes a target to have 30% of energy consumption supplied by renewable energy by 2025. For biogas, the targets are 19 MW by 2020, and 51 MW by 2025.

  The government plans to formulate a Green Industry Policy in 2016, with the objectives of promoting environmental measures, reducing environmental impacts, and improving the sustainability of domestic industry. It is expected to introduce certification mark systems for green industry, such as industries and corporations that engage in environmentally-friendly production, recycling, energy efficiency, and increased productivity, to support the publicity activities of the government, and to offer tax incentives. The biogas generation/recovery system that
KPN intends to install is aligned with these kinds of renewable energy targets and policies to promote environmentally-friendly manufacturing.

Also, in Laos, forest loss and degradation is accelerating as the economy grows. In 2005, the government formulated the Forest Strategy 2020, with targets to restore the forest cover ratio and each year is gradually strengthening regulations for obtaining and utilizing forest resources. The implementation of this project will utilize biogas as fuel and reduce the consumption of coal and wood, and therein is aligned with the direction of the relevant regulations of the host country.

3. Study Plan

(1) Subject and Contents of the Study

1) Financing Plan

【Issues to be resolved】

Regarding the financing plans for the initial investment, it is necessary to confirm various aspects, including KPN’s financial capacity and method of paying for procurement of materials and equipment. Also, if financing is required, it is necessary to confirm factors such as the lending terms. Interviews will be conducted to determine KPN’s borrowing history to confirm the company’s creditworthiness. Among the financial plan for maintenance costs, for personnel costs, it is necessary to conduct a careful review of whether or not there is a portion that can be shared in relation to existing factory operations. In addition, it is necessary to confirm the policies and plans relating to future business continuation and development.

【Details of research implemented to solve issues】

We received KPN’s financial reports of the past three years and reviewed KPN’s financial status and borrowing history. It was also confirmed that KPN has applied for financing to expand the business and increase revenues, but financing was not received, and we confirmed the reasons. Because the firm will seek funding domestically from Lao financial institutions as the context for medium-term business improvement, we also conducted interviews about the business improvement plan.

2) Preliminary design

【Issues to be resolved】

For the preliminary design of the biogas system, it is necessary to estimate the maximum load considering various factors including ground and soil conditions in the vicinity of the planned construction site of the digester etc., as well as parameters such as seasonal variations in the volume and COD concentrations of effluent from the factory. Other factors include the specifications of biogas boilers considering the thermal energy required for tapioca production processes, and clarification of expected supply capacity and surplus amount of biogas generation.

【Details of research implemented to solve issues】

Visits were also made to KPN and Biotrix, which is expected to develop the preliminary design and construction plan, and interviews and field studies were conducted, covering points such as the production status of KPN’s factory, the status of effluent, and the specifications of existing boilers, etc. In November 2015, an effluent sampling study was conducted, producing the findings that the system will have the capacity to supply an adequate quantity of biogas from effluent to meet the heat demand requirements of the boilers. With these results, we proceeded with
detailed design of the biogas system and calculation of approximate costs.

3) Construction plan

【Issues to be resolved】

It is necessary to develop a construction plan that is properly coordinated with the timing of the busy season for tapioca starch production and operations. At present, it is expected that the installation of a biogas system would take about nine or ten months from the start of construction until the supply of biogas begins.

【Details of research implemented to solve issues】

With technical support from Biotrix, we considered a construction plan for installation of equipment. The installation of a biogas generation/recovery system is expected to take between nine and twelve months from the start of construction to completion. In particular, for construction of the digester, we confirmed that construction must be done during the dry season, because construction is not suitable in the rainy season. KPN indicated its preferred schedule of evaluating and discussing the biogas project feasibility and funding procurement in 2016, and installing equipment in 2017.

4) Project operational plan

【Issues to be resolved】

Some tasks include securing personnel for operation of the biogas system, training of operation and control capabilities, operation/control organization, and MRV implementation, etc.

【Details of research implemented to solve issues】

Details such as specifications and operating procedures of the system to be installed by the project have yet to be determined, but at this point in time, in principle, it is expected that the project will be operated by existing personnel. Therefore, we confirmed details such as training and instruction for system operation.

5) Other

【Issues to be resolved】

It is necessary to estimate emission reductions of CO₂ and other greenhouse gases.

