OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

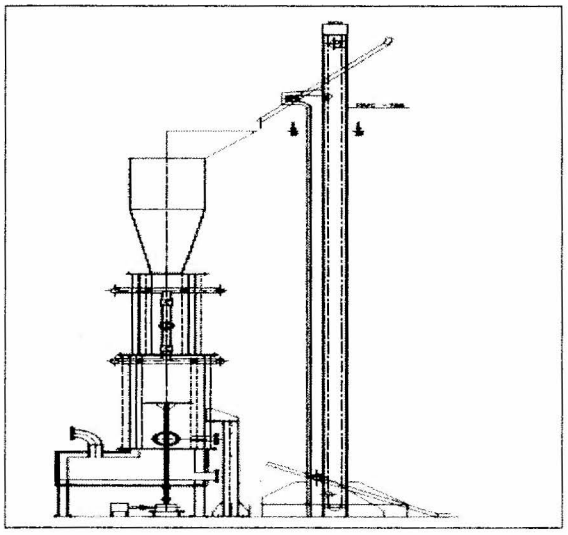
Interim Progress Report-

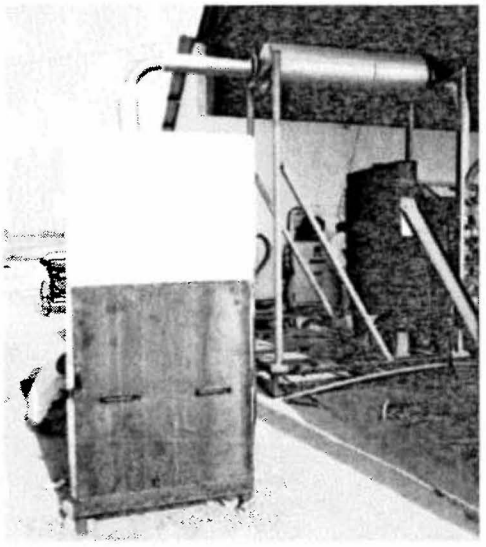
Contract No. 3000019138 (SAP ID: 100258)

Promoting small biomass power plants in rural Thailand for sustainable renewable energy management and community involvement

Prepared for

The United Nations Industrial Development Organization





Prepared by

The Energy and Resources Institute

April, 2015

Table of contents

List of figures

Background

The objective of the project is to promote small biomass power plants in rural Thailand for sustainable renewable energy management and community involvement. The capacity of the proposed biomass gasifier based power plant will be 250 kW_e. Two biomass gasifier systems, each with capacity of 125 kW_e will be provided to produce the required power output of 250 kW_e. The proposed site was Phrae district in Thailand. The project was aimed to use bamboo waste produced from the chopstick industries in Napoon. The nodes of bamboo produced as a biomass waste from these industries are suitable for biomass gasification and power generation. The bamboo waste (Nodes) available from the industries is freshly harvested and having moisture content above 50%. A detailed study was carried out to estimate the biomass potential at the site, (team members from TERI, University of Chiang Mai and UNIDO Thailand. During the feasibility study the team had meetings with local administrations and briefed about the features of the new technology of gasification. Later, there were several queries regarding the environment aspects of the system in context of the regulations in Thailand. The queries were answered based as and when, as per the requirements and status of the technology. Several changes were incorporated in the design of the gasifier systems to address the issues related to the local requirements. Few of them are improved ash removal system, mechanized fuel feeding system and fuel dryer. The system to be supplied will be able to produce 250 kW_e of power (3 phase, 415 V). The beneficiary want to supply the power produced in local grid. In this case it is required additional grid interface equipment, to pump the power in to the local grid. TERI

There were several queries from UNIDO Thailand, on issues and possible solutions related to the proposed biomass power plant. In February 2015, there was a communication from UNIDO Thailand, that there will be a change in the proposed site due to grid compatibility. The sustainability of biomass availability and its suitability for gasification need to be analyzed critically, before finalizing the proposed project site.

This is an interim progress report, which consists of the design improvements and other activities carried out, after submission of the first progress report, in April 2014. The important communications (with questions and answers) related to the various aspects of the projects are provided as annexures (1 -5) to this report. Design of additional components, worked out after submission of the first progress report is:

- Mechanized fuel feeding system
- Improved ash removal system
- A dryer for biomass using the engine exhaust
- Information related to vendor to support the beneficiary for grid interface activities

Introduction

During the field visits, the beneficiary in Thailand was informed about the proposed technology and its salient features through a presentation, in presence of the representative from UNIDO, Thailand. Subsequently, since February 2014 TERI has been receiving several queries from UNIDO, Thailand. The quires can be broadly categorized in three different categories. They are (i) Design features of biomass gasifier system, (ii) Details of the civil structure and (iii) Role clarification in work components of different stakeholders. In the first progress report, most of the queries were addressed in details. Thereafter another set of questions were addressed to TERI on which were answered as addendum to the first progress report. At this point of time new coordinator has taken charge in Thailand who wanted further clarification on civil construction and fuel handling system. A set of environment regulation was received on 4th April 2014. Another document was received on 15 may 2014. Another announcement on environment regulation was received on 31st July2014. All this issues were addressed adequately in the progress report and in the addendum to the first progress report. Further clarification was provided related to several questions on 25th August 2014. Starting from 28th February 2014 till 15th August 2014 we have been addressing the queries to the earlier coordinator as well as newly appointed coordinator to the project in UNIDO-Thailand. There was a substantial delay in finalizing the civil structure due to the uncertainty of the proposed site. As a result of this, the civil construction work is not yet initiated, on ground. There is a need to expedite the civil construction work in order to complete the project without further delay. Further, such delays cause adverse impact financially, as the cost of hardware goods/ materials keep increasing along with time. The manufacturer was informed to have adequate stock of high temperature resistant materials to minimize the impact of the delay in fabrication in the overall system cost. The fabrication of the gasifier system and purchase order for the genset will be initiated on receipt of the civil work completion schedule and site finalization.

While waiting for the progress and information about the civil works at site, a mail was received from UNIDO Thailand 3rd Feb 2015. The mail from UNIDO Thailand refers that the project site, which was selected earlier, during initiation of the project, is having issues due to grid compatibility. It was also proposed for change of site as well as change of feed material.

1. Mechanized Fuel Feeding System

A biomass fuel feeding system was designed to minimize the human involvement in biomass feeding. The feeding system was mechanized and can be controlled using a switch provided with the feeder system. The mechanical feeding system is a skip hoist which will enable to feed the gasifier at the required frequency. Generally the gasifiers are fed once in 2 hours at its full load, operating conditions. The skip hoist used for feeding the biomass, to be integrated with limit switches to operate the system with safety and trouble free. The skip hoist has bucket elevator, which move vertically up and tilts the fuel

to the gasifier, through a fuel chute attachment. The fuel chute connects the bucket and the gasifier with an appropriate slope for easy flow of biomass fuel. A sketch of the fuel feeding system is provided in figure 1.

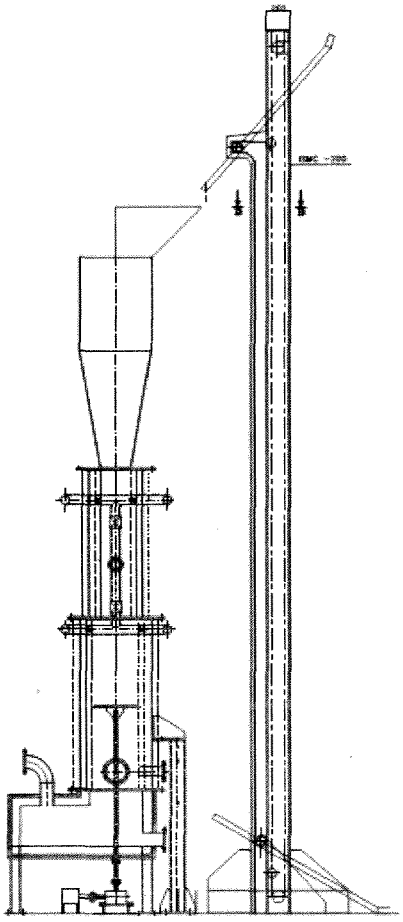


Figure 1 A sketch of the mechanized fuel feeding system

The mechanized fuel feeding system needs to be installed vertically. It needs a foundation made of RCC. The foundation drawing will be provided to the beneficiary, to carry the necessary civil works at site, prior to shipment.

