Validation Report of a Greenhouse Gas Mitigation Biomass Gasifier Power Plant Project in the north-Indian State of Bihar

Academic term paper
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Validation Report
A final Draft

GAIYARI II

Preface

In the context of an accademical term paper of the Departament of Environmental Sciences of the Swiss Federeal Institute of Technology Zurich in cooperation with the company *myclimate*, I had the opportunity to write this Validation Report on a Greenhouse Gas Mitigation Project in India which is cofinanced through the Clean Development Mechanism (CDM) procedures by myclimate.

At the beginning, the intention of this term paper was to write a Project Design Document (PDD) for a biomass gasifier project in south India. Unfortunately for me, but positive for this project, the Grid State Board of Karnataka State announced that grid power will be provided, just two weeks before my departure to India. Thus, the CDM project failed and with it the need of a PDD.
myclimate then decided to put the focus of this term paper to another project from its portfolio called GAIYARI II. For this project, which was with the same local partners, *DESI Power*, as the former project, the PDD was already done according to the information that *myclimate* and I received.
My task was to obtain the PDD from *DESI Power* in Bangalore and to write a Validation Report based on a site visit and on further information on the Project Design of the Biomass Gasifier Project GAIYARI II in the north-Indian State of Bihar. This Validation Report was intended to be handed over to myclimate and its certification panel.

When I arrived in India in February 2005, the PDD was not yet finished despite contrary to my assumption. I was put off to later. Finally travelled to Gaiyari with the project's Feasibility Report in my pocket, which was not according to the official course of action, but a compromise to avoid further delay. Before leaving for the site visit, *DESI Power* decided to have the GAIYARI II project under a bundled 100 village project with the intention of submitting it for validation under the official UNFCCC-CDM. This decision would make my validation work redundant. However, *myclimate* decided to continue because of the risk of failure of such an ambitious project to bundle 100 villages under the CDM procedures.

My work on this paper mainly consisted of three parts:

The first part was the thorough study of the Clean Development Mechanism especially of its role for India and the requirements of a PDD as well as of renewable technologies such as the biomass gasifier power plants. The knowledge I had from my studies in environmental sciences helped me get familiar to these issues. Furthermore, I studied the diploma thesis of Patrick Bürgi, which is a PDD of a biomass gasifier power plant in Varlakonda in south-India. I gained inside into the field of global CO_2-trade.

The second part was the work in India. It was a very interesting experience in the field of development work with its joy and troubles. It was my second stay in India, so I was not so stressed to acclimatise to Indian condition and culture. I stayed about one week at the local site in Gaiyari and I enjoyed it very much. I had the opportunity to stay for two days in Bahabari and see a working biomass gasifier power plant in rural conditions.
I learnt that one of the most important things, especially in the fields of development work, is to understand the hierarchy of a community or of a company and get personally to know the responsible persons.

The third part was the writing of the Validation Report, which was very challenging, especially the assessment of project’s sustainability and the biomass fuel plantation.

Finally, I want to thank

Patrick Bürgi and myclimate for the opportunity of this term paper and support;
Tamara Law and friends for support, the nice stay in Bangalore and the translation of the newspaper article;
Prof. Spreng and Kaushik Deb for support;
DESI Power for support;
Mr. Bulluji Sharan and his wife for the wonderful stay in Araria, Gaiyari and Bahabari.
Mr. Mohammed Shahid and Mr. Bulluji Sharan as guides
Corinne Otto for making my term paper more understandable.

While the site stay, a journalist of a local newspaper interviewed me:

ग्रीन हाउस गैसों के बढ़ते स्तर पर नियंत्रण जरूरी

जा.प्र., अररिया

पृथ्वी के वायुमंडल में कार्बन डायआक्साइड जैसी ग्रीन हाउस गैसों के बढ़ते परिणाम को नियंत्रण में नहीं लाया गया तो नतीजे खतरनाक हो सकते हैं।

जरूरत इस बात की है कि ऐसे ऊर्जा स्रोत काम में लाए जाएं, जिनसे नेचर में कार्बन अपने मानक स्तर पर बना रहे। ये बातें स्विटजरलैंड के न्यूरिच शहर के पर्यावरण विज्ञान शोधकर्ता एन्डी गैन्टेन्बीन ने यहां जागरण से एक विशेष भेंट में कही। स्विटजरलैंड की माई क्लाइमेट की ओर से इस इलाके में पर्यावरण मानकों का अध्ययन करने आए श्री एंडी ने कहा कि अमीर इलाकों के लोग, कारखाने आदि ज्यादा प्रदूषण उत्पन्न करते हैं। लेकिन घाटा पूरी दुनिया को होता है। औद्योगिक इकाई के कचरों और कारखानों द्वारा प्रचुर मात्रा में निकाली जा रही सीओटू गैस पृथ्वी के चारों ओर मौजूद 10 कि.मी. त्रिज्या वाली गैसीय पट्टी को गंभीर क्षति पहुंचा रही है।

आने वाले समय में इससे न केवल ग्लोबल वार्मिंग का खतरा है, बल्कि मानव सभ्यता को स्वास्थ्य संबंधी कई अन्य गड़बड़ियां का भी सामना करना पड़ सकता है।

Translation by Tamara Law

Control on increasing levels of green house gases necessary

If the effect of increasing levels of green house gases (GHGs) like carbon dioxide in the earth’s atmosphere are not controlled the impact could be extremely harmful.

It is required that only such energy sources be used that can help maintain the natural standard levels of carbon. From Switzerland’s city Zurich, Environmental Science researcher, Andy Gantenbein, spoke about this at an awareness meet organized here. Andy from ‘myclimate’, Switzerland, studying the environmental standards in this area, said that people from wealthy regions, industries etc. produce more pollution. However, the entire world suffers the adverse consequences of this. Waste from industrial units and factories produce a large amount of CO2 gas, which is seriously harming the 10 km radius of gaseous layer around the earth. In the coming years, not only is there a danger from global warming but also, our civilization will suffer adverse health impacts.

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Abbreviations

BOD	Biological Oxygen Demand
BOVS	Cooperative form Baharbari
CAR	Corrective Action Request
CDM	Clean Development Mechanism
CEF	Carbon Emission Factor
CER	Certified Emission Reduction
CH_4	Methane
CL	Clarification request
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_{2e}	Carbon Dioxide equivalent
COD	Chemical Oxygen Demand
DNA	Designated National Authority
DESI	Decentralised Energy System India
DPK	DESI Power KOSI
EmPP	Employment & Power Partnership Project
GDP	Gross Domestic Product
T&D	Transition and Distribution
GHG	Greenhouse gas(es)
GRID	Group of Rural Industries and Developers
GWP	Global Warming Potential
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
MP	Monitoring Plan
N_2O	Nitrous oxide
NGO	Non-governmental Organisation
NH_3	Ammonia
ODA	Official Development Assistance
O&M	Operation and Maintenance
PDD	Project Design Document
R&D	Research and Development
RET	Renewable Technology
RPM	Respirable Particulate Matter
SPM	Suspended Particulate Matter
SSC	small-scale
T&D	Transport and Distribution
UNFCCC	United Nations Framework Convention for Climate Change
VER	Verified Emission Reduction

Conversion Factors and Definitions

1 hp = 0.756 kW	1 acre = 0.405 ha
1 INR = 0.029 CHF	1 CHF = 34.5 INR
1 INR = 100 paise	

1 INTRODUCTION

The Clean Development Mechanism (CDM), provided for under Article 12 of the Kyoto Protocol, enables Annex I countries (developed countries and economies in transition) to meet their reduction commitments in a flexible and cost-effective manner. It allows public or private sector entities in Annex I countries to invest in green house gas (GHG) mitigation projects in developing countries. In return, the investing parties receive credits of Certified Emission Reductions (CERs), which they can use to meet their targets under the Kyoto Protocol.
While investors profit from CDM projects by obtaining reductions at costs lower than in their own countries, the gains to the developing host countries are of finance, technology, and sustainable development benefits.

The Indian company *DESI Power* (Decentralised Energy Systems India Pvt. Ltd.) seeks to implement renewable energy projects in India under its Employment&Power Partnership Programme (EmPP) with the aim of reducing GHG emissions and contributing to local sustainable development. In cooperation with the Swiss company *myclimate*, the 100 kW project activity *GAIYARI II* shall be realized in the north-Indian state of Bihar.

myclimate is a leading provider of carbon offset solutions in order to combat climate change. myclimate maintains a portfolio of high-quality carbon offset projects. All projects include technologies in the field of renewable energies or energy efficiency and are developed according to the rules set out in the Clean Development Mechanism of the Kyoto Protocol. Projects must additionally contribute to sustainable development of the host country. All projects must either be registered under the CDM (CER projects) or be validated and verified by an independent certification panel (VER projects).

The purpose of this report is to collect information on the Biomass Gasifier Power Plant GAIYARI II and to validate the project design. This Validation Report is then submitted to myclimate's certification panel for validation and verification process after which, myclimate can purchase Verified Emission Reductions (VERs) from the GAIYARI II.

1.1 OBJECTIVE

All myclimate projects must be developed according to standardized CDM procedures in order to guarantee the generation of high-quality Emission Reduction Certificates [1]. Depending on the size of the project, it shall pursue registration under the Kyoto Protocol (CER projects) or be in compliance with the myclimate VER Standard for micro-scale projects, which is based on the CDM Gold Standard [2] developed by WWF. The main difference between these project categories is the validation / verification process. In the case of CER projects, validation / verification is carried out by accredited organisations on a commercial basis, which leads to relatively high transaction costs. In the case of micro-scale VER projects, the GHG reduction volume is too small in order to bear these transaction costs. Therefore, myclimate opts for independent validation through Swiss experts on an honorary basis. In case of a VER project, no endorsement by the host country's Designed National Authority (DNA) is required.

The myclimate VER Standard requires that all projects pass an additionality test and exhibit sustainability benefits, such as health improvements or local economy support, in addition to greenhouse gas emission reductions.

For all CER / VER projects, a validation report is required. The purpose of the validation is to have an independent third party assessing the project design and to give assurance to stakeholders of the quality of the project and its intended generation of emission reductions (CERs and VERs). In particular, the project's baseline, the monitoring plan, and the project’s compliance with relevant UNFCCC and host country criteria are validated in order to confirm that the project design as documented is sound and reasonable and meets the stated requirements and identified criteria.

For GAIYARI II as a small-scale project(1), there is no demand for an extensive validation of points, such as baseline study or monitoring plan to fulfil the requirements of the UNFCCC small-scale CDM. Importance has been additionally attached to the feasibility and the sustainability of the planned project. Background research is also included in the chapters.

UNFCCC criteria refer to the Kyoto Protocol criteria and the CDM rules and modalities as agreed in the Bonn Agreement and the Marrakech Accords. India signed the UNFCCC in June 1992 and ratified it in November 1993. The Kyoto Protocol was signed in August 2002 [3], which came into force an 16th of February 2005.