【Details of research implemented to solve issues】

We interviewed KPN and verified information and key issues in connection with design of methodologies. For consideration of methodologies, with regard to calculation of reference emissions, since it is necessary to treat wood fuel as non-renewable biomass, we interviewed the Lao government's Department of Forest Resource Management (DFRM) in the Ministry of Environment and Natural Resources (MoNRE), which has jurisdiction over forest resources, and inquired about topics including Laos’s forest resources policies, relevant legislation, and so on. As a result of consideration based on site visits, it is expected that GHG emission reductions of CO₂ is 4,749tCO₂/year, whereas that of CH₄ is 1,874tCO₂e/year.
(2) Organizational Plan of the Study

The organizational structure of this study is shown below.

<table>
<thead>
<tr>
<th>Names of participants</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Consultants, Co., Ltd</td>
<td>Overall management, project management plan, economic/financial assessment and plan formulation, JCM methodology development</td>
</tr>
<tr>
<td>Climate Consulting, LLC</td>
<td>JCM methodology development, support for site visits</td>
</tr>
<tr>
<td>Biotrix Asia Company Ltd.</td>
<td>Technology evaluation, outline design, construction schedule and cost estimation, effluent stream analysis</td>
</tr>
<tr>
<td>KPN Tapioca Factory Co., Ltd.</td>
<td>Economic/financial assessment and plan formulation, providing information of the plant for JCM project formulation</td>
</tr>
</tbody>
</table>

(3) Study Schedule

The implementation schedule for this study is indicated below. Because the factory started operation at the end of October, after the rainy season ended, we waited until the factory was operating and then conducted measurements and analysis of effluent quality in November. Based on the findings, we discussed with KPN the biogas generation and recovery system to be introduced, and prepared the preliminary design, cost estimates, and construction plan.

4. Study Results

(1) Feasibility of the Project

1) Implementation Plan of the Project

- Construction plan and operational plan of the project

A construction plan for the project is shown below. It is expected that the installation of a biogas system would take about nine or ten months from the start of construction until the supply of biogas begins. As construction is not suitable in the rainy season (June to November), start construction from the middle of November when the rainy season ends.
Operation of biogas system will be conducted by factory staff under the factory manager. During the operation in the first year of installation, KPN makes O&M contract with Biotrix who designs the biogas system for maintenance and management of the system and for providing trainings to the factory manager and factory staff.

## Tabla2. Construction plan of the project

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestion plant design</td>
<td>Site survey, Land preparation, Digestion construction, Wastewater tank, sludge house, Main building, Degradation foundation, biogas foundation, biogas storage and heat exchanger.</td>
</tr>
<tr>
<td>Civil Work and Structure</td>
<td>Digester cover and lining and filling water, Water piping installation, Gas piping installation, Rimp installation, Gas piping installation, Hare installation, Scrubber installation, Methane storage foundation, Cooling and heat exchanger installation.</td>
</tr>
<tr>
<td>Mechanical Work</td>
<td>MUS, WOB, PLC and control panel, Lighting system inside the building, Lighting system outside the building, Main power wiring to equipment.</td>
</tr>
<tr>
<td>Electrical Work and I&amp;C</td>
<td>Instrument installation, Lightning protection, Test system.</td>
</tr>
</tbody>
</table>

- **Project implementation structure**

In terms of the project implementation, the following structure is being considered. It is assumed that the JCM equipment subsidy program will be used for this project.

![Project implementation structure](image)

- **Management Structure and Achievements of Project Implementation Entities**

Management Structure and achievements of KPN are shown below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of establishment</td>
<td>17 November, 2010</td>
</tr>
<tr>
<td>Company history/ownership</td>
<td>Pharmaceutical factory, an another group company, started operation in Vientiane in 1990. KPN started operation in November 2011. The elder sister of the KPN factory manager has ownerships of both pharmaceutical factory and KPN.</td>
</tr>
<tr>
<td>Capital</td>
<td>Registered capital</td>
</tr>
<tr>
<td></td>
<td>Total capital</td>
</tr>
<tr>
<td>Sales (Million USD)</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>2013</td>
</tr>
<tr>
<td></td>
<td>2014</td>
</tr>
</tbody>
</table>
Balance of payments (Million USD) | 2013 | 2014 ▲0.72 | 2015 ▲0.77
--- | --- | --- | ---
Total employees | 70 (Factory in operation) ※When factory stops operation in the rainy season, most employees do not come to the factory but half of the payment is provided to them. | | 
Site area | Company-owned 203ha (Factory/office, lagoons, company-owned farm) | Land lease from the government 78ha (Land lease term: 30 years) | 
Tapioca starch production | 2012 2,996t | 2013 2,835t | 2014 4,200t 2015 2,300t | 
Customers | 705 of the production is exported to Taiwan, Thailand, Saudi Arabia, Italy, etc. 30% is sold to domestic customers. |