2. Improved Ash Removal System

An improved ash handling system was developed to have a long duration operation. A secondary ash storage pit is introduced in the design of the system to accommodate more quantity of ash. This component will enable increased ash storage for continuous operation of the system. The improved ash removal system can minimize the human involvement and frequency of ash removal. The ash removal system will be incorporated with suitable equipment for easy handling.

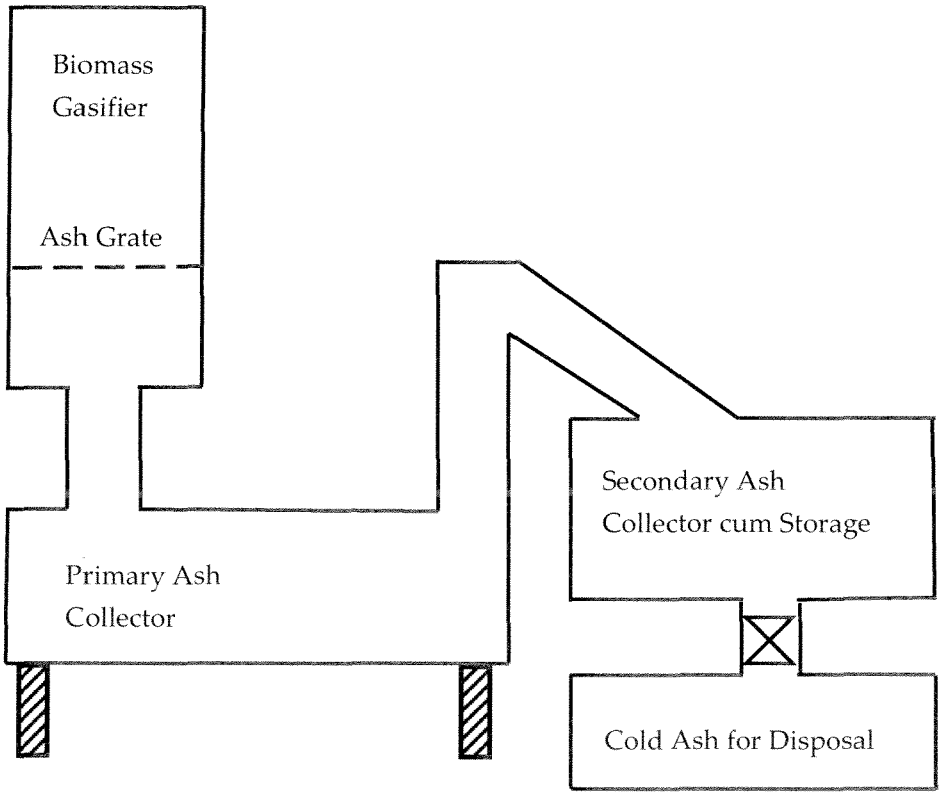


Figure 2 Improved ash handling system

3. A Dryer for Biomass using Engine Exhaust

Moisture content in fuel wood affects the quality of the producer gas. Drying the fuel wood is a challenge during winter and rainy season. Use of wet biomass above 10 % Moisture can lead to several problems related to operation and maintenance of the gasifier. Waste heat from the engine exhaust, a potential source of energy to dry wet biomass. Waste heat from the engine available from the exhaust is being used to dry the wet biomass. The flue gas after the engine exhaust is at more than 350 °C. Efficient

drying of wet biomass can be achieved through the high temperature waste heat available from flue gas of the engine. To overcome the problem of high moisture content, a dryer has been designed. A prototype biomass dryer was made as per the design specifications and tested using engine exhaust. Dried biomass can be removed from the bottom of the dryer by opening a slide door and a lock of a grill door. To avoid any additional pressure drop to the engine exhaust, the drier was designed with a minimum pressure drop across the drying bin and flue gas path(less than 50 mm WG). A sketch of the dryer with the details of the components is shown in figure 3. A view of the dryer tested using the engine exhaust is shown figure 4

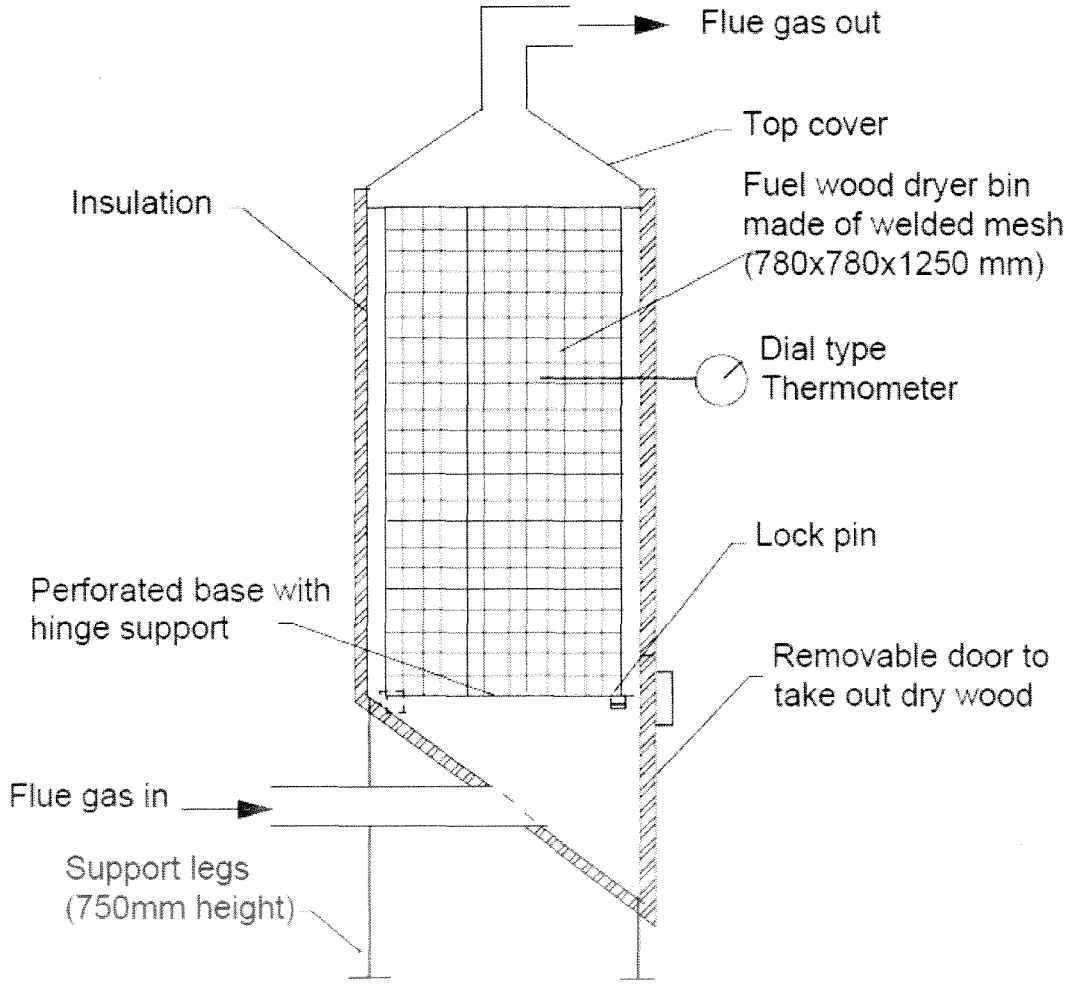


Figure 3 A sketch of the proto type fuel dryer with its components

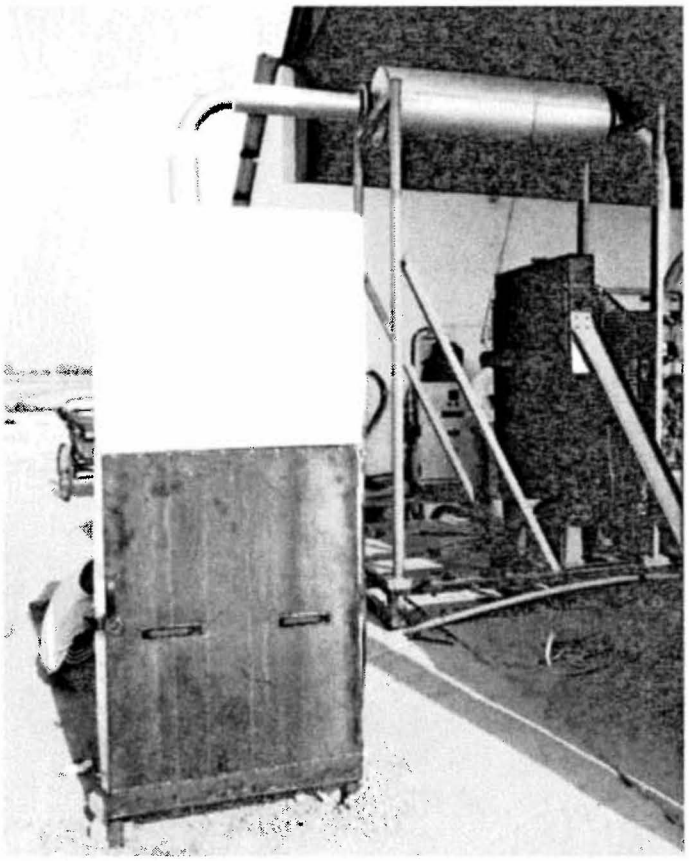


Figure 4 A view of the prototype biomass dryer connected to the exhaust.