In general, myclimate only purchases Emission Reductions on delivery, i.e. after certification of the CERs / VERs. In justified cases where emission reduction selling is vital for project construction, myclimate can purchase ER before construction, but no more than the projected emission reductions of one year.

The aim of this validation report is to reduce the risk of project failure and provide feedback on the consistency of the Project Design Document, particularly in case the project is rejected as a CDM project. In the case of the GAIYARI II project, Prof. D. Spreng of the Centre for Energy Policy and Economics (CEPE) of the Swiss Federal Institute of Technology (ETH) is responsible for certificating the validation report.

A site visit in Gaiyari was undertaken in April 2005 to assess whether the Project Design meets the host country’s and myclimate’s requirements. At that time, the PDD was not yet ready, so the local circumstances in Gaiyari were validated against the assumption made in the Project Feasibility Report. However, as the major parts of the subsequently provided PDD are based on the Project Feasibility Report, the purpose of the site visit, i.e. to asses the environmental conditions and the feasibility, could be sufficiently fulfilled. The subsequently provided draft PDD on the 100 Village EmPP Project was revised and compared with the Project Feasibility Report and where corrections in assumptions has been undertaken, it also has been changed in the Validation Report. Thus this Validation Report is based mainly on the draft PDD on the 100 Village EmPP Project and additionally on the Feasibility Report. Both reports are attached in the Appendix.

The structure of this report has the shape of the validation report template given by the International Emission Trading Association (IETA) [4] and thus allows an easier access for the certification panel member.

DESI Power has decided to have all its projects under a bundled 100 Village EmPP Project, which will be submitted for validation under the UNFCCC-CDM procedures. Since GAIYARI II is covered under the 100 Village Programme, myclimate does not need to do a validation for its own once the UNFCCC approves of the PDD.

(1) For small-scale project activities, the capacity of renewable energy generators shall not exceed 15 MW [UNFCCC].

1.2 SCOPE

The validation scope is defined as an independent and objective review of the Project Design Document, the project's baseline study and monitoring plan, and other relevant documents. Of special interest are the project feasibility and sustainability. The information in these documents is reviewed against Kyoto Protocol requirements, UNFCCC rules, and associated interpretations. This report has, based on the recommendations in the Validation and Verification Manual, taken a risk-based approach in the validation, focusing on the identification of significant risks for project implementation and the generation of CERs / VERs.

1.3 GHG PROJECT DESCRIPTION

1.3.1 Location and Circumstances

The project site is in Gaiyari, Zero mile, Araria, District Araria, in the north-eastern part of the state of Bihar in India (Fig. 1). Bihar is the poorest state of India in terms of gross state product [29].

Fig. 1: (Forest cover) map of state of Bihar and Araria district
(source: State Forest Report 2001 [35])

The district Araria is almost completely rural with about 99% out of 1.61 Mio. people living in rural areas. Agriculture is the backbone of Bihar's are well as Araria's economy. It is mainly based on Paddy, Maize and Jute [36]. On the spot, fields of wheat, banana trees, bamboo and various

vegetables could be seen. The major industrial activities in the district are mills i.e. jute mills, rice mills, sawmills, plywood mills etc..
There is a great need in the state of Bihar for irrigation development and for packages of technological inputs and support to improve the farmer's productivity performance in order to reach the national performance level [5].

Gaiyari is a neighbouring village as well as the periurban industrial zone of the town Araria, which is located 2 kilometres north of Gaiyari. The location is called Zero Mile after a road crossing where the mileage of roads begins which lead in all four directions (ill.1).

The industrial activities in Gaiyari consist of rice mill, saw and plywood mills and some mechanical shops providing equipment for agriculture, transportation and daily life. These activities are subsumed in the PDD as micro industries.

Only 40.3% of Bihari villages are electrified compared to the all India level of 84%. Only 6% of households of Bihar are electrified (all India 35%) [6].
The situation in Gaiyari is different from the situation on state level. Because of the periurban situation next to the capital of the district, Gaiyari is more or less fully connected to grid power. The reality is that the voltage fluctuation of grid power and its erratic availability, means some few hours per day, is not suitable for industrial activities. For this reasons, the required electricity is generated by diesel gen sets, which run all the time. Diesel based electricity is therefore the current energy scenario for the micro industries in Gaiyari.
The biomass gasifier power plant of DESI Power is projected to generate electricity on a CO_2-neutral way and to sell it to the micro industries through a separate mini grid. The cost of the gasifier-based electricity will be cheaper as the fossil fuel based electricity from diesel generators. Thus the project activity GAIYARI is able to replace the electricity of diesel gen sets and their green house emission.
The diesel gen sets will remain as backup systems working on bio-diesel or fossil-diesel for emergency cases.

1.3.2 Biomass Gasifier System

The Decentralised Energy Systems India Pvt. Ltd. EmPower Partnership Project activity in Gaiyari consists of the construction and the running of 2 x 100 kWe biomass based power plants GAIYARI I & II. myclimate will purchase CERs/VERs only from GAIYARI II, which has an output capacity of max. 90 kW.
The system is an IISc-DASAG downdraft opentop solid biomass gasifier, which combusts dry biomass under sub-stoichiometric conditions to producer gas. After being cooled and cleaned, the producer gas is burnt in a pure gas engine to produce electrical energy. The main fuels are agro residues, such as rice husk briquettes, and biomass from a sustainable fuel-forestry plantation near the project site. During the gasification of wood and agricultural residues, ash (from the gasifier and from the cleaning section) and condensate (mainly water) is produced. The latter can be polluted by phenolics and tar.
In emergency cases, diesel generators will provide the energy services running on bio-diesel from oil seeds. The oil seeds are not yet available on the local market and the realization of this ambitious emergency plan depends on the staying power of the project's players. In worst case, the diesel generators will provide energy as usual, i.e. with diesel fuel until the project activity runs regu-

larly again. While this case, the project activity GAIYARI cannot generate ER.

The start of construction is expected in November after the monsoon season. The project will be operational in April 2006. The biomass gasifier power plant GAIYARI II will displace anthropogenic GHG emission from fossil fuel based power in the micro industries, which are described later in this validation report. It is expected to work 18 hours per day on 330 days per year generating nearly 500 MWh per year during a crediting period of 10 years.

The electricity of this *renewable energy project* is generated *by the user*, so it is eligible as a category I.A small-scale CDM project activity as outlined in Appendix B to the simplified modalities and procedures for small-scale CDM project activities [7].

1.3.3 Promoters of GAIYARI

Decentralised Energy Systems India Pvt. Ltd. (DESI Power)
DESI POWER KOSI (DPK) Pvt. Ltd.
Group of Rural Industries and Developers (GRID)
Baharbari Odyugic Vikas Swavalamvi Shakari Samit Ltd. (BOVS) as local cooperative

DESI Power, GRID and BOVS are shareholders of DKP, which will run the power plant and supply power to micro industries and for irrigation or lighting.

1.3.4 Customers of Electricity

The project activity will generate electricity for a preliminarily defined group of local micro industries and enterprises, located around of the project site, and for energy services and water pumping (Fig. 2).

Waste heat from engine exhaust will be used for steam generation in the rice mill, which is located just next to the project activity. The rice mill is the major electricity consumer in the group of local micro industries and at the same time the loader of rice husk, which will be the main fuel of the project activity.

The GAIYARI project activity will run five bore well irrigation pump of 3.5 kW and sell the irrigation water to farmers. The Ground Water Board of Bihar states that in Araria district is still potential for irrigation with ground water [23]. The intention is to use the irrigation channel system (ill.14; 15), which has been constructed for irrigation with water from the large Kosi dam project on the Nepali-Indian border [8]. The dam was to be constructed for flood control and for the production of hydropower during Nehru's regency, which lasted from 1947 to 1964. The dam has never been built and the so far realized irrigation channel system southwards has remained unused over 40 years. The intention of the project's proponents is to fix the system, which shall deliver the irrigation water to farmers. The project's proponents will be responsible for maintaining the channel systems.

Name of the Industries	Name of Company	Maximum Load (kW)	Motor No/KW	Picture Number
Irrigation Pump (no. 5)	DPK	17.5	5x03.5	26 (Bahabari)
Briquette Machine	BOVS	08.5	1x08.5	-
Rice Mill	Ma Ambe Udyog	42.0	1x42.0	16 and 17
Saw Mill 1	Isryl	10.0	1x10.0	18
Saw mill 2	Dawood	10.0	1x10.0	18
Saw Mill3	Ibrar Ahmad	10.0	1x10.0	-
Badi Plant 1		40.0	1x40.0	-
Badi Plant 2		10.0	1x10.0	-
Work shop 1	National Eng. works	05.0	1x05.0	23
Work shop 2	Sarwat Eng. works	05.0	1x05.0	-
Work shop 3	Sultan	05.0	1x05.0	-
Ply wood Mill	India ply wood	10.0	6x1.50	20
Petrol Pump	National Service centre	08.0	4x02.0	21
Madersa (School)	Darul Uloom	10.0	Domestic consumption	22
Evening Lighting for shops	Local members	06.0	100X60	-
Rest house	Simla Rest House	07.5	Domestic consumption	-
Rest house	Ahmad Gust	07.5	Domestic consumption	-
Joity Oil	Gulam Rashol	05.0	1x05.0	-
Lighting For Shop	Mahfooz	05.0	100x50.0	-
Total Connected Load		**221.5**		

Fig. 2 Table of consumers of electricity from GAIYARI project activity. (source: Feasibility Report)

India and Nepal have taken up again the discussion [9] about a Kosi dam, which shall regulate the floods and provides hydropower. This project would, despite of all controversies associated with large dam projects, change the electricity situation in Araria. However, the Kosi dam project will probably not be finished during the period of GAIYARI project activity in consideration that the average construction time of forty-nine hydro projects, reviewed by the World Bank's Industry and Energy Department in 1990, was five years and eight months [11]. The Three Gorge Dam project in China, which will be the world's biggest dam, has a construction time of 15 years [44].

1.3.5 GAIYARI's Environment and Fuel Forestry

The project site is in the Eastern Himalayan foothill plain with mainly alluvium-derived soils. The climate is hot sub-humid with hot summers and cool winters, with 1400 to 1600 mm rainfall mainly during monsoon season between June and September. The growing period varies from 180 to 210 days [10]. The soils are very suitable or suitable [33].

Gaiyari is situated along an old Kosi river bed, which is called the "the river of sorrow" [12] because it has shifted from east to west over 120 km in the last 200 years and wiped out many towns and villages and laid big areas of land waste because of the sand deposit. It is planned to set up the fuel forestry on wasteland on the sand banks of the old Kosi (ill.5). During the monsoon season, the riverbed is filled with water (ill. 6).

ill.1 Zero mile tower and centre point of Gaiyari. View in westward direction from the road, which lead in direction to the power plant GAIYARI. Araria is located about 2km north from the zero mile tower.