The KPN tapioca starch factory is managed and operated by the factory manager, under the president and chief executive officer, who is also the owner of the company. Under the factory manager is a small but functional factory organizational structure, with the department of production, department of cultivation, and department of management, finance, and marketing. Cassava, which serves as raw material for tapioca starch, is procured from the company’s own plantation or the nearby cassava growers.

2) Financial Plan of the Project

The initial investment for project implementation is estimated at 200 million yen, and annual operation and maintenance costs are estimated at 4.5 million yen.

The initial investment is to be funded at the project start and time of equipment installation by KPN’s own capital and borrowing from a local bank, and after completion of the installation and launch of operations, the JCM equipment subsidy is expected to be applied. Anticipated lenders include the Bank of Lao PDR to which KPN has applied for funding, but if it becomes possible to obtain financing from a bank backed by Thai capital that has branches in Laos, it could become a lending candidate. If financing from domestic banks is difficult to obtain, other options may be considered, including a combination of self-financing and borrowing secured by company assets.

<table>
<thead>
<tr>
<th>Item</th>
<th>FLR biogas system and Getabec thermal oil heater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total project cost</td>
<td>203 million Japanese yen</td>
</tr>
<tr>
<td>Annual operational and maintenance cost</td>
<td>4.5 million Japanese yen</td>
</tr>
<tr>
<td>Feasibility of the project</td>
<td>With subsidy 4.2years Without subsidy 7.8years</td>
</tr>
<tr>
<td>(1) Payback period</td>
<td>22.8% 9.5%</td>
</tr>
</tbody>
</table>

※ VAT excluded

As shown above, If JCM Financing Program is utilized, a payback period is calculated to be 4.2 years, which is nearly an ideal figure. However this is calculated based on the assumption that KPN maintains their tapioca starch production at 90 t/day with the situations that their production lines are almost fully operated and their sales are steadily increasing, and besides a boiler is operated with fossil fuels (either coals or heavy oil). In the current status, their sales and productions have not reached that much, and they are still at the stage of trying to ascertain customers making fixed price contracts for their business stabilization.

Thus, considering KPN’s financial situation (especially their long-term debt) and business situation, utilizing JCM financing Program can be a high anxiety factor for the Japanese project implementer in the international consortium. Therefore, Policy for improvement of business plan, and more specific and feasible financial plan needs
(2) Permits and Licenses for the Project

The permits and licenses required for installation of a boiler and biogas generation/recovery system have not yet been confirmed. However, it is worth noting that regarding whether or not this project is seen as a change in the details of existing applications, there was a difference of opinion between the Department of Industry and the Department of Commerce within the Lao Ministry of Industry and Commerce, so prior to actual project implementation it will be necessary to consult with the Chapasek Province Department of Industry and Commerce, which has authority over this project.

(3) Contribution from Japan

For this project, the installation of Japanese-made biogas boilers was considered initially. However, boilers sought by KPN able to burn a combination of biogas, light oil and heavy oil were not available from Japan. In addition, because the cost did not match the amount KPN sought, it was decided to forego the installation of Japanese-made boilers. Options worth considering include the potential to use Japanese-made burners attached to boilers.

(4) Environmental integrity and Sustainable development in host country

1) Environmental Integrity

Installation of the biogas generation/recovery system is expected to improve the situation with offensive odors caused by effluent and to improve water quality. In addition, because the project will help improve the environment by reducing the consumption of coal and wood fuel used in boilers, no negative impacts are expected for the environment and society from implementation of this project.