4. Information related to vendor to support the beneficiary for grid interface activities

A supplier for grid connection related equipment was identified and contacted. We had discussion with the experts, who works on grid interface systems. The grid interface equipment supplier can be engaged in installation and commissioning at the site. A quote was obtained and communicated to the beneficiary for engaging the grid interface provider. Based on the interaction with the supplier, it was estimated that the grid interface system will cost about US$ 60,000. This estimate includes grid interface panels, controls, step- up-transformers, installation and commissioning charges. The beneficiary can include this amount for estimation of the budget required for grid interface.

5. Conclusions

A detailed analysis of biomass potential was carried at the site, which was proposed originally, during the initial phase of the project. The design of the biomass gasifier system with a capacity of 250 kWe (2x 125 kWe systems) was completed. There were several enquiries about the system related to environment and operation al factors. The questions were answered as per the features of the proposed system.

After submission of the first progress report, design of additional equipment was completed (like biomass dryer, mechanized biomass fuel loading system and improved ash removal system). On 3rd Feb 2015, it was informed (by UNIDO Thailand) that there is a change in the proposed site and fuels. Keeping the producer gas engine or the gasifier related equipment in idle conditions for a long time may create problem at later stage, while commissioning. To initiate the procurement of the equipment, it is important to know about the finalized location, fuels to be used and completion of civil construction with necessary infrastructure at the proposed site.

To add more clarity on the project progress and status, the key points of several communications related to the project are provided as annexures (1 to 7).

Annexure 1 - Detailed reply for the questions received in April and May 2015

Clarifications for the mail received on: 6th April 2015

1.The detailed specification/dimension/weight of all machines such as gasifier reactors, gas cleaning systems, bowers, motors, gas engine, etc. as shown in Figure 4 and 5 in TERI 1st progress report.

The civil construction requirements along with the location of the equipment are provided in the interim progress report, (Annexure 7). A separate drawing on the foundation detail is attached along with this report.

2. Piping system, does TERI prepare the piping system from India? or Will TERI purchase from Thailand during the installation?

Complete set of pipeline required for gas line (connecting the gasifier equipment) will be provided along with the system. Water line for the cooling tower and heat exchanger has to be provided at site as part of the civil work. Electrical line from the control panel to the individual equipment (Blowers and motors) and Genset to the control panel also part of the civil work. I request you to please go through all the reports submitted so far, for more clarity about the system and the roll of TERI and beneficiary.

3. Refer to the Figure 4 in TERI 1st progress report, our project partner wants to know what kind of basement of each machine/equipment? Would you also provide us the dimension of basement of each machine?

Please refer the civil construction requirements (annexure 7) in the report.

4. For electricity supply during start up, you mentioned in section 3.3.5 of TERI 1st progress report, that it needs power from grid at 8-9kW. Therefore, the project partner wants to know who will support the Power control Panel and/or electrical system drawing? If TERI does not support the Power control panel and no drawing for electrical line system, then, they will ask electrical engineer to design electrical system and power line in this plant.

Control panel for all the equipment will be provided along with the system. Electric line should be made available at site to connect the equipment and the control panel.

Clarifications for the mail received on: 9th April 2015

Thank you very much for your photos.
In your photo, what are the differences between the Green engine and Enerton (blue box)?.
You are proposing the gas engine look like Enerton (Blue box), Right?

The photographs sent were from a 50 kWe biomass power plant, designed to supply electricity to the nearby villages. The electricity produced from this power plant is supplied through a dedicated mini-grid. At this location there is no power available from grid. The biomass power plant needs some electricity

during the startup of the system. Hence, a small diesel genset (Enerton, in Blue box) is being used as a bake up to the system to produce the power, which is required to start the gasifier system. The Green engine coupled with the alternator is the main unit. This engine is a natural gas engine used to run on producer gas (biomass gas).

As the grid power is available at site, the proposed system will not have any genset as a backup.

Clarifications for the mail received on: 22nd April 2015

1) Does it need the specific room for this engine to reduce noise?

By the way, regarding to the grid interface system supplied by TERI as you mentioned in email on 11 October 2014. Please see the attachment.
I would like to ask you that:

The engines will be procured with acoustic cladding, which will take care of noise. Generally closed rooms are not recommended for the engines, to have better ventilation. Regarding grid inter face please see the answer to the next question.

2) Can we use this system for connecting with grid for electricity supply in the plant before it is produces by Gasification system?
Or 3) Does our project partner (Phrae PAO) has to buy the 3 phase Electrical system (Control box and others accessories) separately?

The capacity of the biomass power plant is to produce 250 kWe (2x125 kWe). The power output from the genset will be three phase power rated at 415 V AC. More details were provided in the earlier reply. The same may be referred from the interim report, attached with this mail.

The beneficiary has to buy the interface system according to the local grid specifications. TERI has not incorporated any budget for grid interface system. More details may be seen from the First progress report and from the interim report.
The function of getting power from the grid for initial startup and providing the produced power to the grid has to be performed by the grid interface control panel.
Also please refer B - The comments and clarifications related to the detailed engineering design mailed on10th July 2014, which is presented as annexure 5, in the attached report.

Clarifications for the mail received on: 4th &11th May 2015

Can we use Bamboo pellet in 250kW BGPP?
Acceptance of pellets in the proposed system depends on the pellet quality/property. During the gasification process, most of the pellets disintegrate in the reactor and reduces the gas quality. Hence pellets based gasifiers are generally proposed for the system where the gas is fired directly using burners. When running IC engines the gas need to be pure enough to protect the engine from wear and tear. Hence, the proposed gasifier is designed to use fuel like bamboo nodes. The gasifier also can accept Corn cob to some extent, as it is.

From the presentation on estimation of Biomass potential in Wieng Ta Sub-district shows that, the combinations of bamboo nodes and corn cob have the required potential for running the biomass gasifier based power plant.

Annexure 2 - Communication: 13th February 2015

It was learned about the change of the originally proposed gasifier power plant site, in the middle of the project (3rd February 2015). Enormous effort and hard work went on feasibility study and design of the gasifier system to use bamboo and corn cob.

In the communication, it was proposed, change in biomass fuels, to be used in the proposed site [Cassava waste (root), Top& Leaves of sugar cane, Para rubber wastes, Palm wastes (empty fresh fruit branch)]. As it was communicated earlier, the gasifier reactor is designed to gasify biomass which has a set of specific properties. The proposed biomass gasifier plant can be used with, any woody type biomass waste (like bamboo waste, corn cob, coconut shell etc). The key parameters, which influence the suitability of gasification, are Void fraction (space available in between the biomass particles), Bulk density (weight of the material in kg/m3), carbon content and volatile matters.

Cassava roots may be a suitable fuel for gasification. Biomass waste from sugar cane and palm olive fruit bunch belongs to loose biomass category which do not produce gas, which is suitable for dry gas cleaning equipment. The gasifier designed to use biomass cannot support rubber waste gasification.

It is important to know about the availability of cassava root (tonnes per year) and the availability of other agro residues like corn cob and coconut shell or bamboo waste. If needed, a study on biomass potential assessment for gasification at the proposed location can be conducted for the sustainable operation of the system.

Regarding the fabrication of the system, earlier communication (Dated 5th Aug 2014) may be referred. For a quick reference, some of the relevant points from the mail sent on 5th Aug 2014,(in red colored font) are copied here:

"The transportation and delivery of the proposed biomass gasifier plant was scheduled to be in December 2014. However, fabrication and transportation of the system is linked with the civil construction and other basic infrastructure needs as provided in the civil structure requirement at site. TERI's expert team shall plan a visit after the completion of the civil structure to inspect the building and to access the preparedness for installation and commissioning at the project site. As communicated earlier the gasifier system will be fabricated and shipped only after finalization of site and civil structure is made ready for accommodation of the equipment's. The producer gas engine can be procured and stored for long period at idle conditions.

