MOEJ/GEC BOCM Feasibility Study (FS) 2014
Summary of the Final Report

“Waste Heat Recovery and Utilization in Textile and Garment Factories”

(Implementing Entity: PEAR Carbon Offset Initiative, Ltd.)

1. Overview of the Proposed JCM Project

<table>
<tr><td>Study partners</td><td colspan="3">Kurose Chemical Equipment Co. Ltd. (Japan)
Tex Master Buying Solution (Bangladesh)</td></tr>
<tr><td>Project site</td><td colspan="3">Bangladesh</td></tr>
<tr><td>Category of project</td><td colspan="3">Energy saving</td></tr>
<tr><td>Description of project</td><td colspan="3">The project is to install heat exchangers for recovering waste heats from wastewater of textile dyeing process and applying the heats to warm up fresh water required for textile dyeing process.
The project targets three Bangladesh textile and garment factories. The factory are Hams Garments Ltd., Giant Textile Ltd. Delta Composite Ind. Ltd located Gazipur district of Dhaka Division.
The core technology is the heat exchanger that will be provided by Japanese manufacturer, Kurose Ltd. and other related equipment such as pumps and control panels are planned to adjust from Japan. The local partner is Tex Master Buying Solution, a local consultant and buying house.</td></tr>
<tr><td rowspan="2">Expected project implementer</td><td>Japan</td><td colspan="2">PEAR Carbon Offset Initiative, Ltd.</td></tr>
<tr><td>Host country</td><td colspan="2">Giant Textile Ltd. (GTL)
Hams Garments Ltd. (Hams)
Delta Composite Ind. Ltd (Delta)</td></tr>
<tr><td>Initial investment</td><td>106,200
（Thousand yen）</td><td>Date of groundbreaking</td><td>September 2015</td></tr>
<tr><td>Annual maintenance cost</td><td>1,800 (Thousand yen)</td><td>Construction period</td><td>5 months</td></tr>
<tr><td>Willingness to investment</td><td>The target factories are taking interests in the project</td><td>Date of project commencement</td><td>February 2016</td></tr>
<tr><td>Financial plan of project</td><td colspan="3">50% of the total cost is from factories and rest of 50% is from the subsidy of JCM</td></tr>
<tr><td>GHG emission reductions</td><td colspan="3">2,397 (t CO2/year)
1) Reduction of fossil fuel consumption due to reduction of steam consumption (2,397 t CO2/year)</td></tr>
</table>

2. Study Contents

(1) Project development and implementation

1) Project planning

The study (feasibility study) approximately estimates the total cost for the three factories is 106.2 million Japanese yen (including custom taxes). Among them, the heat exchangers cost 25 million Japanese yen, control panels cost 14.4 million Japanese yen, pumps cost 20.5 million Japanese yen, local construction, piping and wiring works cost 14.5 million and rest of equipment cost 12.5 million Japanese yen. Annual maintenance fee is 1.8 million Japanese yen. Among the total cost, GTL shares 28.5 million Japanese yen, Hams shares 29.8 million Japanese yen and Delta shares 47.9 million Japanese yen. The table 1 in below shows the costs in detail. However, the cost does not include margins of Japanese entities involved in the project implementation.

Table 1 Estimated Cost

		Heat exchanger	Wiring and piping work	Submersive water pump	Ancillary equipment	Control board	Auto valve	Flow meter	Export packing freight	Other (instruction, test operation)	Total
Hams	TK		2,586,850								-
	JPY	8,510,000	3,939,773	4,247,483	2,064,236	4,094,400	294,750	1,147,000	4,071,574	1,400,000	29,769,215
	US$	70,917	32,831	35,396	17,202	34,120	2,456	9,558	33,930	11,667	248,077
Delta	TK		4,436,400								-
	JPY	8,920,000	6,756,637	12,007,035	3,597,634	6,188,200	699,880	1,482,000	6,578,950	1,700,000	47,930,336
	US$	74,333	56,305	100,059	29,980	51,568	5,832	12,350	54,825	14,167	399,419
GTL	TK		2,506,850								-
	JPY	7,600,000	3,817,933	4,247,483	2,328,236	4,094,800	0	1,147,000	3,883,504	1,400,000	28,518,955
	US$	63,333	31,816	35,396	19,402	34,123	0	9,558	32,363	11,667	237,658
Total (3 factories)	TK		9,530,100								-
	JPY	25,030,000	14,514,342	20,502,000	7,990,106	14,377,400	994,630	3,776,000	14,534,027	4,500,000	106,218,506
	US$	208,583	120,953	170,850	66,584	119,812	8,289	31,467	121,117	37,500	885,154