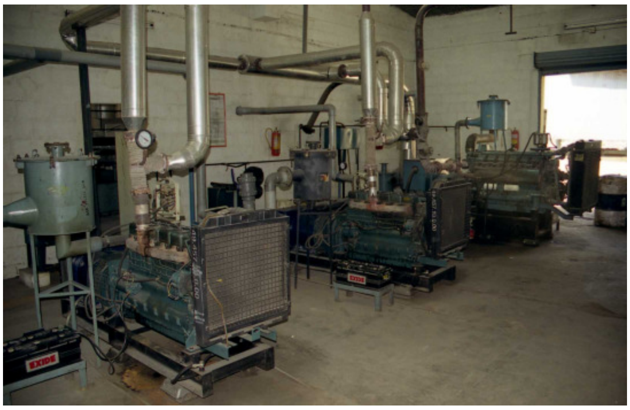
ill.2 Former bed of Kosi River outside of Gaiyari village. View from the same road as above, toward northeast in direction of Araria.

ill.3 Former bed of Kosi River, which is filled during the monsoon season. View towards south on the projected fuel forestry site.

ill.4 Building of DESI Power's dual-fuel biomass gasifier power plant at MVIT College near Bangalore

ill.5 IISc/DASAG downdraft opentop solid biomass gasifier at MVIT College.

ill.6 Wastewater treatment system at MVIT, which will be of same type for GAIYARI project activity



ill.7 Diesel generators at MVIT biomass gasifier power plant

ill.8 Storage of woody chips at DESI Power's 40kW biomass gasifier system in Bahabari, a small village in the neighbourhood of Gaiyari.

ill.9 An employee refills the tube of the gasifier system at MVIT.

2 METHODOLOGY

The Validation Report consists of the following three parts:

- a desk review of the Project Design Document, the Project Feasibility Report and background documents
- follow-up interviews with project stakeholders on site visit
- the resolution of outstanding issues and the issuance of the final Validation Report and opinion.

Corrective Action Requests are issued where a risk to the fulfilment of project objectives is identified, i.e. when:

- mistakes have been made with a direct influence on project results;
- CDM or host Party requirements have not been met; or
- there is a risk that the project would not be accepted as a myclimate GHG mitigation project or that emission reductions will not be verified.

Although only the GAIYARI II project activity has to be validated as a myclimate's VER project, in case of project's feasibility and sustainability, the Validation Report has attached importance to the requirements of both plant units together. The reason is to asses the needs and impacts of the biomass project activity GAIYARI with its two units and to prevent competition for resources between them. This focus is adequate on these sensitive issues and allows a more holistic view beyond the system boundaries of GAIYARI II.

2.1 REVIEW OF DOCUMENTS

The Draft Version of the Project Design Document for the 100 Village Project, dated on 4th April 2005 and the latest Project Feasibility Report, dated in April 2005 submitted by DESI Power and additional background documents related to the project design and baseline were reviewed. Both reports are attached in the Appendix.

2.2 FOLLOW-UP INTERVIEWS

Interviews have been conducted with promoters and project participants to confirm selected information and to resolve issues identified in the document review. Representatives of DESI Power, DESI Power Kosi, GRID, BOVS were interviewed on the following topics:

DESI Power	General project goals, implementation, technical questions, waste water treatment
DESI Power Kosi	Fuel forestry, organisations, perspectives
GRID	micro-industies, locations, fuel forestry, stakeholder meeting
BOVS	Role of BOVS in the Gaiyari project

2.3 CORRECTIVE ACTION REQUESTS

Before submitting this report to the certification panel for validation, it has to be reviewed by DESI Power, Bangalore, India, and Dr. H. Sharan, Co-Chairman of DESI Power, Seuzach, Switzerland to ensure that no corporate confidential information is included in the report.

This issue is in accordance with paragraph 6 of the CDM modalities and procedures, which states that information obtained from CDM project participants marked as proprietary or confidential shall not be disclosed without the written consent of the provider of the information, except as required by national law. **Information used to determine additionality, to describe the baseline methodology and its application, and to support an environmental impact assessment shall not be considered as proprietary or confidential.**

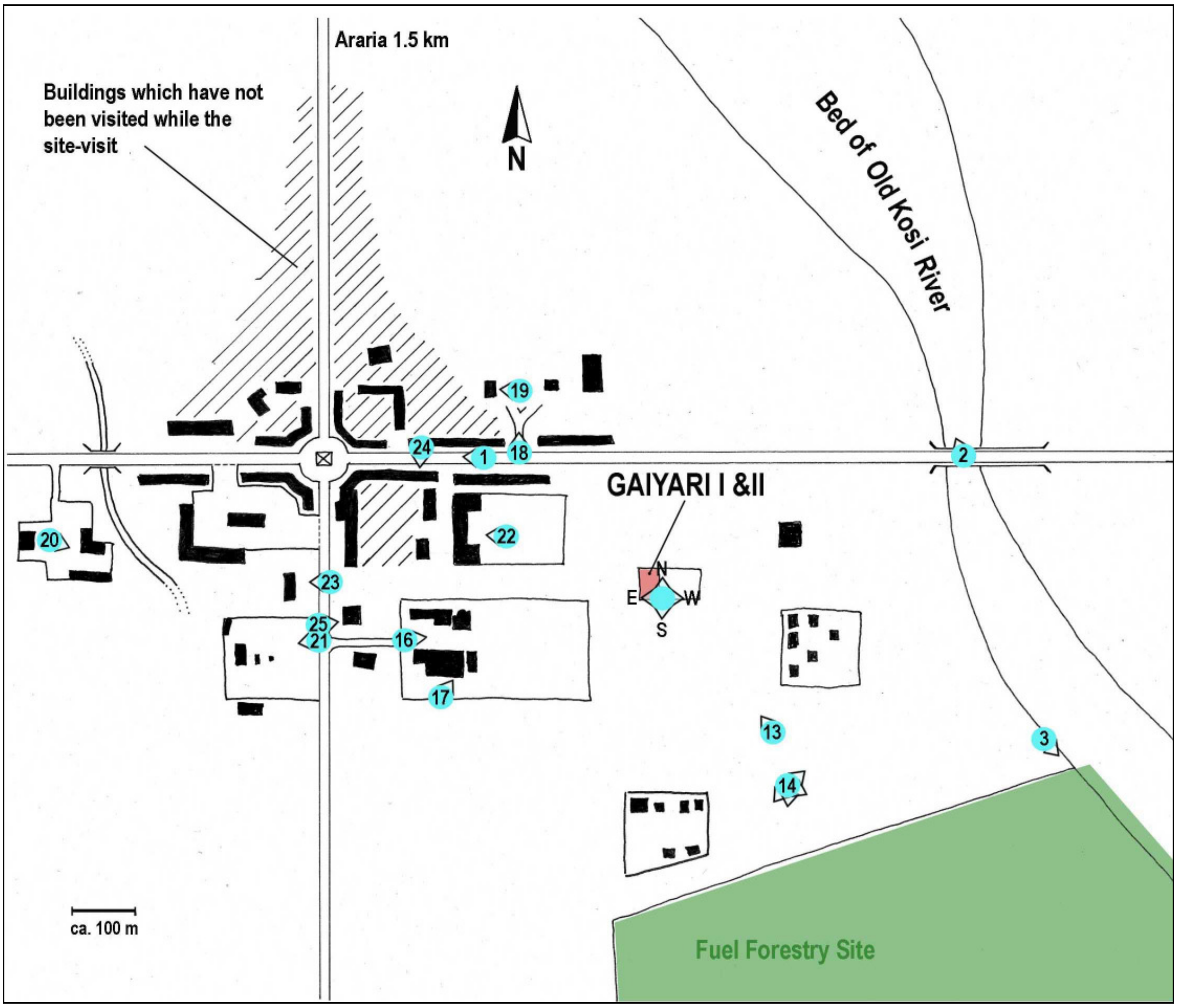


Fig. 3 Sketch of Gaiyari with picture points. The number on the points shows the number of illustration in this report. The vertices indicate the direction of view.

3 VALIDATION FINDINGS

3.1 PROJECT DESIGN

> "*…Recognizing that small-scale projects could face a significant barrier to implementation due to high transaction costs, the EB elaborated simplified modalities and procedures for this class of projects, including streamlined requirements for baselines and monitoring, project boundary and leakage, and validation and verification…*"
> [UNFCCC]

3.1.1 Project Boundaries

The project boundary shall encompass all anthropogenic emissions by sources of GHG under the control of the project participants that are significant and reasonably attributable to the CDM project activity.

For the small-scale CDM project activity I.A, the project boundary shall be delineated *by the physical, geographical site of the renewable energy generating unit and the equipment that uses the electricity* [13].

Therefore, only the biomass gasifier reactor, the gas engine and the generator up to the panel board from which the customers will purchase the electricity, have been encompassed within the project boundaries.
The fuel forestry, which is initiated and under the control of the project participants, remains outside the project boundaries, according to the simplified modalities for I.A small-scale CDM projects under UNFCCC guideline [s. Appendix II].

Most of the land, on which the fuel forestry is planned, belongs to shareholders of the project activity, associated in the GRID. The wood for the project activity will be purchased in a market-like mechanism, which means that farmers and tenants sell wood to the power plant. The project participants are responsible for a sustainable maintained fuel forestry to mitigate leakage. They have a viable interest for a good performance of the power plant, because the higher the performance, the higher is the cost-efficiency, thus the shorter is the pay back period. This circumstance may lead to a good interconnectivity between the project activity and the fuel forestry and could therefore lead to a good performance of the power plant. However, the sustainability of the fuel forestry plantation remains a sensitive issue for the viability of the mitigation project.

The micro industries (Fig.2) as customers of electricity from the GAIYARI II project activity, defined in the PDD, stand beyond the project boundaries. However, as shareholders of the project activity assembled in GRID, they have influence on the project activity and its performance. Around the project site, there are enough micro industries to purchase the generated power.
The irrigation related services are not displacing any current activity because there is no irrigation energy consumption currently.

ill. N, E, W, S: View in all four directions from the southern end of the land on which the power plant GAIYARI I & II will be installed.
In westward direction, behind the trees, the property of the rice mill begins. There is a large place for drying paddy.
(ill. 10, 11, 12, 13)

ill.14 View northwest toward the power plant site. Irrigation channel system from the past, which is planned to fix.
Chimney of the rice mill is observable on the left side.

ill.15 180º-view over the fuel forestry site. View range is NE to SW toward south. Here again, the irrigation channel system.

3.1.2 Technology and Experience

Technology Background

Renewable energy technologies (RETs), particularly decentralized options, are desirable in Indian context, due to their contribution towards improving the quality of life in remote rural areas where it is not possible to provide grid-connected power [14]. RETs have therefore significant benefits for the host country.

Biomass gasifier technologies electricity generation was promoted in the mideighties with an aim to develop and commercialise 5 horsepower engines for farm irrigation. Gasifier engines have been used also for village electrification and for captive power generation in oil extraction, saw mill and chemical units. The gasifiers in these applications have penetrated where cheap processing waste, such as from rice mills and plywood mills, is available as a feed-stock [15]. All over the host country over 2000 biomass gasifier systems have been installed with a capacity of 22MW [16].