The fabrication of the system and procurement of the genset are linked with finalizing the location of the site, biomass fuel, and schedule for completion civil structure. Hence, it is suggested to mail the plan of activity related to the site preparation and completion of civil work (along with water supply and electrical connections and grid interface), at the proposed site. This will enable to start the fabrication and to finalize the schedule for shipping of the system".

Annexure 3 - Clarifications: 11th October 2014

The questions and answers

1. Does TERI start the fabrication of the gasification system and its equipment?

   We have finalized the design of the gasifier and specs of the producer gas engine, as per the details provided in the first progress report and in the addendum to the progress report. As communicated earlier, fabrication of the system, procurement of the genset and other equipment are linked with availability of civil structure and other infrastructure at site. Hence, the fabrication of the system and procurement of the engine is yet to be initiated.

   We would like to complete the project without much delay. More delay in the activities will have financial implication on overall cost of the system.

2. Does TERI plan to ship the gasification system to project location in December 2014?

   Refer the answer to Question 1.

3. Does this system will arrive the project location in February 2015? If yes, then, Phrae PAO will find the location to store these equipment before installation at new project location in December 2015.

   Refer the answer to Question 1. We will be able to work out a revised schedule after receipt of the detailed schedule of civil structure and other infrastructure availability at site. As we have written earlier, too much delay on fabrication and procurement of genset and other equipment will have financial implications. We have to work out a plan of action to minimize the financial implications.

4. Do you need to do the site visit to the new project location?

   This depends about the detailed information available about the proposed site.

5. As you mentioned that the installation needs 4-5 weeks working period and required 8-10 person and crane. Therefore, 250kW biomass gasification power plant will be installed during January-February 2016. This plant will start commissioning in March 2016. Is it correct? Please kind confirms.

   Please refer the answers for question No. 1 and 3. The installation and commissioning are linked with the civil work and other infra-structure requirement at site. The delay in completion of this activity will delay installation and commissioning, proportionally. However, we have to see how quick we can complete this project without further delay.

6. Regarding budget requirement for grid interface.

   We had discussion with the experts, who works on grid interface systems. The grid interface system will cost about US$ 60,000. This includes grid interface panels, controls, step- up-transformers, installation and commissioning charges. You may include this amount for estimation of the budget required for grid interface.

7. I do hope that the design of TERI biomass gasification power plant will not cause any accident.

It is important to understand the features of the proposed technology (details are there in the first progress report and its addendum). Continuous questions and clarifications on environment and others issues delayed the activities substantially. Once again we suggest that the person raising questions should go through the report or informed about the technology difference provided in the first progress report (and its addendum) to get more clarity about the system.

The proposed system is based on advanced gasification technology. The system is designed by keeping the safety aspects, in priority. The proposed gasifier will not be having any obstruction in fuel feeding system to hold fuel wood pieces. The proposed system will be having a mechanized loading system using a skip hoist (from the ground level to the top of the gasifier). The gasifier system is designed in such a way, that the operation of the system, including fuel loading is simple, safe and easy.

However, the biomass power plant consists of many motors, blowers, high temperature reactors and heat exchangers. Hence it is important to be cautious when working with this equipment. The system will be provided with an operation and maintenance manual. The operation manual will have a list of instructions on "Dos and Don'ts". In view of the safety aspect, it is important to follow the instructions provided in the manual as well as the instructions given during installation and commissioning.

Additional information

Related to equipment details:

We need to get more information related to your queries on skip hoist and other equipment details, from the manufacturer. I will send a separate mail related to equipment details.

Related to fuel availability:

The biomass gasifier can work with any woody biomass like corn-cob, bamboo-node, fuel wood etc. There is a large potential for corn cob. Though it is seasonal one may work out a storage system to bridge the gap.

Bamboo fiber waste belongs to the loose biomass category. Its physical and combustion property will vary a lot in comparison with loose biomass fuel. According to several technical issues a same gasifier cannot work with solid biomass and loose biomass (individually or in a combination which has more loose biomass like bamboo fiber). Densification of bamboo fiber will be more complicated and expensive than fuel wood or corn cob. The gasifier may accept a small portion of bamboo- fibers mixed with bamboo nodes. The combination of woody biomass and bamboo fibers are not yet experimented. Hence, the exact combination can be arrived after installation with practical results.

Annexure 4 - Clarifications: 25th August 2014

The answers are embedded in Red colored font

1. Please provide the function of RCC roof. He has question why do you need this type of roof.

In General gasifier systems are provided with a staircase and steel platforms. In smaller biomass gasifier systems, fuel charging is done manually; the fuel wood is carried manually till top of the gasifier hopper for loading, through a staircase. Manual lifting of fuel can be managed in smaller systems without much difficulty. When it comes to larger systems where a large quantity of fuel needs to be handled, it is essential to ensure the convenience of the operators. Hence, it is proposed to build RCC roof to facilitate the fuel handling and charging activities. There will be fuel handling and charging equipment located along with adequate access/working area for handling this equipment. If you want to go for a separate store rooms and staff rooms half of the building can have the non-RCC roof using roofing sheets with suitable supporting structure. In such a case, the total area of RCC roof may be reduced to half.

2. What is the design of feeding system of biomass fuel to refill the gasifier? Please see the attachment.

The fuel feeding arrangement of the attached diagram in the ppt. file (Ref: your mail dated 15/08/2014) shows the fuel feeding operation from the storage shed to the gasifier top. I would like to bring to your kind attention that the fuel feeding system to be supplied by TERI will lift the fuel from the ground level to the top of the gasifier for charging. Please refer the answers (iii and iv) for question No. 1 of the addendum to the first progress report.

The fuel supply management includes procurement, storage and transportation of the fuel till the gasifier power plant. To facilitate the beneficiary with ease in operation of the gasifier system, it was proposed that a vertical skip-hoist will be provided next to the gasifier. The skip-hoist will lift the fuel from the ground level to the top of fuel hopper.

To add more clarity:

i. The fuel from the fuel storage shed is taken in a trolley to the proposed fuel feeding system and the fuel is unloaded in the fuel holding bin of the skip hoist.
ii. The fuel holding bin of the skip hoist will be located below ground level (and the top of the fuel holding bin will be up to the ground level). The fuel from the trolley can be directly tilted to the fuel holding bin of the skip hoist. The fuel bin will be lifted by a chain drive and till top of the gasifier to charge the fuel hopper.
iii. A single skip hoist will be used to lift the fuel required for both the gasifiers.

3. In Staff room is a control room, Right? Why do we need it at the second floor? Can we design the tools room and staff room on ground floor?

Please refer Fig. 7 and 8 of the first progress report. Control room and staff room are separate ones. Control panel and engines are shown in ground floor where as the staff room is shown in the first floor. You may find the answers for other part of this question as part of the answers provided for question one.

4. Do generators have to install in special room for noise control?

Please refer the answer for question No. 6 of the addendum to the first progress report. The engines will be provided with acoustic cladding to reduce the noise level. This is an enclosure to suppress the noise of

the engine. Generally the engine room should have good ventilation. It is also advisable to have a single layer of brick wall (for a height of 2.5 m) for the area marked for engine and control panels (Please refer Fig. 7 of the first progress report)

5. Dose this building has a brick wall or metal sheet?

There is no brick wall required for the area referred for gasifier and gas cleaning equipment. To protect the gasifier and equipment, a welded mesh structure may be provided for a height of 3 M.

Brick wall may be provided for a height of 2.5 m for the area where the engine and control panels are located (Refer the answer to Question No. 4). Brick wall is needed for the staff room and store room.

During our visit to the site, we have given a detailed presentation along with question and answer sessions. It is good to get the doubts clarified at the initial stage of the project. However, the doubts should be cleared in a short period. The fabrication of the gasifier system and procurement of other equipment is substantially delayed due to several mails seeking clarifications of various aspects. Delay in the planned activities also has financial implications since the material costs are keeps on increasing along with time. Hope with these answers things will get clarified and we can proceed with procurement of the equipment needed for the gasifier system and the genset.

The system specification and additional clarifications are provided in the first progress report and in the addendum to the first progress report. It may be noted that, most of the answers for the questioned are referred from these reports. Please go through them and it will provide more clarity about the proposed system.

Annexure 5 - Clarifications: 5th August 2014

Please find the embedded clarifications along with the questions.

i. Does TERI supply the wood chipper machine for this project? If not, What is the suitable dimension/size of fuel and its moisture content? These parameters need to be controlled for using any kind of biomass wastes for this gasification system in case the bamboo nodes are shortage.