Regarding financing, the target factories will responsible 50% of the total cost correspondingly and the rest 50% will be adjusted from the subsidy of BOCM. In order to realize implementation of the project, an international consortium that consists of Toyota Tsusho Corporation, PEAR and target factories is planned to be established. The consortium is responsible for project implementation and also MRV implementation.

In the consortium the Toyota Tsusho is a representative entity and response for financing and management of the project. PEAR is responsible for MRV implementation including methodology development, monitoring plan development. Construction time is tentatively planned to be September 2015 and operation time is to be February 2016. However, the final implementation plan in detail will be completed discussing with factories by confirming their investment concern.

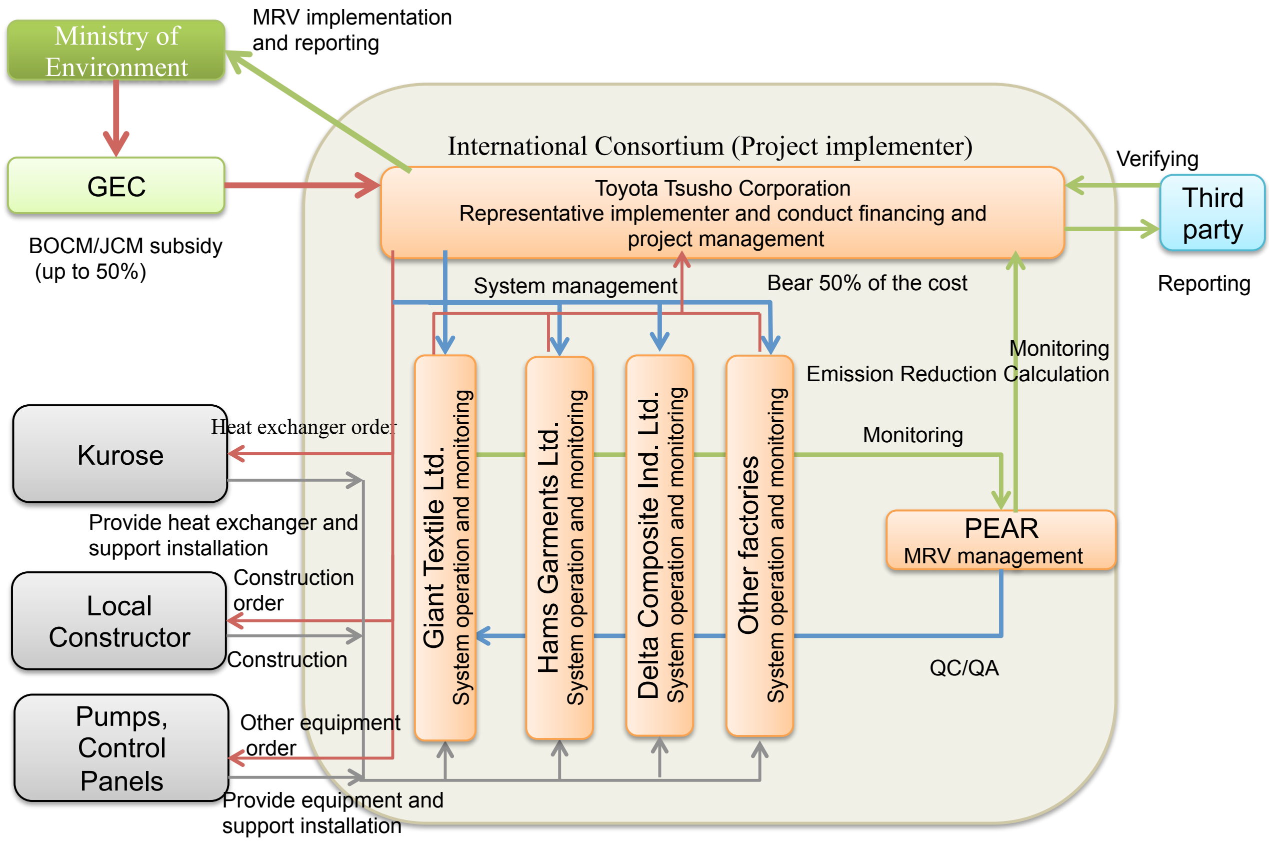

Figure 1 Project Implementation Scheme

Through the project, target factories can save energy and then corresponding cost for the energy. Energy savings (natural gas) from the project are 335,728 m^3/year, 471,352 m^3/year and 783,097 m^3/year for GLT, Hams and Delta respectively.

5 Tk/m^3, 8 Tk/m^3 and 10 Tk/m^3 different scenarios of natural gas prices are taken for economic analysis of the project. Here 5 Tk/m^3 is the current price for natural gas. Bangladesh government is considering increasing the price of natural gas. At the moment, it is decided to double the price for domestic natural gas use. Though it is clear that the price of industrial gas use will also be increased in the future; however, it's timing and range are not clear yet.

Table 2 Information of Project Energy Saving Impact Calculation

Parameters/Factories	Hams	Delta	GTL	Total
Temperature of feed water in the project (℃)	50	50	50	
Temperature of feed water before the project (℃)	26	26	26	
Amount of feed water (t/y)	153,720	241,200	105,840	
Water heat capacity (kJ/kg ℃)	4.1855	4.1855	4.1855	
Boiler efficiency	0.90	0.85	0.87	
CO2 emission factor of boiler fuel (t CO_2/TJ)	54.3	54.3	54.3	
System electricity consumption (MWh/y)	133	181	124	
Emission factor of electricity source (t CO_2/MWh)	0.67	0.67	0.67	
Emission reductions (t CO_2/y)*	737	1,179	481	2,397
Net caloric value of natural gas (MJ/m3)**	36.4	36.4	36.4	
Energy saving (m3/y)	471,352	783,097	335,728	1,590,177