Despite of the minor success of gasifier programme, it is a matter of concern that a quarter of the gasifier installed are not in use. The primary reason for this failure is the distortion in capital cost of the gasifier caused by the subsidy. The gasifiers were used primarily to obtain a diesel pump-set at low cost, because the cost of a dual fuel mode gasifier is less than the cost of the diesel set at current subsidy level. Besides, the technological problems resulting in low utilization persist due to multiple causes like the shortage of wood due to other wood uses. Technology research and development (R&D) and reliable biomass supply are thus the key issues, which still needs to be sorted out [15].

On the basis of the cost of mitigation, feasibility of implementation, environmental and other benefits and on the consonance with the country's overall development priorities, TERI made an overall ranking of options of projects in the energy sector. Among them, biomass power was ranked as renewable with highest priority for power generation in India [17]. Biomass and cogeneration technologies will have the highest shares in mitigation GHG with lowest shares in investment in the time frame from 2000 to 2035, when the relative share of RETs in carbon mitigation vis-à-vis their share in investments are compared [18].

Technology Experience

The gasifier system, which DESI Power is installing in Gaiyari, was developed in the Indian Institute of Science (IISc) in Bangalore. The licensee of these systems is NETPRO Renewable Energy Ltd., a sister company of DESI Power. NETPRO Renewable Energy Ltd. was promoted by DASAG Energy Engineering Ltd. Switzerland, which undertook the re-engineering, and design improvements of the gasifier based power plants. NETPRO designs and supplies the gasification island, packages the total power plant including the engine and provides site services and the training of the staff [21].

After several years of successful field experiences with IISc-DASAG/NETPRO dual fuel gasifiers, DESI Power is installing two 100% producer gas power plants in Gaiyari. The development of the pure gas engine has progressed to the stage of commercial maturity. This has some operational advances over the dual-fuel engine because there is no attention to take on the diesel replacement performance, which is usually lower than the feasible replacement performance. The inappropriate diesel replacement drove up the power price even more than the diesel components usually does in dual-fuel engines [22].

The project design engineering of GAIYARI reflects current good practice. In reference to tar production, the downdraft gasifier has been described as the cleanest of the main categories of gasifiers [19]. It consumes up to 99.9% of the tar so that the gas can be piped in engines with minimal tar cleanup [20].
The commercially produced gas filters have replaced the former state of art technology using sand filters, which enhance the performance of the plants(1).
In collaboration with NETPRO/DESI Power, the University of Applied Sciences Waedenswil, Switzerland is doing research on a better, cheap and biological wastewater treatment, which could easily be installed afterwards. By now, it is not foreseen in the PDD to do so.
The NETPRO Technology R&D is constantly enhancing the performance of the gasifiers. For the GAIYARI project activity the latest state of art technology of gasifier systems is projected to be installed.

3.1.3 Biomass fuel

The fuel for GAIYARI I and II are mainly briquettes of rice husk and wood from a fuel forestry plantation. On a maximum Plant Load Factor (PLF) of 61% with an output of about 500 MWh per year and a biomass to power conversation factor of 1,4 kg/kWh(2), 700 t of dry biomass is required for each of the power plants.
One of the problems often cited with biomass based power generation activities, is the lack of biomass market in rural areas [22]. Thus, same for Gaiyari, the required amount 700t of biomass cannot be purchased on the market. The fuel supply has to be well organized in advance and the risk of fuel shortage is to split on different types of biomass.

The requirements of biomass and land shall be assessed as follows (Appendix I):

Rice husk

As long as agriculture can be considered as the backbone of Bihar's economy, agro residues remain the main fuel source for the project activity.

The rice husk for briquetting comes from the rice mill about 200 – 300 m east of the power plant site (Fig.2; ill. 17). The rice husk is usually used to generate steam for rice proceeding processes. Since under the project activity, it is scheduled to use waste heat from the gasifier exhaust for steam generation, the rice briquettes can be used as fuel for the gasifier. The rice husk will be sold by the rice mill, which, in turn, purchases waste heat and electricity for rice proceeding from GAIYARI I and II. A contract on this deal has not been envisaged.

The rice mill produces about 9000 kg of rice(2) per day. The rice paddy consists approximately of 68% rice, 22% husk and 10% brain [24]. That means that the rice mill produces about 2900 kg of rice husk per day. It is adequate to calculate with a handling loss of about 10%. With the resulting amount and a gasifier conversation value of about 1.4 kg/kW(3), a power generation of about 1860

(1) according NETPRO's Chief Engineer Mr. K. Ramachandra, March 2005
(2) According to information of a rice mill employee, March 2005; an estimate, which probably change seasonally
(3) based on the 135 kg/hr to 100 kWe gasifier installed in Gaiyari

kWh per day is possible. The power plant GAIYARI I&II will need at minimum 2560 $kW_{biomass}$ daily for a PLF of 47% in the starting period (8h x 140kW on 330 days per year and on the assumption that the rice mill work also around 330 days per year). Thus, rice husk cover only about 72% of the required biomass energy for project activity. On the expected rise of the PLF to 61% after 5 years of the crediting time, rice husk cover only 56% of the energy need. Thus, the project activity requires biomass from the planned fuel forestry plantation and cannot be dependent only on rice husk briquettes.

Fuel Forestry

The fuel forestry is planned as seasonal crop on wasteland or marginal jute cropland. The main fuel species is nitrogen-fixing Daincha (*Sesbania sesban*), which will be harvested only 4 months after sowing. It is considered as a seasonal crop that grows in the months after the monsoon season. The fuel forestry will be planted on 100-200 acres i.e. 40-80 ha.

The national production rate of fuel forestries is reported to be around 4.2 t/ha/yr [37]. The Daincha harvests are usually between 8-17t/ha/yr, although it is reported that in India, the harvest can be as high as 20t/ha/yr. It is reported that 200 days after sowing, the average woody biomass production is 19 t/ha and the green matter production 26 t/ha [25]. To reach this high yield, 125,000 plants/ha or about 12 trees per square meter were sown (!). These values give a rough impression on the harvest estimate. A conservative assumption is appropriate in this situation.

In case that the size of the wood chips plays a role in improving the power plant performance and in preventing any obstruction or tar entrainment in the product gas [26], the greater main stem diameter can be achieved during same growing time the less trees are sown per area [25]. The dried wood of Daincha is very brittle and can decay during the cutting processes, which is what has been observed during the site visit in Bahabari. This makes the wood pieces even smaller.

On a conservative assumption of 8t/ha, the total amount of harvested wood out the fuel plantation on 40-80 ha is 320-640t with an energy value of 228-456 MWh/yr, which covers about 21-42% of the total energy need. On a progressive assumption of 20t/ha, 800-1600t could be harvested with an energy value of 572-1144 MWh/yr, which covers about 104-208%.
The assumptions are based on 1,4 kg biomass per unit and a maximum PLF of 61% of 2 x 100kW power plant.
If, in a hypothetical case, GAIYARI I&II had to run only on fuel from the energy plantation, a plantation area of 194 ha (485 acres) would be necessary for a PLF of 61% on the conservative assumption. No information has been collected to assessed if such an area of wasteland would be available.

However, as long as agro residues remain the main fuel for GAIYARI I & II, the planned fuel forestry area is sufficient for a PLF of 47% on the conservative assumption. The conservative assumption is practical because of the short growing time and the lack of experience with energy plantation in Gaiyari. Further, there is no concrete solution how to store the wood to protect them from wetness and rottenness.
On a PLF of 61%, scheduled five years after implementation of the project activity, the rice husk as estimated above, will cover around 56% of the power plant's energy need. By then, a minimum plantation area of 200 acre must be set up.

3.1.4 Sustainable Development

The host party requirements for sustainable development are outlined as social, economical, environmental and technological well being [27].

Under the Biomass Gasifier Programme of the Ministry of Non-Conventional Energy (MNES), a subsidy of INR 1.5 million per 100 kW power plant on gas engine and biomass gasifier system is provided [28]. The gasifier systems are therefore in line with relevant legislation plans in the host country.
Energy constitutes one of the key infrastructural inputs for socio-economic development [14].

To assess the project's sustainability, it is referred to a Multi-Attributive Assessment (MATA-CDM), which has been made for a dual-fuel DESI Power biomass gasifier project in Varlakonda, Karnataka State in India [29]. The conclusion has been that the project's overall utility considering the social, environmental and economical dimensions of sustainability can be considered as positive despite of its rather ambivalent environmental performance. Matters of concern were the project's impact on air and water quality (Fig.4).

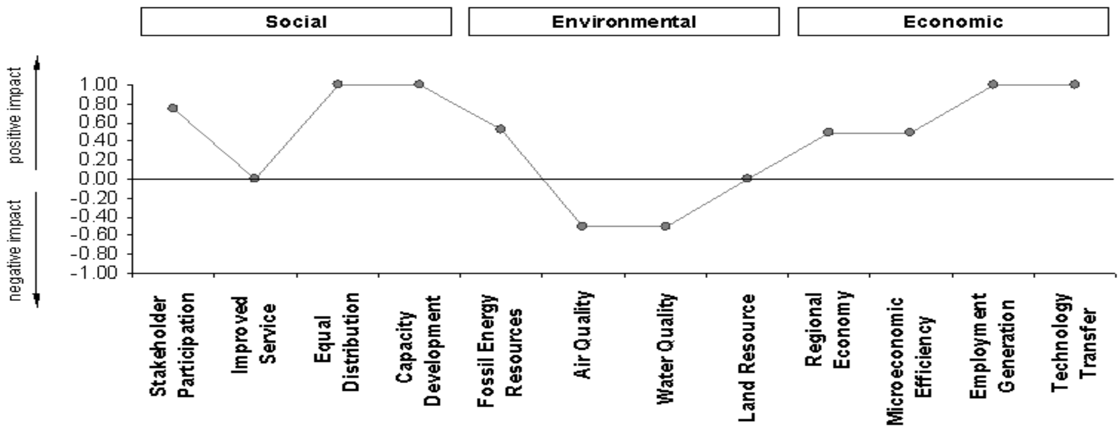


Fig. 4 The MATA Sustainability profile of the Varlakonda project [29]

Host Country Criterion **Social well-being:**
The CDM project activity should lead to alleviation of poverty by generating additional employment, removing social disparities, and contribution to the provision of basic amenities to people leading to improvement in their quality of life [17].

The project activity creates additional employment for the power plant, for briquetting application and biomass collection. Because of the improvement of the soil condition after nitrogen-fixing Daincha intercropping, the amount of the subsequent crops may rise and thus also generate employment. Under project activity, the expenses for imported fossil fuel to run the diesel engines under baseline change to expenses for locally grown biomass fuel and thus stay in the regional economy, which increases the GDP of Gaiyari. For these two reasons, it can be expected that the project activity leads to alleviation of poverty.