Yes, TERI shall supply two fuel wood cutters (with circular saw, which is operated manually) along with the gasifier system. The fuel size should not exceed 10 cm from any of the dimension i.e. length/ width/ height/diameter in order to maintain continuous flow of the fuel inside the gasifier reactor. The moisture content in the fuel should be less than 10% for optimal operation of the system.

ii. Environmental impacts related to noise, air pollution, and any kind of wastes from Biomass gasification system. Please find the list of laws and regulations of Thailand for TERI to make sure those TERI Biomass Gasification system compliance Thai laws and regulations.

Concerns related to environmental impacts have been addressed in greater details in the first progress report submitted to UNIDO on 24 June 2014. Further, if in case there are any further clarification required related to the subject matter addressed beyond what is addresses in the addendum of the first progress report, Kindly feel free to write to us.

iii. Does TERI start fabricate the gasifier and other equipment?

TERI has completed following activities i.e. design of biomass gasifier, cleaning and cooling train, identification of suitable engine, identification of gasifier manufacturer. However the order for gasifier and the engine shall be placed only on the receipt of the second installment which is due on submission of the first progress report. Though we have submitted the first progress report we were unable to proceed for seeking the second payment since there is chain of communications with several questions, even after submission of the addendum to the first progress report. I would like to bring to your kind notice that engine supplier and the gasifier manufacturer shall require at least 4 to 5 months for the supply of the same.

iv. When do they plan to deliver the gasification system?

The transportation and delivery of the proposed biomass gasifier plant was scheduled in December 2014. However, fabrication and transportation of the system is linked with the civil construction and other basic infrastructure needs as provided in the civil structure requirement at site. TERI's expert team shall plan a visit after the completion of the civil structure to inspect the building and to access the preparedness for installation and commissioning at the project site. As communicated earlier the gasifier system will be shipped only after the civil structure is made ready for accommodation of the equipment's.

Though the project is initiated in the month of January 2014, since then we have been receiving different versions of CoP, till July 2014. Also considerable time has been spent in defining the roles of various stakeholders through several mail communications, which indeed has not sorted out yet. This was causing difficulty in finalizing the schedule.

Hence I would request you to kindly mail us the activity plan (prepared with the dates) for completion of civil work along with water supply and electrical connections at the proposed site, at

the earliest. This will enable us to start the fabrication and to finalize the schedule for shipping of the system.

v. How long for installation gasification system at project location?

The installation and commissioning of the biomass gasifier power plant shall take about 4 to 5 weeks. However this may vary depending on the capacity of the local manpower and availability of other infrastructures for installation.

vi. How many manpower required for installation? and who take care the cost of man power and others cost during installation?

The manpower requirements for installation of the equipment's are two welders, two fitters and at least 5-6 labors. A crane is also required for unloading the equipment's and positioning in the air marked space in the power plant. More information related to installation and commissioning are provided after point XV.

vii. Do they have any work plan as the above issues?
The response for the same is covered in the reply to the questions I, ii, iii and iv as explained above.

viii. The drawing about housing of gasifers, gas engines and their components.

The detailed drawing i.e. plans and sectional view of the building has been provided in the first progress report. This includes the area required for power plant housing i.e. the gasifier, cleaning cooling train and the gas engine (Chapter 3 and 4). Further a detailed discussion related to the civil drawing is also provided in the addendum (In the first progress report). According to the building details provided in the first progress report (Chapter: 4), the beneficiary need to prepare a detailed estimate of budget for civil construction in the proposed site.

ix. Would you please kind support me the information?

I hope the detailed response provided in the above sections would clarify all the quires raised in the mail. However I would request you to kindly go through the Progress report once for better understanding. However if there are any further clarifications required on any of the specific point kindly feel free to write to us.

x. Does TERI prepare the operating manual, maintenance procedures and number of operating staffs? If yes, please send to CMU for translation into THAI.
The operation and maintenance manual will be prepared and mailed at the time of dispatch of the system from India.

xi. It would be good to have a VDO presentation of TERI biomass gasification project in other countries that similar to the project in Phrae. To give a concrete concept and clear picture for the local people who totally does not know about Biomass gasification power plant.

This technology is new and much improved version of the gasifier system (Refer the first progress report for more details). During our visit, about the proposed technology, a ppt presentation was made at Phrae. Currently, there is no Video presentation available on this technology

xii. How this project design for dust and noise protection? Is it require special room for noise protection?

Please go through the reports submitted, which covers in details regarding the noise reduction of the engine. Dust collectors are provided to facilitate the collection of dust which indeed has been discussed in details in the progress report and in the addendum.

xiii. Does this project will impact on human heath especially respiratory system?

This is a biomass gasifier plant. The producer gas generated from the gasifier is directly fed to an IC engine for power generation. The exhaust of the IC engine is bound to be similar to other IC engines working on producer gas. Hence there is no direct exposure of the producer gas to the human being.

xiv. Does this project will impact on the reduction of production of Orange and other orchards, and animal farms?

Such test was not conducted so far to the best of our knowledge. As this plant is completely operated on biomass there is no foreseen impact on Orchards and animal farms.

xv. If this power plant is operating and then finds the evidences that this power plant provides the adverse impacts on the environment, human health. What are the TERI responsibilities for these particular issues?

Please go through the addendum related to the environmental issues. In which the status of the system to be supplied is given in detail. Please put the specific question refereeing any particular point of the reports submitted and referred from any other published document. TERI is not responsible for any such impacts beyond the specifications provided in "Chapter A" of the addendum to the first progress report.

Regarding the installation and commissioning:

The role of TERI and beneficiary, related the installation and commissioning of the plant was communicated to UNIDO on 4th Aug 2013, prior to the award of the project.

"TERI's expertise will be applied in supervision and guidance for installation and commissioning of the gasifier systems at the proposed sites. TERI would like to have the co-operation of the local partners in procuring the services of local technicians and manual labor. Hence the expenditure against the engagement of local technicians and manual labor should be met by UNIDO/ Local service provider / local agency / Local user which are over and above the budget quoted. This has been mentioned in the deviations submitted along with the bid document".

Installation and commissioning is always to be done by the beneficiary. Organizing the local manpower and equipment to handle the gasifier components (like crane) has to be mobilized and managed at the site by the beneficiary. We can provide the details about the equipment and manpower required for installation and commissioning. The beneficiary can work out the budget according to their cost at site. TERI will design the system to minimize the man power requirement at the site through pre-assembling and detachment of the system before shipping.

Annexure 6 - Clarifications: 10th July 2014

Addendum -to the first progress report

Following the submission of the first progress report, a document was received related to environment aspects (legally approved). In the addendum to the first progress report, the environment aspects were addressed as per the status of gasification technology and based on the features of the proposed environment friendly gasifier system. There was a set of questions on the detailed engineering design, about various factors like civil construction, system design and grid interface. A comprehensive report has been prepared, addressing the comments, as an addendum to the first progress report (as a part of the second progress report).

The addendum consists of two chapters as follows.

A. Environment aspects
B. The comments and clarifications related to the detailed engineering design

A - Environmental aspects and regulations related to biomass power plants in Thailand

Table A: Regulations: Noise level

Announcement of National Environmental Committees

a) on value of noise disturbance, Volume 29, B. E. 2550 (2007), Book no. 124, Special Chapter 98 (d), Page 23
b) on assessment of General Noise standard, Volume 15, B. E. 2540 (1997)

Code of practice/ standard/ Clause	Remarks
a) Noise disturbance level is hereby identified at 10 Decibels A b) The max. Noise level not exceeding 115 dB (A). The average noise level in 24 hours not exceeding 70 dB (A)	• The engine will be provided with an acoustic cladding, as per the engine manufacturer's specifications. • The system will be provided with the prescribed norms and standards by the engine manufacture. • Testing and measurements are in the scope of the beneficiary. • TERI will supply the 250 kWe biomass gasifier based power plant along with the equipment which is related to only energy monitoring.