*1.0 as boiler efficiency and 0.8 as emission factors of electricity are applied to calculate emission reductions.

** http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=3&pid=52&aid=10

The economic analysis for each factory respecting for varies gas prices are given in the tables below.

Table 3 Economic Analyses

Gas Price	10 Tk/m^3			8 Tk/m^3		5 Tk/m^3	
	Hams	Delta	GTL	Hams	Delta	Hams	Delta
IRR	39%	42%	23%	25%	27%	13%	15%
Payback period (year)	2.4	2.3	3.8	3.5	3.3	5.3	5
Net benefits (million)	46	79	24	27	48	13	24

The results of economic analysis from the perspective of target factories in the table above show the payback periods for the gas price in 10 Tk/m^3 are very attractive. For the gas price in 8 Tk/m^3, the figures also seem acceptable. In the case of current gas price (5Tk/m^3), except GTL that uses CNG with the price of 10Tk/m^3, payback periods are within 6 years that are not attractive for factories. However, it is clear that the gas price will be increased in the near future that makes the project feasible for factories for long term.

Moreover, there is a loan scheme from IDCOL (Infrastructure Development Company Limited) for projects that promote renewable energy and energy efficiency. Factories are able to have loans up to 60% of the total investment with an interest rate of at least 9% under the scheme. Economic analyses for the case of 60% loans with 10% interest rate are shown in the table 4 below.

Table 4 Economic Analyses (for the case of loan)

Gas Price	10 Tk/m^3			8 Tk/m^3		5 Tk/m^3	
	Hams	Delta	GTL	Hams	Delta	Hams	Delta
IRR	79%	98%	41%	44%	49%	15%	19%
Payback period (year)	2.9	2.7	4.9	4.5	4.2	7.8	7.1
Net benefits (million)	38	89	16	19	35	5	11

2) Permits and Licenses for the project development and implementation

According to the Environmental Conservation Rules, 1977, textile and garment factories belong to red category that requires EIA for implementation the kind of projects. However, this project targets factories that are holding Environmental Clearance Certificates and then there is no need to conduct any EIA additionally. Furthermore, the system being introduced under the project is a close system that will not generate any kind of solid or liquid wastes and pumps in the system also works with the pressure lower than 0.005MPa and then no risk even if pipe clogging happen. However, even that keeping in mind to report to the department of environment before starting the construction.