KPN implemented an IEE when operations first began. When a new factory is constructed, it is necessary to implement an IEE and EIA, but in a case like this project, in which a biogas generation/recovery system is installed in an existing factory, it is possible to see the system as effluent treatment equipment associated with the factory, so a new IEE and EIA is not required. However, in the environmental management plan prepared periodically by the owner after EE and EIA implementation, prior to starting construction it is necessary to submit documents to the competent authorities indicating the system outline, installed equipment, and social/environmental impacts, and accept an inspection.

2) Sustainable Development in host country

There are two dimensions of this project’s contributions to sustainable development: direct contributions to society and the economy, and contributions to the promotion of socioeconomic policies in Laos. In terms of social dimensions in the target region, the project will create additional employment through the construction and operation of the biogas system. Also, by avoiding the use of wood as boiler fuel, the project can contribute to the Lao government’s forest protection policies. In terms of economic dimensions, the project can contribute to tapioca starch production at lower costs thanks to improved energy self-sufficiency. In addition, by supporting consideration of the environmental aspects of production processes, including proper effluent treatment, the project can contribute to improvement of the company’s market competitiveness.
5. JCM methodology Development

(1) Data Collection and Analysis

This project involves (1) a change in the effluent treatment system, and (2) boiler conversion. Accordingly, each aspect requires consideration of a reference scenario and reference emissions. Reference emissions are the total of CO₂ emissions associated from consumption of fossil and other fuels in the boilers, plus CH₄ generated from the open lagoons.

To calculate reference emissions, for the boilers, it is necessary to carefully review and consider their fuel and energy efficiency, and for the effluent treatment system, the status of the existing lagoons. Below is a consideration of these points in the context of this project.

- **Boiler fuel**
  
  When its operations began, KPN operated its boilers using coal, but due to the low current production volume of tapioca starch, rather than coal, the company’s main fuel is logged timber from nearby developments, such as road improvements and hydropower plant development. In such cases, the wood is not renewable energy sourced from forest thinning, but is classified as non-renewable energy from logging. For this timber, it is necessary to be able to define it as non-renewable biomass, and to calculate its emissions as part of a JCM methodology. The CDM treats the majority of wood biomass in Laos as non-renewable biomass (NRB), and the CDM Executive Board (EB) has set the NRB ratio at 87% when biomass is used. (Default values of fraction of non-renewable biomass for least developed countries and small island developing States, EB67 Report Annex 22.)

- **Energy Efficiency of Boilers**
  
  For calculation of reference emissions, it is necessary to establish a reference scenario and the energy efficiency of boilers that will be installed by the project. However, for KPN’s existing boilers (coal-burning boilers), catalog values could not be obtained, and for the efficiency of project boilers as well, it is not easy to properly determine their efficiency level by actual measurements or other means. Thus, to be conservative, it is believed that the suitable approach would be to establish these numbers using default values.

- **Existing lagoons for effluent treatment**
  
  KPN treats effluent in a total of five open lagoons. However, considering the quality of bottom sediment some of the effluent probably permeates into the ground and a sufficient amount of effluent is not being retained in the lagoons, especially during the period when the factory is not operating. The actual lagoon depth is 3.5 m, but considering this situation and a conservative approach, it is believed to be appropriate to use the lower limit of no more than 2 m for effluent depth as established by the IPCC.
Calculation formula and parameters for reference emissions

The following is a consideration of the formulas to calculate reference emissions.

\[ RE_p = RE_{fs,p} + RE_{wt,p} \]

- \( RE_p \): Reference emissions during the period \( p \) [tCO\(_2\)-eq/p]
- \( RE_{fs,p} \): Reference emissions from fossil fuel consumption of boiler during the period \( p \) [tCO\(_2\)/p]
- \( RE_{wt,p} \): Reference emissions from anaerobic fermentation of wastewater during the period \( p \) [tCO\(_2\)-eq/p]

\[ RE_{fs,p} = (1 - R_{fw,p}) \times PC_{bg,p} \times NCV_{bg} \times (\eta_{Pj}/\eta_{RE}) \times EF_{CO2,i} + R_{fw,p} \times PC_{bg,p} \times NCV_{bg} \times f_{MRB} \times (\eta_{Pj}/\eta_{RE}) \times EF_{CO2,projected,fs} \]

\[ RE_{wt,p} = Q_{ww,p} \times COD_{in,p} \times \eta_{COD}_{RE} \times MCF_{ww,RE} \times B_{0,ww} \times UF_{RE} \times GWpch_4 \]