Table B: Regulations: Air quality-

Announcement of Ministry of Natural Resources and Environment

a) on determination of emissions control standards for air pollutants of new electric power plants, Book no. 127, Special Chapter 7 (d), Page 18, January 15, 2010

b) on value evaluation of contaminants in the air emitted from plants which generate, transmit or distribute electricity, B. E. 2547 (2004)

Particulars	Code of practice/ standard/ Clause	Remarks
Electric power stations using biomass fuels (Referring clause 2)	**Dust Particles-** Not exceed 120 mg/ m^3 **Sulfur dioxide** – Not exceed 60 ppm **Oxide gases of nitrogen** calculated in the form of Nitrogen Dioxide – Not exceed 200 ppm	• Producer gas engine emits much lower than the dust content compared to the engines work on conventional fuels. • As sulfur is not a component of producer gas. Hence, SO_2 should be within the limit. • Nitrogen is one of the major components of the producer gas. Hence, NOx in the exhaust is usually in the range of 150 to 400 ppm depending on the engine capacity, load and fuel quality • Testing and measurements are at the scope of the beneficiary. TERI will supply equipment which is related to only energy monitoring.
(Referring Clause 3)	The excess air volume for burning shall be at 50 percent, or the excess oxygen volume for burning shall be at 7 percent.	Generally for internal combustion engines, about 20% of excess air is supplied to optimize the performance of the engine.

Table C- Regulations: Ambient air quality

Announcement of National Environmental Committee

a) on determination of national ambient air quality standards, volume 28, B.E. 2550 (2010)

b) on determination of national ambient air quality standard, volume 24, B.E. 2547 (2004)

Remarks
• There is no reported value available on ambient air quality with respect to 100% producer gas engine operation. Actual ambient air quality in regular operation of 100% producer gas has to be studied. • Oxygen gas is not the component of producer gas. Producer gas is product of partial combustion and reduction. • As sulfur is not a component of producer gas. Hence, SO_2 should be within the limit.

Table D: Regulations: Wastewater discharge

a) Announcement of Ministry of Science and Technology on standard control of wastewater discharge from sources under the types of industrial plants and industrial estates, volume 3, B. E. 2539 (1996)

b) Announcement of Ministry of Industry on determination of wastewater quality discharging from factories, volume 2, B. E. 2539 (1996)

c) Announcement of National Environmental Committees on standard control of wastewater discharge from sources under the types of industrial plants and industrial estates, volume 3, B. E. 2539 (1996)

Remarks
• There is no water scrubbing cleaning system in the proposed design of the gasifier plant. Thus, the proposed system will no generate waste water. • The proposed biomass gasifier system is designed with advance technology and environment - friendly. Hence, it does not produce polluted water and eliminates the need for any effluent treatment plant.

B - The comments and clarifications related to the detailed engineering design

There were few clarifications was sought by the beneficiary. The comments and clarifications are as follows:
(Comments are in black colored font and the clarifications are in red colored fonts)

1. Civil Structure

- Unmatched civil structures between June 2013 version (page 1) and TERI version (page 2-3) as shown in the attached file.

- Fuel storage shed on the 2nd floor of the civil structure is not suitable. It needs manpower to transport the fuel to the 2nd floor. The structure must be very strong for the heavy load of fuel on the upper floor with and then it must be ferro concrete. The construction cost of structure will be very expensive.

- There is no roof for the fuel storage shed; it is not suitable when it rains.

- TERI should design and provide better fuel conveyor system that can transport fuel from the fuel storage shed on the ground floor.

i. TERI shall provide the details regarding the floor area requirement of the civil structure with technical details. This includes equipment layout plan and area requirement for service, operation and maintenance of the proposed biomass power plant.

ii. The area required for equipment and the space for free movement of the operators change based on several factors such as Type of end-use application, duration of operation, fuel loading frequency and engine specifications. As per the discussions and observation from the field visit, the proposed dimension of the biomass gasifier based power house were arrived.
Another factor that has contributed in the variation in proposed floor area for the power house is due to variation in the area requirement of a normal engine and engine with acoustic cladding as desired by the local community why indeed is accounted for in the new plan.

iii. In the report, it was suggested, the fuel storage should be away from the gasifier system, keeping the safety aspects in view. The fuel supply management that includes procurement, storage and transportation of the fuel till the gasifier power plant has to be managed by the beneficiary at the beneficiary's convenience. Hence, the beneficiary can decide the location size, shape and structure of the fuel storage according to their local needs and convenience. The system needs about 30 cubic meter volume of fuel per day, when the plant operates under full load conditions.

iv. A vertical skip-hoist will be provided next to the gasifier. The skip-hoist will lift the fuel from the ground level to the top of the fuel hopper of the gasifier.

v. The proposed fuel storage on the gasifier shed is for a capacity of 2.5 to 3 tonne, which is indeed required to top up the reactor once in 4 to 5 hours of operation at full load conditions.

2. Gasification

- In the topic number 3.2 "main gasifier unit" paragraph 2, ""the fuel hopper is designed to store and feed fuel to the reactor for five hours of the continuous operation.", what does it means? After five hours of

operation, the gasifier must be stopped for feeding the fuel? How does it effect to the electric system? Can TERI design continuous operation without stopping the system for feeding the fuel?

i. The fuel hoper is designed to store fuel and feed the same into the reactor during five hours of continuous operation. Which indeed a clear indication that the fuel charging interval should be in the range of four to five hours.
ii. There is no need to stop the gasifier after five hours.
iii. During the fuel charging period the power output (load on the engine) need to be reduced since the top lid of the gasifier reactor shall be opened for fuel charging. The duration of the fuel charging is kept as short as possible in order to retain the overall power production rate. The system is designed to operate continuously. During fuel charging of the entire system will be shifted to suction (induced draft) mode. The details of the same shall be provided along with the operation manual.

3. There is no information about the heat exchangers cleaning when there is tar or dust on the heat exchangers.

i. The system is designed to produce the producer gas with low impurities (tar and dust). Dust collectors are provided at the base of the heat exchanger. The dust is collected in the dust collectors which indeed need to be cleaned periodically.
ii. In Heat exchanger I, The producer gas temperature will be in the in the band of 150- 500° C. Hence, there will be no condensation occurs in this heat exchanger. Only dust is collected which needs to be removed from the dust collectors periodically using the valves provided bellow the heat exchangers.
iii. Heat exchanger II and Heat exchanger III are operated at low temperature. These heat exchangers are provided with condensate collector. The condensate collected need to draw off the heat exchanger through the vent out valve provided at the bottom.

4. In the topic number 3.3.3 Gasification efficiency and gas quality, there is no information on qualification of gas output from the system. TERI need to provide more information on qualification of suitable fuel such as moisture etc., TERI need to provide gas output quality, Tar quantity, heating value, temperature.

i. The fuel (wood/ bamboo) used in the biomass gasifier should not have moisture content more than 10%. Increase in moisture content in the fuel will increase the impurities in the gas, which intern effects the engine performance as well as adverse impacts on engine maintenance.
The proposed gasifier is dual fired down draft gasifier with dry gas cleaning system.
ii. Generally, the tar content in the raw gas is in the range of 100-200 mg depending on the fuel quality. When fuel is dry(less than 10 % moisture), the impurities in the gas at the engine inlet (after cleaning and cooling train) is of the tune 50 mg/Nm^3 this includes total tar and dust. The compositions of tar are very complex and it consists of innumerable complex chains of hydro carbons. They are classified as light tar which can burn as fuel and heavy tars which can condense in the line. The dual fired downdraft gasifier based power generation systems are in field operation in India since 2012 without any problem, which indeed reflects on the quality of gas produced in such gasifiers and its suitability to drive an IC engine.
iii. However quality of the gas is predominantly fuel specific. When the gasifier is operated on fuel wood, having moisture content within the specified limit of 10% moisture content the heating value of the producer gas is in the range of 1100 to 1200 kcal/ Nm^3. The temperature of the gas at the out let of the gasifier is between 500 to 600 °C. The producer gas temperature is brought down closer to the ambient (to the order of 10 to 15 °C above ambient), before it is fed into an IC engine.

5. Gas engine and generator must be new and must be guaranteed from the producer not from TERI.

i. The gas engine and generator will be new.

ii. None of the existing engine manufactures in India who can give a letter of guarantee to run the engine on the producer gas. Hence it would be very difficult to produce the same. There is no engine designed particularly to run on producer gas as in the case of natural gas, petrol, Diesel etc. In general the engines used in biomass gasifiers are natural gas engines. Additional spare parts required for regular operation and maintenance can be procured from the engine supplier, for a period of one year.

6. In the topic number 3.3.4, based on the discussion at the Phrae office, TERI will **explore** the possibility of noise reduction by incorporating an acoustic cladding through the engine supplier. The word "explore" must be changed to "ensure". TERI will **ensure** the possibility of noise reduction by incorporating an acoustic cladding through the engine supplier. It is to guarantee that it can reduce noise to be in accordance with the limited noise level in the national laws and regulations.

i. TERI would request the engine supplier to supply the engine with the acoustic cladding. However the acoustic cladding and noise reduction would be as per the regular standards followed by the engine manufacturers in India.