The villagers of the cooperative called BOVS from the small village Bahabari around 20km away from Gaiyari are involved in the project activity. They have been working with DESI Power since the pioneer gasifier EmPP project has been set up in their village [30]. This cooperation enhances the relationships beyond the community borders towards a collective feeling of managing energy problems independently.

The use of biomass continues to be predominant in the rural households and the traditional artisan type craft and industry sectors. In this segment, biomass continues to retain the tag of “poor man’s fuel”. On the supply side, the market for the biomass fuel does not exist since most biomass fuels are home grown or gathered by the households for their own needs, particular for cooking [15].
The biomass gasifier project activity, which provides energy service for micro industries and thus local independence from the unreliable grid power and expensive diesel based power. Thus, it enhances the value of the local and renewable biomass fuel and helps to create a biomass fuel market.

Host Country Criterion **Economic well-being:**
The CDM project activity should bring in additional investment consistent with the needs of the people [17].

The governmental subsidy for the GAIYARI project activity and the premium purchased ER by myclimate bring additional investment into the region. The project activity provides reliable electricity from local energy sources. The money saved from imported fossil fuel under baseline enhances the local cash flow and leads to additional local investment.

The fuel forestry is scheduled on wasteland and marginal cropland, which will therefore increase the farmer’s income from wood selling.

Host Country Criterion **Environmental well-being:**
This should include a discussion of the impact of the project activity on resource sustainability and resource degradation, if any, due to the proposed activity; biodiversity-friendliness; impact on human health; reduction of levels of pollution in general [17].

Fossil Energy Resources (1/7)

The GAIYARI project will replace parts of locally needed fossil fuel by sustainable grown biomass fuel and helps on a small scale to decrease India’s dependence on oil imports. India had a net oil import of over 1.4 million bbl/d in 2003 [31], which is around the amount of Iraq’s daily oil export [32].

Land resources (2/7)

The major factor that determines land availability for biomass production for energy is the demand on land for food production [33]. The Response Strategies Working Group of the IPCC has projected that the use of land for food production in the developing countries of Asia, Africa, and South and Central America will increase by 50% by the year 2025 [34]. The potential land categories for biomass production are part of marginal cropland, degraded pastures and forest land [33].

The food versus fuel issue is critical for a densely populated country like India. The policy approach for India at present considers only the use of degraded land, for energy plantation rather than switching the land already under crop production for energy crops [15]. The estimates of degraded land in India vary from 20% to 40% of total land.

Degraded lands have poor vegetation cover and are currently used only for grazing. The grass production is low and range from 0.4 to 1.6 t/ha/yr. hence, the only opportunity cost of the land categories considered is grazing by livestock [33].

The land used in the GAIYARI project can be considered as degraded pastures and marginal cropland where current crop productivity is low. The fuel forestry is planned as a seasonal crop replacing marginal jute production. Due to nitrogen fixing benefits it enhances the soil condition and therefore can also be sown as an intercropping for managing the condition of the soil.

Biomass (3/7)

In the Araria district, only about 2.2 percent of the total area is covered by forest [35], 62 km^2 out of 2830 km^2 [36]. The fertile land on the plane of Kosi River has been widely deforested.

All over India, the consumption of wood has annually grown at 2 percent rate over the past two decades. During the next four decades, the non-energy use of wood is expected to grow at 3 percent annually [37]. Considering the enormous amount of biomass, which will be needed for the 100 Village EmPP Project as well as for the saw and plywood mills in the region, the project proponents promote the fuel forestry and have declared to strengthen the sustainable biomass supply within their EmPP Programme.

The main fuel biomass species Daincha (*Sesbania sesban*) is a tropical *leguminosae* native in India. It is best adapted to moist climate with annual rainfall in excess of 1000mm. It is a soft woody, 1-4 m tall, extremely fast growing, perennial nitrogen fixing tree and thus can be used as an integrated bio fertiliser with a nitrogen fixing rate up to 200 kg N/ha [25]. Daincha can be planted easily as an intercropping on other agricultural fields to improve the soil condition and to generate other income from the fuel and fire wood market. The fertilising benefit after intercropping of Daincha should be communicated clearly to the local partners to reduce the need for artificial fertiliser. The average application of fertiliser in Bihar is around 63 kg/ha [38]. The experience with this tree species in plantages will grow due to the to the project activity.

In addition to the benefits of fuel and fire wood production and green manure, Daincha provides animal fodder and has potential for reforesting eroded land and grassy wasteland [25]. The leafs can be eaten, containing high protein concentrate, and are a rich source of lysine and threonine, which can be used to supplement cereals and millet.

Biodiversity (4/7)

Monoculture tree plantations contribute little to the conservation, study, and use of the biodiversity.

Air Quality (5/7)

In the PDD, the reference values to indicate the exhaust gas emission are taken from the dual fuel IISc/DASAG gasifier at the Xylowatt power plant in Switzerland [29]. These values meet the Swiss standards for gas engine exhaust, which are higher than the Indian ambient air standards according to the Indian Environment Protection Rules (EPR 1986 b).

The conclusion of the ambient air sampling at the MVIT power plant of dual-fuel technology near Bangalore (ill. 4) is that the ambient air standards for SPM and CO cannot be met inside the power plant, whereas RPM and SPM concentrations outside the power plant exceed the limits [29]. The ambient air quality outside the power plant can be improved by augmenting the stack height. Further, a better building design shall allow better natural ventilation of the premises.
The dual fuel IISc/DASAG gasifier as reference for GAIYARI II is appropriate because its pure gas IISC/DASAG gasifier is the successor model of the dual fuel gasifier.

Feedstock, such as herbaceous crops with high nitrogen content like Daincha and rice husk, raises questions about nitrogen-containing constituents. Analysis of these materials would require further research.

The project activity replaces several diesel generators of different sizes causing also hazardous emissions. The properties of exhaust emissions from engines running on producer gas are generally considered to be acceptable, comparable to those of diesel engines [26].
The project activity does not a priori improve the air quality, but because less people are exposed to emissions from the project activity than from multiple diesel generators, a general improvement of the situation can be expected.

Water Quality (6/7)

The estimated coverage of safe drinking water in some districts around Araria is 100% and thus, the same can be estimated for the Araria district [38]. The groundwater table lies very close to the surface. In the Araria district, 60% of the groundwater level is less than 10 meters below the ground surface [39]. Any adverse effect through waste effluents can affect the local ground water very quickly.

The 100 kW biomass gasifier needs 15 m^3 water per hour for gas cooling and cleaning [Feasibility Report]. The water is reused after the cooling and sedimentation processes. Part of the water is reused after passing an additional wastewater treatment compartment, including wet oxidation and adsorption on activated carbon.

The recycling of wastewater leads to higher contaminant concentrations. After 700-800 hours of operation [29], the water has to be replaced by fresh water for maintaining the pH value. The replaced water will be discharged to the ground and has potential for environmental hazard.

All wet gas-cleaning systems generate wastewater that is contaminated with inorganic and organic pollutants including dissolved organics, inorganic acids, NH_3, and metals [19]. The concentration of the pollutants is always significant even for downdraft gasifiers, which tar production is considered to be low. It has been observed that the fuel size plays an important role for tar evolution [26]. In addition, the kind of feedstock used, influences the contaminants of wastewater.

Considering the high COD, BOD and phenolic compounds that has been measured in DESI Power's gasifier in Varlakonda, which exceed the discharge standards for public sewers, the design of the water treatment unit is far from being sufficient in order to clean the effluents in satisfactory way [29].

Various technologies have been proposed in literature [19, 40] for these wastewater treatments before their final disposal. Not yet included in the GAIYARI project design is the biological treatment before the disposal of wastewater. DESI Power is presently conducting a research study on a biological wastewater treatment to improve the wastewater discharge quality in cooperation with the University of Applied Sciences Waedenswil, Switzerland. However, most water-soluble tar components are refractory to the usual biological wastewater treatments and will remain for further careful study [19].

In NETPRO's newest gasifier system design, an industrial filter replacing the former sand filters cleans the producer gas. The gas filter has to be cleaned after 130 hours(1) with water or chemicals, which are also swept away into the ground. No further information can be provided with regard to this matter.

Ash Disposal (7/7)

The ash does not constitute an environmental hazard and can be disposed of in the normal way [26]. The ash disposal has been indicated as safe and suitable as fertilizer, representing no risk for soil or groundwater contamination [29].

Host Country Criterion **Technological well-being:**
The CDM project activity should lead to transfer of environmental safe and sound technologies with a priority to the renewable sector […] that are comparable to best practices in order to assist in upgradation of the technological base [17].

The project design engineering reflects current good practice. The installation of a pure gas engine, which is the latest state of art technology, indicates the progress of gasifier systems. GAIYARI II is part of it.

Projections for renewable technologies in the power sector show, that the RET will grow faster than the overall generation capacity. Renewable based capacity increases thirteen times over 2000 to 2035, reaching 22 GW in 2035. Under no mitigation scenario for India, the share of RET in overall capacity increases from present 3 percent to 6 percent in 2035. Latest projections by the MNES plan additional 10 GW of renewable capacity between 2000 and 2012, constituting 10 percent of the overall power generation capacity additions. Analysis results under no mitigation scenario project a feasible capacity addition of 6 GW in the same time period, that is 60 percent of the government target. Additional capacity build-up is constrained by a number of barriers, primary among them being investment availability [18].
On the basis cost of mitigation, feasibility of implementation, environmental and other benefits and on the consonance with the country's overall development priorities, TERI made an overall ranking of options of projects in the energy sector. Among them, biomass power was ranked as renewable with highest priority as renewable for power generation [17].

(1) according NETPRO's Chief Engineer Mr. K. Ramachandra, March 2005

The decentralized energy supply saves T&D losses of power grid and thus fossil fuel resources, such as coal, which has the main share in Indian grid power.

In addition, the promoters have also planned to run an oil expeller to produce oil from the oily seeds of Castor (*Rhizinus communis*) and Jatropha [45]. This oil is able to run diesel engines in emergency case. The practice will have to overcome the lack of experience with seed oil as fuel. This issue has also a well-being impact on the three dimension of sustainable development. No further information has been collected on these issues. This issue is not explained further in the PDD.

3.1.5 Findings on Project Design

The design engineering does reflect current good practice and has been professionally developed.

The Project Design meets the requirements for project boundaries according to the simplified modalities for I.A small-scale CDM project activities under UNFCCC guidelines. A difficult and sensitive issue remains the position of the fuel forestry outside of the project's boundary. Biomass projects have to mitigate leakage through unsustainable biomass use. The project participants are responsible for the sustainability of the fuel forestry. More importance on this issue has been attached later in this report.