3) Advantage of Japanese technology

The core technology of the system is the heat exchanger of Kurose. The heat exchanger is spiral heat exchanger without distance piece that is a patented product of Kurose.

Say heat exchanger, there are several types. The spiral type is apt for heat collection from wastewater containing solid and gelled substances. Though, tubular heat exchangers had a history of being applied in textile industry. At present, it has been seen seldom in the field due to its nature of low efficient and space consuming. Plate type heat exchanger had been applied widely in China. However, prompt clogging with textile scraps and pastes make its maintenance cost high from repeated breaking down and assembling for cleaning. In most factories they exist in a dormant state for many years. Even in China where labor cost is not so high they have been abandoned from many years.

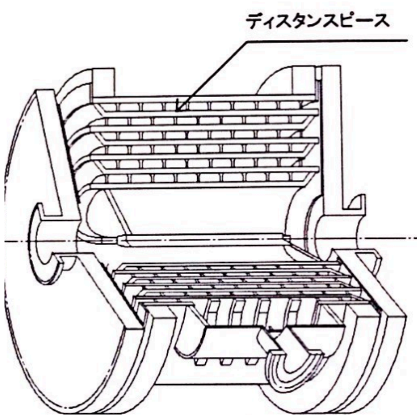

Figure 2

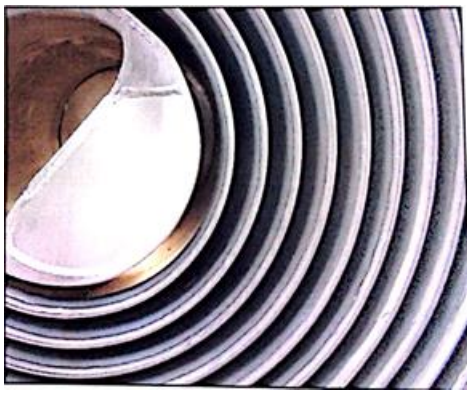

Figure 3

The figure 2 and 3 below shows structure of the spiral heat exchanger. Generally, there are distance pieces between flow channels as shown in the figure 2. However, in the case of liquids with long thread line/fibers, the spiral heat exchanger with the distance pieces easily occurs clogging.

On the other hand, Kurose has developed a spiral heat exchanger without distance pieces (refer to figure 3) that is low fouling and easy to clean. Compare to tubular heat exchangers, it has advantages of high efficiency, low maintenance and space saving.

It is costly compare to the plate type heat exchangers. It has been widely applied at wastewater treatment plants in Japan. Along with the increasing of energy cost, an increased number of chemical factories and paper mills have been applying the spiral heat exchangers without distance pieces.

Moreover, the heat exchangers are been highly appreciated by domestic textile factories that started to apply the technology. Regarding the spiral heat exchanger, the domestic (Japan) market share is nearly 100%. In overseas, it is also high valued. For example it has acquired U stamp of ASME (American Society of Mechanical Engineers), manufacturing licenses in China and Korea.

In Bangladesh, there are cases of application of tubular and plate heat exchangers in textile and garment factories. However, there has been no any case for application of heat exchangers for recovering waste heat of wastewater from dyeing sections.

For the project the spiral heat exchanger without distance pieces is selected for application due to aptness of the technology for the project. The project will be the first case of applying such a kind of technology in Bangladesh Textile and Garment factories.

It is clear that the project will realize energy saving through the technology. It is expected that the project will contribute to sustainable development in Bangladesh textile industry by expanding the technology among the factories.

4) MRV structure

Parameters are selected carefully from the perspective of developing a methodology that is simple, transparent and conservative as well compare to methodologies of CDM. As a result, the following 4 parameters are selected for monitoring ex post of the project.

No.1 : Temperature of the feed water (hot) to dyeing machines after the project (°C)
No.2 : Temperature of feed water (fresh) to heat exchanger after the project (°C)
No.3 : Amount of the feed water (hot) to the dyeing machines after the project (t/y)
No.4 : Amount of the electricity consumption of the system after the project (MWh/y)

For measuring the No.1 and No.2, temperature measurement system that has functions of data transmission through frequency conversions will be installed to ensure continuous data collection and recording. For the parameter No. 3, flow meters with data transmission functions will be installed to promise continuous data collection and recording. A dyeing master (or an assigned person for the task) in each factory will collect the data recorded automatically once a week and record them into data sheets prepared beforehand.