7. In paragraph 4, Chapter 6 conclusion, "TERI will supply the 250 kW_e (3 phase;415 V) biomass power plant. **The beneficiary has to procure any equipment which is required to use the power procured from the proposed biomass power plant. In case of using the power through the grid, the beneficiary has to procure the interface component, which is required to link the power plant and the grid. In such a case, the procurement of the component, installation, commissioning and obtaining relevant permission from the local electricity authority is in the scope of the beneficiary's responsibility.** The component and other requirements to be organized for the grid connection by the beneficiary are provided in Annexure 3." and paragraph 6, **"Manpower arrangement for installation commissioning and regular operation and maintenance of the system, have to be arranged by the beneficiary**. TERI's professional will be providing all the technical support during installation and commissioning of the biomass power plant."

TERI mentioned that local authorities need to provide interface equipment, this is not in line with the understanding of local authorities as discussed earlier with UNIDO. In addition, the manpower arrangement for installation commissioning is local authority's responsibilities. It also not in line with the understanding of CMU, Phrae PAO, Napoon SAO. Local authorities have never been informed that they need to provide co-financing for both interface equipment and installation commissioning manpower.

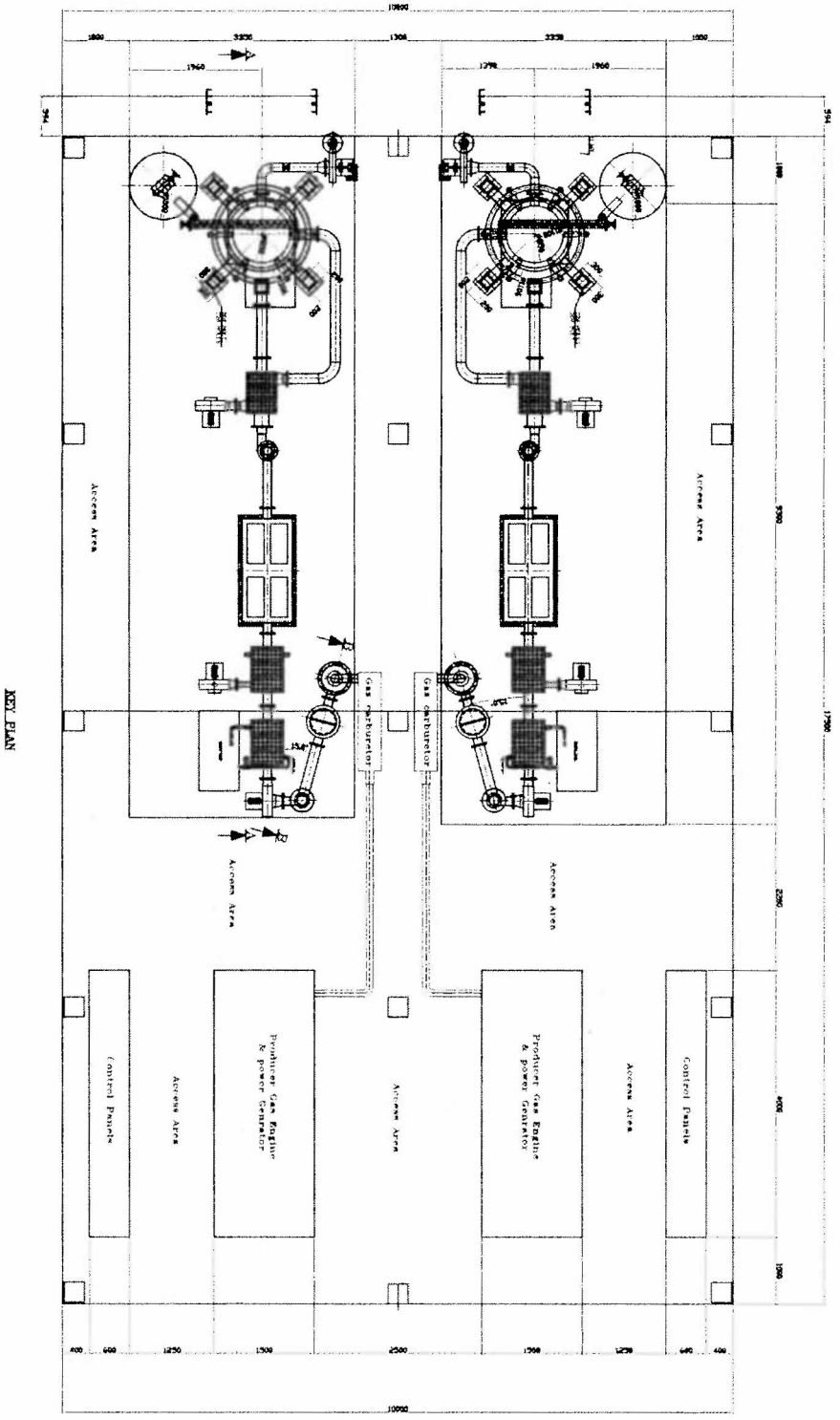
i. The scope of the project is to "Supply of a 250 kWe (2x125kWe) Biomass Gasifiers system, Capacity building and Related Technical Services". The choice of using the power, produced from the biomass gasifier plant, is at beneficiary's scope. Under the contract awarded to TERI, the scope is limited to Supply of the gasifier system and capacity building only hence we would like to bring to your kind notice all other components beyond the supply of the system cannot be addressed under this contract. Hence I take this opportunity to reiterate once again that the beneficiary should proactively pursue activities related to procurement of grid interface equipment, service and legal permissions required for grid connection.

ii. Technical services, training and capacity building will be provided for installation and operation of the system. Technical experts from TERI will be available to provide guidance during the installation and commissioning of the system. Local manpower need to be organized and managed by the beneficiary for installation and commissioning.

Annexure 7 - Details for civil works

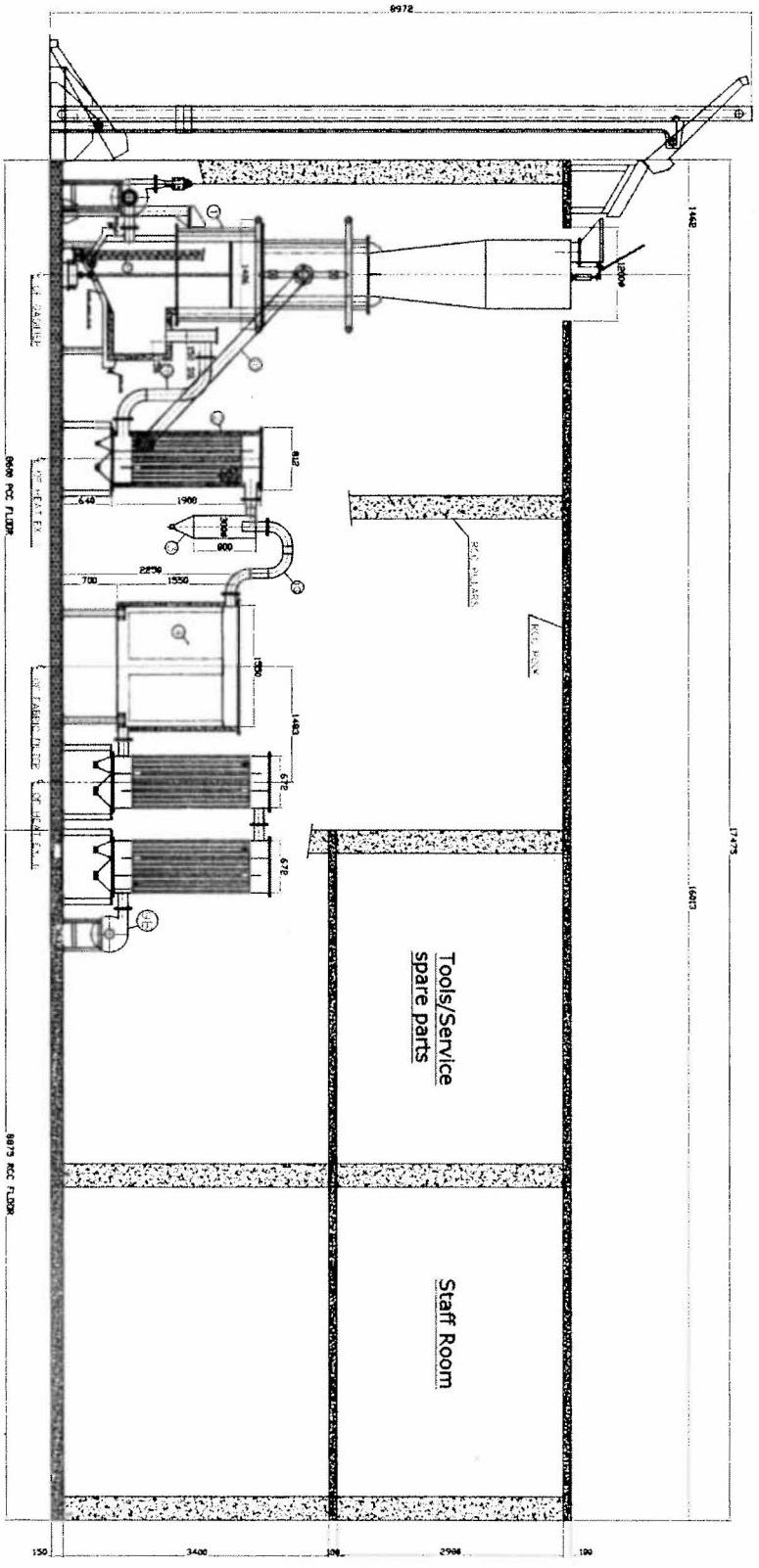
The detailed drawings of the gasifier system are provided in this chapter. The main gasifier unit and the fuel feeding system will be having foundations. The foundation drawings required for these two components are given in detail. The rest of the components will be placed on the floor. These components will be fixed at the ear marked locations using fastener-bolt. The fastener bolts will be sent along with the system, as per the requirement. The foundation work needs to be done as per the drawing, along with the civil construction works. The drawings provide the basic requirement of area and height of the shed. Earlier there was communications regarding the shape of the building and fuel storage. The clarification on this regards may be referred for more details about the civil works.