Agro residues as main fuel, particularly rice husk, are feasible and covers at minimum 56% of GAIYARI's energy need. For this, waste heat from the GAIYARI power plant has to be used, as scheduled, in the rice mill. It has not been assessed whether the substitution of rice husk through waste heat is feasible to keep the performance of rice proceeding process the same.
The GAIYARI biomass gasifier project would not be able to work without the additional biomass supply from the fuel forestry plantation. The biomass supply from the fuel forestry plantation on available 40 to 80 ha of degraded land is feasible as second fuel. In the beginning of the project activity, a bit more than 40 ha would be necessary in the case, that the estimated amount of rice husk as above is available. For the second part of the crediting period, around 80 ha is necessary. It is recommended to enlarge the necessary areas for unpredictable cases of short falls because of disease or fire.

The GAIYARI project activity is assessed as good for social and economical sustainable development referring to the sustainability assessment of former DESI power biomass gasifier power plants.
The environmental sustainable development is rather ambivalent.
The wastewater treatment for biomass gasifier systems is not yet fully optimized. It has to be considered that the water effluents may have potential adverse effects on the water quality and thus remain a matter of concern.
The quality of ambient air can be improved though a better building design with an augmented stack height.

ill.16 Rice mill with the rice-drying place in the background. View toward power plant.

ill.17 Accumulation of rise husk in the back of the proceeding building. Chimney of rice husk fired oven for steam generation.

ill.18 Entrance to the two sawmills.

ill.19 Workers of the left saw mill. The diesel generator in the back-ground provides the energy.

ill.20 Ply wood mill. The wires of the power grid overhead.

ill.21 Petrol station south of the bus station.

ill.22 School Darul Uloom

ill.23 Shop National Engineering Works.

ill.24 Workers in front of a mechanical shop.

ill.25 Motorbike shop left of the way to the rice mill.

ill.26 Irrigation bore well pump working on electricity from biomass gasifier system (example from Bahabari)

ill.27 Meeting of GRID and farmers about the project activity while the site visit. In front, Mr. Bulluji Sharan of DPK.

3.2 CREDITING PERIOD

The project's starting date is clearly scheduled on 1st of April 2006

The crediting period is fixed at 10 years and therefore ends on 04/01/2016. It can be expected that the operational lifetime of the project is more than 10 years with appropriate maintenance.

3.2.1	**Finding on Crediting Period**
	The crediting period is in accordance with the regulation for CDM project activities.

3.3 BASELINE

3.3.1 Methodology and Determination

> *Baseline scenario presumes the continuation of current energy and economic dynamics and provides a reference for comparing the impacts of policies or alternate futures. It assumes what is often called a "business-as-usual" dynamics.* (UNFCCC)

The baseline determination involves a trade-off between the transactions costs of certification and the environmental costs of adverse selection, adjustments for increased emissions at other locations caused by leakage, moral hazard, and change over time in contextual economic, technological, and institutional condition [14].

The baseline is by definition a counterfactual concept and has an inherent element of uncertainty. For that reason, the IPCC [41] reports the range of uncertainty in estimates of emission reduction to be between ±35% and ±60% depending on the project type [14].

The GAIYARI project applies an appropriate simplified baseline methodology for small-scale project activities based on a baseline where diesel is used for power generation. This methodology is accepted for SSC-CDM project activities to Indian conditions [14]. However, in Gaiyari where grid power is sporadic i.e. some hours per day with fluctuating voltage, which prevent an industrial use, the simplified baseline assumptions are justified. The micro industries are highly dependent on diesel based electricity generation. The business-as-usual scenario and therefore the baseline scenario, simplified for the small-scale project activity, is diesel-based electricity, at least until viable power can be provided from the grid. This issue will be discussed in chapter 6.1.

To determine the energy baseline, the project participants use the electricity output of the RET *in use* replacing fossil fuel consumption according to I.A. SSC-CDM in Annex B. As mentioned in Annex B, a potential oversizing of the power capacity installed or energy generated by the CDM project activity shall not be reflected in the baseline and emissions reduction calculation. For this reason, the energy value taken into account shall rather be the energy consumed than the electricity output [13]. It is scheduled that the all energy produced will be consumed.

In the PDD, the emission baseline is calculated as the energy baseline multiplied by the CO_2 emission coefficient for the fuel displaced. The emission coefficient from diesel generation units proposed by IPCC is the default value of 0.9 kg CO_2e/kWh. A higher factor can be used for small-scale projects only with adequate justification.

3.3.2 Predicted Project GHG Emissions

The project activity Gaiyari II consists of a biomass gasifier feeding a pure gas engine. The fuel derives from sustainable biomass. No additional diesel fuel is required and for thus no project GHG emissions are expected.

All three principle GHG in the Kyoto Protocol Annex A have been discussed in the PDD:

- *Emission of CO_2* derives from the combustion of biomass from sustainable fuel forestry or from agro residues. The biomass has sequestered the CO_2 from the atmosphere during growth. The combustion is therefore neutral in the carbon balance.

- *Emission of CH_4* is not expected under sub-atmospheric pressure condition of the running gasifier. All the CH_4 will be burnt in the engine.

- *Emission of N_2O* is very minor and thus neglected in further GHG emissions. The amount of 300 mg of NOx measured from Xylowatt in Switzerland is equivalent to around 160 ppm or 0.16 vol.-‰. Because of its GWP of 296 CO_2-equivalents, the small amount of NOx is equivalent to 4,5 vol.-% CO_2 which cannot be considered negligible. However, the emitted amount of NOx from the diesel baseline is neither regarded in its GHG emission calculation, so it is justifiable to neglect NOx in further project emission calculation.

3.3.3 Baseline Emissions (Appendix II)

The simplified energy baseline for SSC-CDM type I.A. is the fuel consumption of the technology in use or that would have been used in the absence of the project activity. The energy baseline formula used in the PDD is in accordance with Paragraph 4 Option 2. [13]

(b) Option 2:
$\boldsymbol{E_B = \Sigma_i O_i / (1 - l)}$

Where
EB = annual energy baseline in kWh per year
$\boldsymbol{\Sigma i}$ = the sum over the group of “i” renewable energy technologies (e.g. solar home systems, solar pumps) implemented as part of the project.
$\boldsymbol{O_i}$ = the estimated annual output of the renewable energy technologies of the group of “i” renewable energy technologies installed (in kWh per year)
$\boldsymbol{l}$ = average technical distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas, expressed as a fraction. A reasonable default value for distribution losses on low voltage rural distribution grid could be 20%

ENERGY BASELINE

The Feasibility Report outlines a loss of 16% for internal consumption and distribution loss. Thus, 75 kW is available of the bundle of consumers from an average plant load of 90 kW.

$$\mathbf{E_{B\,(PLF\,61\%)} = 5940\ h/yr \times 75\ kW / 0.8 = 556900\ kWh/yr}$$

If the project participants wish to use a different formula to determine E_B, the proposal needs to be accepted in accordance with the modalities for new methodologies for small-scale project activities.

The emissions baseline is the energy baseline multiplied by the CO_2 emission coefficient for the fuel displaced. IPCC default values for emission coefficients may be used. A default value 0.9 kg CO_2equ/kWh, which is derived from diesel generation units, may be used. A small-scale project proponent may, with adequate justification, use a higher emissions factor from Table I.D.1 (Appendix III)

EMISSION BASELINE

$$\mathbf{E_{0.9\,(PLF\,61\%)} = 556900\ kWh/yr \times 0.9\ kg\ CO_2/kWh = 501\ t\ CO_2/yr}$$

The project proponents have taken a higher default value of 2.4 kg CO_2e/kWh and justify by the big amount of small diesel generators in 100 villages of the 100 Village EmPP Programme, which are running ineffectively on low PLF as *mini-grids with 24 hour Service*.

$$\mathbf{E_{1.4\,(PLF\,61\%)} = 556900\ kWh/yr \times 1.4\ CO_2/kWh = 780\ t\ CO_2/yr}$$

The baseline emissions in Gaiyari as an industrial periurban zone of Araria rather derive from diesel generation units for micro-industrial *productive application* or *mini-grid with temporary services* than *mini-grids with 24 hour Service*. These definitions from the Table I.D.1 of the Appendix B vary in emission reduction factor. Thus it would be more conservative to use a more adequate emission reduction factor of 1.4 kg CO_2equ/kWh instead of 2.4 kg CO_2equ/kWh as mentioned in the PDD.

$$\mathbf{E_{2.4\,(PLF\,61\%)} = 556900\ kWh/yr \times 2.4\ CO_2/kWh = 1337\ t\ CO_2/yr}$$

> *In case of uncertainty regarding values of variables and parameters, the establishment of a baseline is considered conservative if the resulting projection of the baseline does not lead to an overestimation of emission reductions attributable to a CDM project activity (that is, in the case of doubt, values that generate a lower baseline projection shall be used* [13].

The power produced by the GAIYARI project activity will substitute unsustainable power of the micro industries. Among them, some can be considered as “mini grids” e.g. diesel generator providing electricity for lightening. However, these “mini grids” work only at nighttime when lighting is required.

3.3.4 Emission Reductions

All the baseline emission will be mitigated and no emission will be produced through the GAIYARI project activity, so the ER correspond to the baseline emissions.
The total amount of emission reduction of GAIYARI II project activity during the crediting period is **4760 t CO_2**, based on the emission reduction factor of 0.9 CO_2/kWh or **7410 t of CO_2**, based on the emission reduction factor of 1.4 CO_2/kWh.

3.3.5	**Findings on Baseline**
	An appropriate simplified baseline methodology for small-scale project activities has been applied in the PDD. The Feasibility Report outlines a loss of 16% for internal consumption and distribution loss. Thus, 75 kW maximum output for the bundle of electricity consumers would be feasible for each unit. The PDD is therefore not consistent on this issue. To avoid overestimation of ER, the Validation Report proposes for GAIYARI II to use an emission reduction factor of 0.9 CO2/kWh. With adequate justification, a higher emission reduction factor of 1.4 CO2/kWh may be eligible. The PDD proposes an emission reduction factor of 2.4 CO2/kWh, which is not adequate for the micro-industrial uses of electricity in Gaiyari.

3.4 LEAKAGE

According to the general guidance of the Appendix B of the simplified modalities and procedures for small-scale CDM project activities *biomass project's leakage shall be considered* (para. 8) *only within the boundaries of non-Annex I Parties* (para. 9).

Leakage is defined as the net change of anthropogenic emissions by sources of GHG which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity. It occurs when an emission reduction from the project directly or indirectly causes an emission increase at an other location or time [18].

The revised PDD has taken into account two important leakage effects:

Emissions from Transport
The PDD shows in a complete and transparent manner that transportation emissions can be neglected for ER calculation because they cause only 0.13% of the expected CO_2 savings. Even when calculated with a more realistic fuel consumption for transportation vehicles of 20 litre rather than 10 litres per 100 km, the transportation emissions of 0.26% of the CO_2 saving can be neglected.

Emissions from fuel forestry
The biomass gasifier project activity on itself would increase the pressure on the local woody bio-

mass resources. That is why the biomass fuel purchased from the additionally planned fuel forestry, which avoids depriving of local forests. The unsustainable use of fuel biomass due to the project activity would cause CO_2 emissions. To avoid such leakage, it is proposed in this Validation Report to improve the monitoring plan with additional biomass reporting.