Calculation formula and parameters for project emissions

The following is a consideration of the formulas to calculate project emissions with reference to small scale CDM approved methodology (AMS III.H. Methane recovery in wastewater treatment).

\[ PE_p = PE_{el,p} + PE_{dc,p} + PE_{fs,p} + PE_{fg,p} + PE_{fl,p} \]

- \( PE_p \): Project emissions during the period \( p \) [tCO\(_2\)-eq/p]
- \( PE_{el,p} \): CO\(_2\) emissions from electricity consumption of the project system during the period \( p \) [tCO\(_2\)/p]
- \( PE_{dc,p} \): CH\(_4\) emissions from effluent wastewater during the period \( p \) [tCO\(_2\)-eq/p]
- \( PE_{fs,p} \): CH\(_4\) emissions from decay of final sludge during the period \( p \) [tCO\(_2\)-eq/p]
- \( PE_{fg,p} \): CH\(_4\) emissions from leakage from biogas recovery system during the period \( p \) [tCO\(_2\)-eq/p]
- \( PE_{fl,p} \): CH\(_4\) emissions from incomplete flaring during the period \( p \) [tCO\(_2\)-eq/p]

\[ PE_{el,p} = EC_p \times EF_{grid,y} \]
\[ PE_{dc,p} = Q_{ww,p} \times COD_{in,p} \times (1 - \eta_{COD,RE}) \times MCF_{Pj,dc} \times B_{0,ww} \times UF_{Pj} \times GWpch_4 \]
\[ PE_{fs,p} = S_{fr,Pj,p} \times DOC_s \times DOC_f \times MCF_{Pj,fs} \times UF_{Pj} \times F \times GWpch_4 \times 16/12 \]
\[ PE_{fg,p} = (1 - CFE) \times Q_{ww,p} \times COD_{in,p} \times \eta_{COD,RE} \times MCF_{Pj} \times B_{0,ww} \times UF_{Pj} \times GWpch_4 \]
\[ PE_{fl,p} = F_{bg,p} \times F \times (1 - \eta_{flare}) \times GWpch_4 \]

Based on calculation formulas shown above, CO\(_2\) emission reductions are calculated to be 4,794 tCO\(_2\). Assuming that statutory useful life of a thermal oil heater introduced in the project is 15 years, CO\(_2\) emission reduction of the project is calculated to be 71,235 tCO\(_2\), whereas CH\(_4\) emission reductions are estimated to be 1,874 tCO\(_2\)/year.

(2) Organizational Plan for MRV

Project owner KPN and Pacific Consultants participate in the international consortium.

At KPN, the CEO, factory manager, calculation/reporting officer, and measurement officer, will mainly be responsible for data acquisition, calculation of GHG emission reductions, and writing and approval of monitoring reports. Pacific Consultants will verify the monitoring reports prepared by KPN and prepare Japanese versions of the reports. If a special problem arises, Pacific Consultants will contact the KPN factory manager and request revisions or other actions. A chart of the MRV implementation structure is provided in figure 3.
The table below indicates the key monitoring parameters.

Table 3: Measurement method and frequency for key monitoring parameters

<table>
<thead>
<tr>
<th>Description of parameter or data</th>
<th>Measurement method</th>
<th>Measurement frequency</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{Biog},p}$: Biogas consumption $[\text{t/p}]$ in period $p$</td>
<td>Flow meter</td>
<td>Continuous measurement</td>
<td>Calibrate according to frequency and methods recommended by device manufacturer.</td>
</tr>
<tr>
<td>$Q_{\text{WW},p}$: Quantity of effluent flowing into project effluent treatment system during period $p$ $[\text{m}^3/\text{p}]$</td>
<td>Flow meter</td>
<td>Continuous measurement</td>
<td>Calibrate according to frequency and methods recommended by device manufacturer.</td>
</tr>
<tr>
<td>$E_{\text{C},p}$: Electricity consumption during period $p$ $[\text{MWh/p}]$</td>
<td>Electrical power meter</td>
<td>Continuous measurement</td>
<td>Calibrate according to frequency and methods recommended by device manufacturer.</td>
</tr>
<tr>
<td>$COD_{\text{TP},p}$: COD concentration of effluent flowing into project effluent treatment system</td>
<td>Analysis in the factory analysis office</td>
<td>Sample measurements (once every three months)</td>
<td>Analyze in accordance with analysis manual prepared before project. Once each year conduct cross-checking through analysis by an external analytical body.</td>
</tr>
</tbody>
</table>