Complete set of pipeline required for gas line (connecting the gasifier equipment) will be provided along with the system. Water line for the cooling tower and heat exchanger has to be provided at site as part of the civil work. Electrical line from the control panel to the individual equipment (Blowers and motors) and Genset to the control panel also part of the civil work. I request you to please go through all the reports submitted so far for getting more clarity about the system and the roll of TERI and beneficiary.

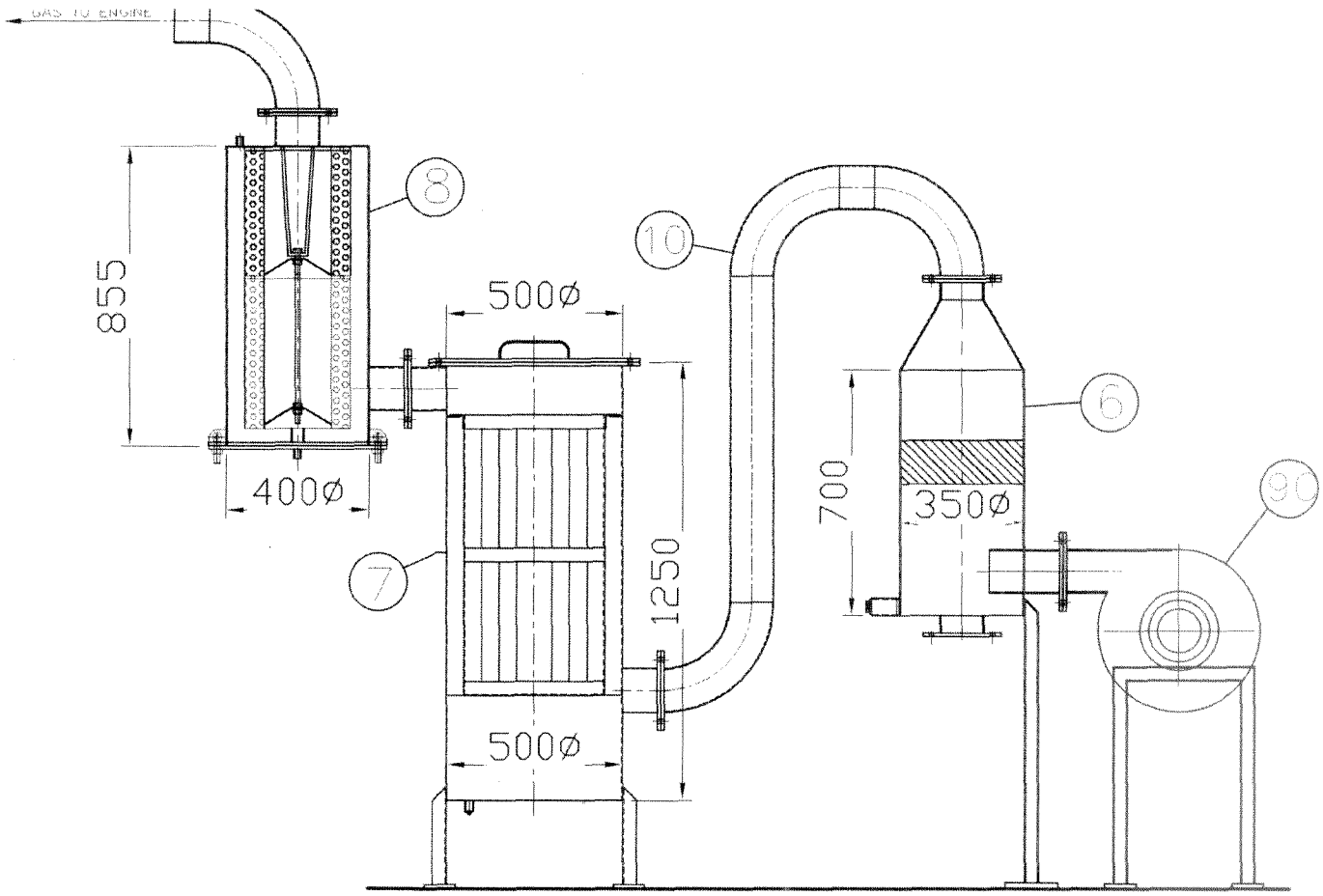

Access Area
Gas carburetor
Producer Gas Engine & power Generator
Control Panels

KEY PLAN

S.No.	DESCRIPTION.
1.	GASIFIER REACTOR WITH ASH PIT
2.	HEAT EXCHANGER
3.	CYCLONE FILTER
4.	FABRIC FILTER
5.	HEAT EXCHANGER
6.	MIST PAD
7.	FABRIC FILTER
8.	PAPER FILTER
9.	SUCTION BLOWER
9A.	PRESSURE BLOWER
9B.	PRESSURE BLOWER
9C.	SUCTION BLOWER
10.	PIPE LINE WITH FLANGE
11.	SCREW FEEDER FOR ASH REMOVAL
12.	ASH STORAGE HOPPER
13.	Fuel FEEDER



ELEVATION FROM "AA"



ELEVATION FROM–"BB"

DETAILS OF GASIFIER COMPONENTS

S.No.	Description (Part name)	Dimensions (LxBxH)	Weight (Estimated/ approximate)
1	Gasifier reactor with ash pit	2200 X 2200 X6600	3500 KGS
2	Heat Exchanger-I No.(440x612	1070 X 770X 2580	500 KGS
3	Cyclone Filter 300 dia	550 X 450 X 1300	45 KGS
4	Fabric Filter 754 x 1554	900 x 1900 X 2300	450 KGS
5	Heat exchanger-2 &3 (486 x 672	725 X 1100 X 2700	800 KGS
6	Water Tank With Pump	600 x 1200 X 700	200 KGS
7	Mist Pad 356 dia	400 X 600 X 1800	65 KGS
8	Fabric Filter 500 dia	525 X 750 X 1600	200 KGS
9	Paper Filter	600 X 600 X 1050	65 KGS
10	Suction Blowers 2 hp. 2880 rpm With (A.L) impeller (belt driven)	650 X 800 X 1250	150 KGS
11	Pressure Blowers 2 hp. 2880 rpm With (A.L) impeller (direct driven)	650 X 800 X 1250	150 KGS
12	Pressure Blowers 2 hp. 2880 rpm With (A.L) impeller (direct driven)	650 X 800 X 1250	150 KGS
13	Suction Blowers 2 hp. 2880 rpmWith (A.L) impeller (direct driven)	650 X 800 X 1250	150 KGS
14	Pipe Line 5" NB with flange	500 X 800 X 3500	400 KGS
15	Screw feeder for ash removal	1250 X 1250 X 2500	200 KGS
16	Ash storage hopper with rotary Feeder	900 X 1300 X 850	250 KGS
17	Chain type bucket elevator for fuel Feeding system	600 X 1650 X 9000	1850 KGS
18	The Engine and genset	3825 x 1500 x 1820	3000 KGS