For the parameter No.4, power meters are installed to control panels of the system introduced to measure accumulated power consumption of the system. A dyeing master (or an assigned person for the task) in each factory will read power meters and record the figures after each shift. Factories managers will collect all data once a week and record them into data sheets prepared beforehand. All meters with sensors will be inspected, maintained and calibrated regularly as per specifications, guidelines from makers.

QA/QC system is very important to ensure reliability of a monitoring. As situations in each factory are different, it is hard and inappropriate to develop a uniform QA/QC system for all factories. Concrete monitoring plans for the factories will be developed in due course of implementation process. In the study, a monitoring and MRV scheme shown in the figure 4 is developed in a general way.

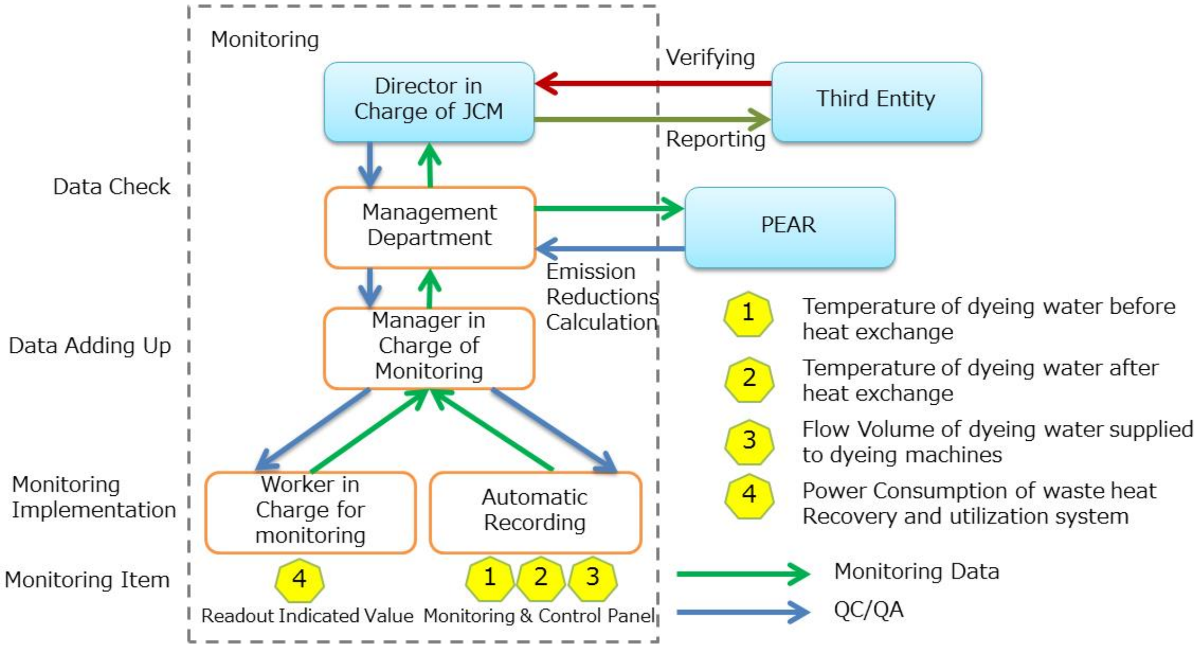

Figure 4 Monitoring and MRV Scheme

5) Environmental integrity and Sustainable development in host country

As mentioned before, textile factories belong to red category that requires EIA for project implementation. However, this project targets textile and garment factories that already held Environmental Clearance Certificates.

Therefore there is no need to conduct any EIA additionally. Furthermore, the system being introduced under the project is a close system that will not generate any kind of solid or liquid wastes and pumps in the system also works with the pressure lower than 0.005MPa and then no risk even if pipe clogging happen. However, even that keeping in mind to report to the department of environment before starting the construction.

Moreover, the project will save energy (natural gas consumption) in Textile and Garment industry that is a pillar industry of Bangladesh. Then the project is seen to contribute to improve energy supply and demand and then sustainable development by contributing energy security of Bangladesh.