The fuel forestry is scheduled on wasteland and marginal cropland, which will therefore increase the farmer's income. Indirect emission due to displacement of food production, which depletes local forests, is not expected.

3.5 MONITORING PLAN

The project applies the monitoring methodology established according to Paragraph 9 of Appendix B of the simplified procedures for small-scale CDM projects [13]). *Monitoring shall consist of: (b) Metering the electricity generated by all systems of a sample thereof.*

The monitoring and reporting procedures based on DESI Power's experience with biomass gasifier power plant can be estimated as satisfying and meet the guideline for simplified methodologies. The data from the electricity meter are transcript to a log book (PDD contains an example of a data sheet). There is no need for estimation or measuring of GHG emission within the project boundaries because GAIYARI is a zero emission project activity.

The simplified baseline will sustain for the whole crediting period as per guideline of UNFCCC for simplified methodologies and procedures for SSC-CDM project activity. According to the simplified methodologies, there is no need to monitor relevant data for determining further and future baseline emission because the simplified energy baseline for SSC-CDM type I.A. is the fuel consumption of the renewable technology in use.
The performance and achieved ER derive straight forward from power generation provided by the GAIYARI II project activity, multiplied by the emission coefficient for diesel generation units.

3.5.1 Monitoring of Impacts

The monitoring plan does not provide any collection and archiving of relevant data concerning the environmental, social and economic impact. The only exception is the checking by a CDM coordinator of DESI Power whether the collection of biomass is in a sustainable manner. It is not mentioned how the checking of this complex issue is being conducted.

For guaranteeing sustainable fuel forestry management, the monitoring plan shall encompass all activities around the fuel forestry i.e. amount of seeds distributed and sown, kind of plant species used for firing, origin and seller of biomass, amount of rice husk used etc.

Such monitoring data are very important to assess leakage from unsustainable biomass use. If the biomass has to be bought on the market, it cannot be assured that the biomass has grown in a sustainable manner. Thus, it could result in project derived GHG emission among other environmental impacts such as deforesting.

3.5.2 Project Management Planning

According to the Draft Agreement in the Feasibility Report DESI POWER KOSI (DPK) Pvt. Ltd., GRID, DESI POWER and BOVS are the promoters of the GAIYARI EmPP Project.
GRID, DESI POWER and BOVS are the promoting shareholders of DPK, which has to function under the standards, systems and procedures set up by DESI POWER for the O&M and management of the biomass gasification power plants and EmPPs.
The training of the local personnel for employment as power station employees such as plant manager and operator has been recognized as very important. DESI Power will impart training and all operators and the manager have been sent to existing gasifier power plants for on-the-job-training. During the first several weeks of the operation of the power plant, the employees will be supervised by an extension DESI Power engineer.

The authority and responsibility of project management has been clearly and sufficiently described. Some important responsibilies are outlined below:

DESI POWER:	Documentation and training of site investigation & biomass management Plant design, erection and commissioning O&M manuals, training of managers and operators Stabilising the operation and supervision Sale of VER/CER, CDM coordination Collection of data, checking of logbook, calibration of meters
DKP:	Organising erection and commissioning of the power plant Organising fuel forestry O&M, financial management and control, bank account Customer care and staff
GRID:	Deal with local micro-industries and farmers Biomass supply and fuel forestry
BOVS:	Agro residue briquettes Training of managers and staff Technical support

Procedures for monitoring, for measurements, for reporting, for corrective actions and for calibration have been identified in the PDD.

3.5.3 Findings on Monitoring Plan

The Monitoring Plan is in accordance with the monitoring methodology for simplified procedures of small-scale CDM projects.
Despite of it, for biomass projects attention shall be given on leakage especially on the possibility of unsustainable fuel forestry.
It is proposed in this Validation Report that the amount of biomass supplied on the market other than from the energy plantation or the rice mill may be used as an indicator for GHG leakage and management improvement.

4 ADDITIONALITY

The additionality assessment is not requested in the official CDM guideline for completing the PDD. However, in the GAIYARI-PDD, the barrier analysis has been chosen to demonstrate the additionality of the project.

The barrier mentioned in the PDD is due to *prevailing practices* in India.

The MNES has set a renewable energy target of additional 10 GW until the end of the 10th Five Years Plan by 2012. The private sector plays an important role in achieving this target [41]. However, the feasibility of this target has been widely doubted [18].
The whole energy sector is not able to overcome the pressure of energy demand, because the economy is projected to grow faster than energy generation capacity can be added. Power shortage will remain for the medium-term future. Therefore the prevailing practice is to implement rather technology with higher emission to generate electricity.

Another prevailing practice is that there is not yet a market to pay a premium on renewable energy. In addition, it is difficult to find investors because the biomass power plant does not yield high profits. Especially for small-scale projects under CDM, investors are not willing to support the comparable high transaction costs [16].

The GAIYARI project activity is the first pure gas gasifier power plant in the region. Under the pilot phase of the CDM, DESI Power has set up another currently operational biomass gasifier in the village Bahabari near Gaiyari, which is running successfully [30]. Other villages are also keen on receiving their own decentralized biomass power plant under the CDM, what will be realized under the DESI Power’s 100 Village EmPP Programme.

Other barriers like limited information, managerial resources, organisational capacity and financial resources can also be mentioned.

The Indian DNA requests emission and financial additionality approval for CDM projects [27]. myclimate requests in addition an environmental additionality.

Emission Additionality:

Though RETs are not cost-effective, they are ‘clean’, and savings in emissions are clearly additional [17].

The project activity leads to real, measurable and long term GHG mitigation with reference to a baseline as can be seen in Section 3.2 and 3.5.

Financial Additionality:

The PDD does not provide any financial analysis, as it is not requested in the official CDM guideline for completing the PDD. In the Feasibility Report of the GAIYARI project, it is stated that myclimate is the only receiver of ER from GAIYARI II. The CO_2 sale finances about 25% of the total project costs. The rest derives from MNES subsidies (33%) for the pure gas engine, local and other equity and loans. No money is therefore drawn off from Official Development Assistance (ODA) to procure CERs/VERs and thus, the request of financial additionality is fulfilled.

Environmental Additionality:

The host country India signed the UNFCCC in June 1992 and ratified the Kyoto Protocol in August 2002. It is a non-Annex A country and thus has no emission reduction target yet. The generated ER of the GAIYARI project activity are therefore not part of a national GHG mitigation programme and is thus additional.

Technological Additionality

There are already over 2000 biomass gasifier power plants running in the host country. However, the IISc/NETPRO Gasifier Power Plant GAIYARI II is of modern pure gas gasifier technology and thus technologically additional.

Energy constitutes one of the key infrastructural inputs for socio-economic development [14], which cannot be provided by the state grid. Hence, biomass based energy generation is a good and feasible solution to develop the Araria district.

5 STAKEHOLDER COMMENTS

During the site visit, the most of the stakeholder micro industries have been visited. It can thus be assumed that the stakeholders have been informed about the GAIYARI project activity, at least after the site visit of a foreigner, which occurs very seldom. A meeting of the GRID has been held to inform about the status of procurement of GAIYARI project activity (ill.27).

Comments by stakeholders have to be invited for the UNFCCC-CDM procurement. They are not required for the myclimate project procurement.

An invitation for stakeholders comments that takes place only on a website would certainly not be an appropriate media, because any disadvantaged people from the region do not have access to internet or are not able to read or write. An independent NGO from the region should therefore invite people to raise concerns.

6 PROJECT FEASABILITY AND RISKS

6.1 Unit Price

The generation cost per unit depends on the PLF and on the composition and the price of biomass. According to the Feasibility Report, the generation cost per unit varies from INR 2.90 to a more conservative INR 4.20 with a steady slight increase during the project activity period to about INR 5.50, which compensates the loss through inflation. The sale price per unit is estimated to be less than INR 5.00 in the beginning and increase to INR 7.50. The increase of the generation cost (2.7% per year) is less than the actual inflation rate of about 5% [46], which mirrors the effect that the higher the PLF rises during the project activity period, the cheaper generation costs are. The sale price is projected to rise for about 4.5% per year, which compensates the loss of the inflation (fig. 3 and 4).

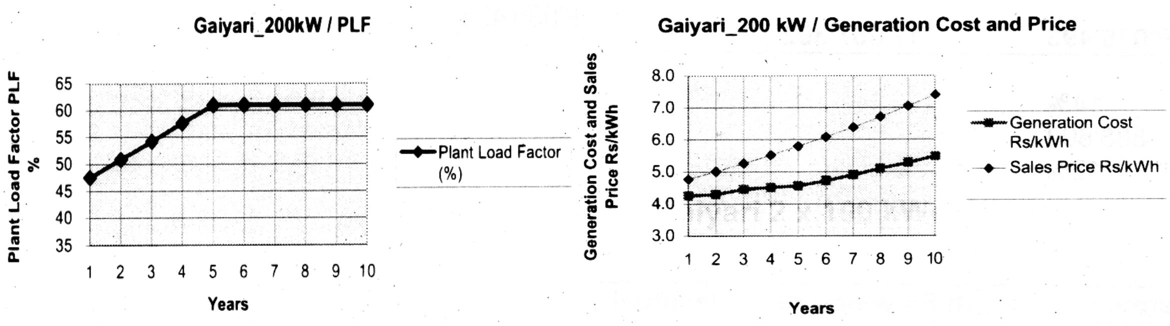


Fig. 3 and 4: Performance of 2 x 100 kWe EmPP plant over 10 years period
(source: Project Feasibility Report)

On a conservative diesel price basis of around INR 35/- per litre [42] and the average specific fuel consumption (SFC) of diesel generators according to manufacturer's data of around 0.23 litre/kWh [14], the unit price would be around INR 8.00. In the PDD, the unit price for diesel based electricity generation is INR 11.00, which would be on a SFC of 0.31 litre/kWh. However, the SFC is highly dependent on the PLF, thus the unit price is negatively correlated with the load factor. Further, it can be expected that the price for fossil fuel will rise during the project's period of 10 years when the tendency of inflation-adjusted rising price for fossil fuel keeps on.

The tariff for grid power supply distinguishes between several Tariff Schedule under the Electricity Act of the Bihar State Electricity Board [43]. The electricity consumers of the GAIYARI project are divided into three different categories of consumers and therefore in three different Tariff Schedules. The unit price for Shop and Guesthouse lighting in *Non Domestic Service III* is between INR 4.00 and 4.40/unit apart from the fixed cost per kW capacity.
The tariff for Irrigation and Agricultural Services for unmetered supply is INR 70 per HP/month for irrigation pumps.
The tariff for Tension Industrial Services including rice mills, saw mills, plywood mills etc. is between INR 3.90 and 4.10/unit besides a fixed charge of INR 60 to 80 per HP/month, which is INR 80 to 107 per kW/month.