6. Post Study Plan toward Project Realization

(1) Post Study Plan

In our discussion with KPN during the third study, KPN proposed that it would like to prepare itself for the project implementation from 2017, focusing during this year, 2016, upon a close examination of the cost and the equipment to be installed in the project and discussions with financial institutions for financing arrangement, in addition to the expansion of customers.

As a result of the above discussion, the project implementation schedule is proposed as follows. Our side will maintain communication with KPN for necessary updates on possible financing procurement and business improvement of KPN, and continue efforts to applying for further feasibility study or application of JCM Financing program.

- April 2016 onward: Confirming updates in KPN’s readiness through periodical communication
- June 2016 onward: Applying for and continuing another Feasibility Study (According to its possibility)
- April 2017 onward:

(2) Issues, solutions and responses

● Issues

<Issue 1: Financial condition and business improvement of KPN>
- The result of the analysis of the internal rate of return for this project at the basis of utilizing JCM Financing program of 50% of the total capital expenditure shows that the investment recovery would be done in 4.2 years, which is presumed favorable. However, it is noted that the analysis is made based on the assumption that the sales would expand strongly and so does the daily production to 90 t with the production facility in full capacity operation, consuming fossil fuel, either coal or heavy oil. The current sales of KPN is short of this figure, and KPN is to extend their marketing in search of larger customers possibly on favorable terms e.g., fix term.
- In the current financial condition of KPN, in particular with its long-term loan and its production level, the Japanese delegate company in an international consortium formed for JCM Financing Program would be required to cover too many unstable elements in KPN. Therefore, it is essential for KPN to provide a more positive and improved financial statements and a more realistic approach to business improvement to the delegate company. In case of applying for JCM Financing program, the consortium would need to consider identifying countermeasures against possible claim of refund of the subsidy, e.g., financial guarantee by parent company, due to an interruption in the project would have occur. The terms of financial issues would necessitate a series of discussions with the owner of KPN and KPN in making an agreeable contract terms.

<Issue 2: Boiler to be introduced>
- Initially, a Japanese-made boiler that only burns biogas was being considered, but KPN requested a boiler that can burn a mixture of biogas plus light and/or heavy oil. Japanese boiler suppliers were contacted regarding boilers that can burn a mixture of biogas plus light and/or heavy oil, but none were found to be available. In addition, considering procedures at the time of maintenance work, KPN has indicated the desire to use a boiler made by a Thai manufacturer. The view was also expressed that Japanese-made boilers would be more costly.

<Issue 3: Applying for the necessary approvals for installation of a biogas generation and recovery system>
- Regarding applications necessary approvals for installation of a biogas generation and recovery system, interviews were conducted with the Department of Industry and the Department of Commerce within the Lao Ministry of Industry and Commerce. However, a difference of opinion became evident between the departments, so it was not possible to obtain a clear answer. Therefore, when it comes to implementation of the project, it will be necessary to provide a detailed explanation of the project to the relevant personnel at the Ministry, and at the provincial government offices, in order to confirm what applications are required for installation of the equipment.

● Solutions and Responses

- Based upon the result of the Feasibility Study, we would discuss and make recommendations on the financial and business improvement of KPN, while pursuing periodical exchange of updates and ideas in view of
apply for JCM Financial Program.

- Regarding the use of Japanese-made materials and equipment, further consideration will be necessary. For example, it would be worth considering Japanese-made burners to equip the boilers.

- It is necessary to consider measures that can further reduce total cost of biogas recover/utilization system. Outside of Laos, in some cases, costs are controlled by having components such as boilers and flares made by hand, and by using simplified control equipment. It will be necessary to continue considering ways to control costs in a way that the project can be within reach for KPN.

- Share with KPN the prepared cost estimates, lists of equipment and devices, and factory layout. In particular, in order to enable consideration of equipment installation, it will be important to share IRR calculations and other measures.