At present, Bangladesh is suffering from lack of natural gas supply that causes difficulty of gaining gas connection for new factories and gas consumption limitation for existing factories. The project that covers 3 factories can save 1.2 million m^3 of natural gas annually and expansion of the project to more factories can promise further saving a far larger amount of natural gas.

6) Toward project realization (planned schedule and possible obstacles to be overcome)

The schedule for future works is given as follows.

February 2015	Completion of the feasibility study
March 2015	Site visit
April 2015	Confirm factories investment willingness

May 2015	Confirm and establish BOCM project implementation system
June 2015	Apply for BOCM implementation project
September 2015	Project start
October 2015	Verification of MRV methodology
December 2015	Project registration application for BOCM joint Committee
January 2016	System operation start Implementation of technology transfer (operation, maintenance and management) Capacity building for MRV implementation
February 2016	Start monitoring
March 2016	Completion of the report for BOCM project.

Tasks:

In order to implement the project as per the schedules, there are some tasks need to be cleared.

The first is the financing. In the study, it is planned that the factories will responsible for financing 50% of the total cost. With the gas price of 10 Tk/m^3, the project incurs enough benefits to motivate factories' willingness to invest. However, if price rise will not be realized or postponed, the projects' benefits will shrink by a large margin and factories' willingness to investment will drop as well. For this, it needs to discuss and negotiate with factories taking several cases into consideration. IDCOL's (Infrastructure Development Company Limited) loan for renewable and energy efficiency promotion projects is considered as an option if factories have difficulties of adjusting their own funds. In a word, it is necessary to confirm the factories' willingness to invest as soon as possible.

The second is technical risks. If the construction of tanks, installment of equipment, piping and wiring can meet technical standards expected is an issue of taking into consideration. It requires developing construction specs in detail, confirming final schedules and costs before implementation. Moreover, it needs to establish a system for construction process management and ensuring QA/QC together with local consultants.

Furthermore, the factories will operate the system of waste heat recovery and application. So it needs to ensure technical transfers including system maintenance and management prior to project operation.

Together with capacity building for MRV, it is important to increase awareness of managers toward maintenance and calibration of monitoring equipment.

Except the issues mentioned above, there is no any big risk that poses an impediment for project implementation. Based on designs in detail and closely working stakeholders, strive for realization of the JCM project as soon as possible.

(2) JCM methodology development

1) Eligibility criteria

The following eligibility criteria are identified for the methodology application.

Criterion 1	Waste heat (heat from dyeing waste water) recovery from dyeing and finishing process in the existing or new textile and garment factories.
Criterion 2	Spiral heat exchanger without distance pieces is applied for heat recovery.

Criterion 3	Targeting factories with dyeing capacity more than 10 ton/day

The heat exchanger is the spiral heat exchanger without distance pieces that will be customized to the factories. The technology is the first trail for textile and garment factories in Bangladesh. The technology ensure reduction of steam consumption in dyeing process that in turn results in reduction of fossil fuel consumption of boilers that provide steam for dyeing process in the factories. The project image is shown in the figure 5 below.

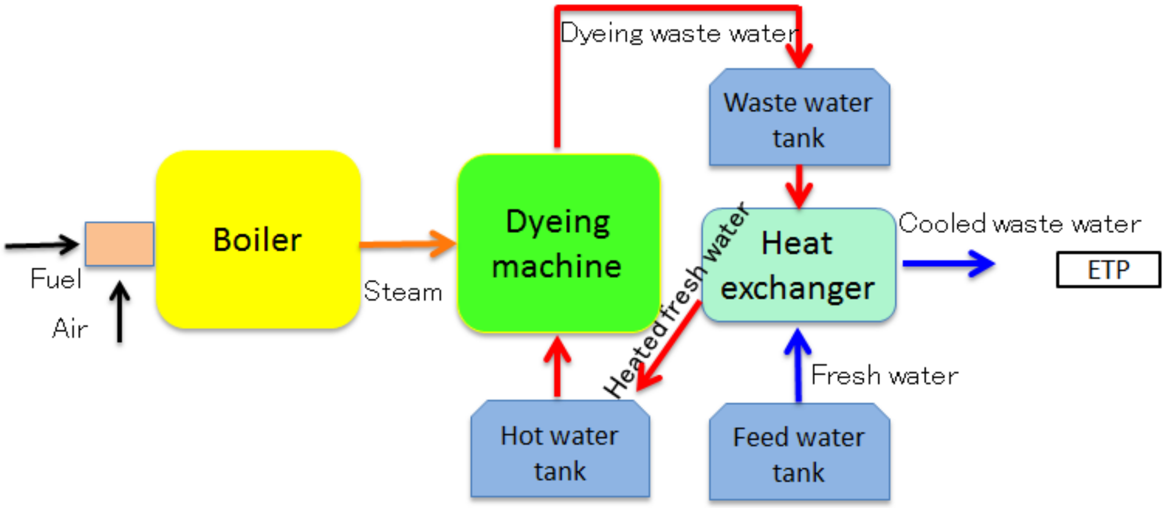

Figure 5 Image of the Project

2) Calculation of GHG emissions (including reference and project emissions)

The reference emission is the emission from consumption of fossil fuel to gain the same amount of energy utilized from waste heat recovery system. It is determined as follows.

[(Temperature of feed water in the project) - (Temperature of feed water in the case of without project)] × (The amount of the feed water in the project)×(the specific heat of water)/(boiler efficiency)×(CO_2 emission factor the fossil fuel that is used to provide energy for dyeing and finishing process).

For the boiler efficiency, 1.0 is applied. For CO_2 other parameters, lower values between upper and lower values are applied for conservativeness.

The equation is give as follows

$$RE_y = (T_P - T_{Re})\times \mathrm{W}_{th} \times \mathrm{F_w} \times \frac{1}{\mathrm{Ef}} \times \mathrm{EF_{CO2,fuel}} \times 10^{-6}$$

$\mathrm{RE_y}$:	Reference emission [tCO_2/y]
$\mathrm{T_P}$:	Temperature of feed-water in the project [°C]
$\mathrm{T_{Re}}$:	Temperature of feed-water in the case of without the project [°C]
$\mathrm{W_{th}}$:	The specific heat of water [kJ/kg °C]
$\mathrm{F_w}$:	The amount of the feed-water in the project [t/y]

Ef: Boiler efficiency [ratio]

$EF_{CO2,fuel}$: CO_2 emission factor the fossil fuel that is used to provide energy for dyeing and finishing process [tCO_2/TJ]

On the other hand, project emission is calculated based on the amount of electricity consumed by the waste heat recovery system and electricity CO_2 emission factor.

$$PE_y = EC_{PJ,y} \times EF_{elec}$$

PE_y : Project emissions [t CO_2/y]

$EC_{PJ,y}$: Electricity consumption by the waste heat recovery system [MWh/y]

$\mathbf{EF_{elec}}$: CO_2 emission factor of electricity [t CO_2/MWh]

In Bangladesh, the most textile and garment factories have captive diesel or gas generators for power generation while grid power supply is not stable. For CO_2 emission factor of power generation, respective emission factors of grid and captive power generator could be used if the proportion of each is available. However, it is usually difficult to identify the proportion. Thus, emission factor of diesel generator, which is the highest emission factor, is used to calculate CO_2 emission for the conservativeness in the methodology.

Among the 3 factories, two factories are using diesel generators regularly. The rest factory is using diesel generators as back up in the case of power outage.

The emission reduction is calculated as follows.

$$ER_y = RE_y - PE_y$$

ER_y: Emission Reductions [t CO_2/y]

RE_y: Reference emissions [t CO_2/y]

PE_y: Project emissions [t CO_2/y]

3) Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
Ef	Boiler efficiency	1.0 is used for conservativeness
$EF_{CO2,fuel}$	CO_2 emission factor of the fuel used for steam generation Natural gas: 54.3 t CO_2/TJ (54.3–58.3)	2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.4, Chapter 1, Volume 2.
EF_{elec}	CO_2 emission factor of electricity: 0.8 tCO_2/MWh (Diesel captive power plant)	Emission factor of diesel captive power is used for the conservativeness (Table I.F.1, Small Scale CDM Methodology: AMS I.F., Ver.2)

		Emission factor of the grid is 0.67 tCO_2/MWh (Official data of Bangladesh Government).