The project's unit price is positioned above the unit price for grid power and below the one for diesel generators. The grid power unit is about 1 INR cheaper than the unit of biomass based elec-

tricity, but it is not available and not suitable. Only in case of subsided irrigation, the grid power is much cheaper depending on how often irrigation is needed per month.
The unit price for diesel-based electricity is about 50% to more than 100% more expensive than the unit of biomass based electricity.

The unit price of GAIYARI project as renewable makes more contribution to internalize externalities. For grid power and diesel-based power, the externalities are not internalized.
If in future policies externalities may have to be internalized for competing fuels, the price for sustainable biomass energy will decrease relatively to the price for non-renewable power supply.

6.2 Project Replacement

The possibility that GAIYARI project activity will be replaced by cheaper energy supply, such as grid power supply, can be estimated as rather low. The basis of this assessment is the reality in which Gaiyari is situated as a town far from important centres of socio-economic affairs and the reality that the State of Bihar has fallen far behind the national mean of installed power generation capacity.
The prospect for a change of the situation in Bihar, which is the poorest Indian state, and thus for the situation in Araria district is rather disillusioning.
And furthermore, analysis results for all over India under a no GHG mitigation scenario baseline a five-fold increase in electrical demand over 2000-2035 while the economy is projected to grow sevenfold over the same period. The electrical generation capacity almost triples over a 35-year period (395 GW in 2035) with coal continuing its dominance in the capacity mix with a declining share from present 60 percent to 50 percent of generation capacity in 2035 [18].

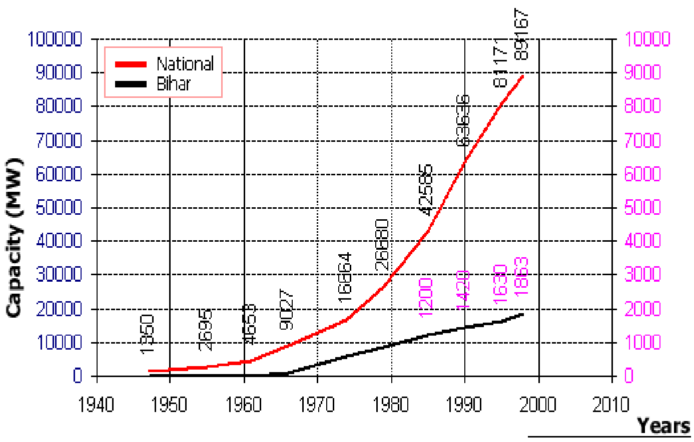


Fig. 5: Historical Growth of Installed Power Generation Capacity (Bihar vs. All India/Other States)

The whole energy sector is not able to overcome the pressure of the energy demand, because the economy is projected to grow faster than energy generation capacity can be added. In the foreseeable future, the rural areas distant from commercially important centres will suffer the most under the gap between power supply and demand.

The micro industries in Gaiyari are dependent on adequate and reliable electricity supply, which may not be available by the state power grid within the crediting period of 10 years. Furthermore, the micro industries are shareholders of the GAIYARI project activity and are interested in good performance as long as it can provide affordable electricity, which is the case when the expensive diesel fuel can be substituted.

6.3 Achievement of Emission Reduction

The project participants anticipate the GAIYARI project to work 18 hours per day on 330 days per year.
The performance of the GAIYARI project activity is dependent on many factors, such as power demand, maintenance, and biomass supply. These factors are again dependent on further circumstances like climatic conditions or socio-cultural events. One matter of concern is the performance during the monsoon season between June and September. The experience DESI Power made under the pilot phase project in Bahabari, which can be taken as a reference for climatic conditions, indicates a collapse of performance during the monsoon season [30]. The semi-rural project site in Gaiyari may not suffer to the same extent as the remote village Bahabari because the infrastructure such as buildings and transportation is more developed.
The monsoon may also influence the performance of the micro industries, especially drying procedures as practiced in rice mills or plywood mills. During that time, these industries will probably demand less electricity than usual.

During the monsoon season less electricity is usually required and it will be difficult for the GAIYARI project activity to keep up its performance. Thus, the performance falls short of expectations during monsoon season, which may influence the performance though out the year. In such a case, the circle of costumers of electricity may have to be enlarged.

A reduced performance of project activity generates less GHG ER than promised, and would generate less income.

6.4 Fuel Forest Management

The management of sustainable fuel forestry remains as source of uncertainty. The lack of local experience on this issue and the complexity of biological systems in its extent, complicate a feasibility forecast.

Positive is the aim to plant different species for fuel plantation because this would reduce the risk of bad harvest e.g. Daincha as main fuel forestry species is described as very susceptible to nematodes [25]. Different species complicate the calculation of the harvest from the fuel forestry.

Furthermore, Daincha shall be harvested as a seasonal crop. Daincha, which is a perennial plant species, will probably not flower within the scheduled growing time of 4 months, thus it will not produce seeds for subsistence economy. The PDD shall state on which extent of area a plantation is projected to produce seeds or whether the seed have to be purchased on the market. The requested amount of seeds for the energy plantation is around 4.8 millions for 80 ha and 6 seeds per square meter. A reasonable fraction of the seed that may not germinate has not been taken into account for this calculation.

7 VALIDATION OPINION

The project design of GAIYARI II is feasible according to the Draft Project Design Document. The lack of grid power and the need of electricity in the periurban industrial zone, called Gaiyari, is a good prospect for good performance of the project activity on the demand site. Due to the high unemployment, which GAIYARI II helps to lower, enough labour forces can be recruited for the power plant and the fuel forestry. The availability of wasteland as well as the abundance of water makes the planned fuel forestry and thus the biomass supply feasible.

The project activity GAIYARI II meets the relevant criteria for CDM project activities. The project activity helps to mitigate GHG emissions and contributes to local social and economical sustainable development.

The environmental development, however, is rather ambivalent. The wastewater disposal may have adverse effects on the environment and on the quality of ground water. This problem is ubiquitous in biomass gasifier power plant systems and remains for further careful study. The quality of ambient air can be improved though a better building design with an augmented stack height.

The project design engineering reflects current good practice. Technology R&D has been identified as first key issue for good power plant performance. The field experience of NETPRO/DESI Power gives some assurance for the feasibility of good performance.

Some points are rather uncertain e.g. whether GAIYARI II is likely to achieve the estimated emission reduction or whether the right emission factor has been taken to calculate the emission reductions. It has been reported that the range of uncertainty in estimates of emission reduction is between ±35% and ±60% depending on the project type. However, conservative assumption shall be taken for the estimates of emission reduction. Further negotiation is requested on these issues.

Furthermore, because of the complexity of the biomass fuel supply system with main and second fuel and its dependence on variable conditions, the monitoring plan shall be developed to assure sustainable biomass supply/fuel forestry. A reliable biomass supply is the second key issue for good performance and thus not to be underestimated.
It is proposed to spread the risk of biomass shortage on several different species, especially because of the risk of disease in monocultures. The fertilising benefit after Daincha intercropping as a positive side effect shall be communicated clearly to the farmers.

This is an unqualified validation opinion and shall lead the certification panel of myclimate as well as the responsible people of DESI Power to the sensitive issues on the project design.

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Appendix I

Spreadsheet for biomass calculation

GASIFIER

Biomass to power conversation value for a 135 kg/hr 100kW IISc/DASAG 100 gasifier	*1.4 kg/kWh*
Energy need for PLF 47 % (2*70kW/0.9 for internal energy loss*18h/day*330days/yr*1/360days/yr)	2560 kWh/day
Energy need for PLF 61% (2*100kW/0.9 for internal energy loss *18h/day*330days/yr*1/360days/yr)	3300 kWh/day

RICEHUSK

Rice mill:	9000 kg Rice/day	
	22% Rice husk	1980 kg/day
	10% Brains	900 kg/day
		2880 kg/day
	10% handling loss	280 kg/day
	Amount of rice husk	**2600 kg/day**
	Possible Energy generation by the gasifier	**1860 kWh/day**
	Fuel coverage PLF 47%	**72%**
	Fuel coverage PLF 67%	**56%**

FUEL FORESTRY

Assumption	Fuel forestry area	Harvest	Harvest total	Energy need for gasifier per year	Energy need for gasifier on working days	Fuel coverage PLF 47%	Fuel coverage PLF 61%
	[ha (acre)]	[t/ha/yr]	[t/yr]	[MWh/yr]	[kWh/day]	[%]	[%]
Conservative	40 (100)	8	320	228	700	**27**	**21**
	80 (200)	8	640	456	1400	**54**	**42**
Progressive	40 (100)	20	1600	1140	3450	135	104
	80 (200)	20	3200	2280	6900	270	208

Appendix II

Spreadsheet on Emission Calculation

Baseline
The energy baseline is the fuel consumption of the technology in use or that would have been used in the absence of the project activity. The project participants may use one of the following energy baseline formulae:

(a) Option 1:

$$E_B = \Sigma_i(n_i \cdot c_i)/(1 - l)$$

Where
EB = annual energy baseline in kWh per year.
Σi = the sum over the group of "i" renewable energy technologies (e.g. residential, rural health center, rural school, mills, water pump for irrigation, etc.) implemented as part of the project.
ni = number of consumers supplied by installations of the renewable energy technology belonging to the roup of "i" renewable energy technologies during the year.
ci = estimate of average annual individual consumption (in kWh per year) observed in closest grid electricity systems among rural grid connected consumers belonging to the same group of "i" renewable energy technologies. If energy consumption is metered, ci is the average energy consumed2 by consumers belonging to the group of "i" renewable energy technologies.
l = average technical distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas, expressed as a fraction.

(b) Option 2:

$$E_B = \Sigma_i O_i/(1 - l)$$

Where
EB = annual energy baseline in kWh per year
Σi = the sum over the group of "i" renewable energy technologies (e.g. solar home systems, solar pumps) implemented as part of the project.
O_i = the estimated annual output of the renewable energy technologies of the group of "i" renewable energy technologies installed (in kWh per year)
l = average technical distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas, expressed as a fraction.

A reasonable default value for distribution losses on low voltage rural distribution grid could be 20%

Table I.D.1
Emission factors for diesel generator systems (in kg CO_2equ/kWh*) for three different levels of load factor**

Cases:	Mini-grid with 24 hour service	i) Mini-grid with temporary service (4-6 hr/day) ii)Productive applications iii) Water pumps	Mini-grid with storage
Load factors [%]	25%	50%	100%
<15 kW	2.4	1.4	1.2
>=15 <35 kW	1.9	1.3	1.1
>=35 <135 kW	1.3	1.0	1.0
>=135<200 kW	0.9	0.8	0.8
> 200 kW***	0.8	0.8	0.8

*) A conversion factor of 3.2 kg CO_2 per kg of diesel has been used (following revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories)
**) Figures are derived from fuel curves in the online manual of RETScreen International's PV 2000 model, downloadable from http://retscreen.net/
***) default values

Fig.1 Table I.D.1 Emission factors for diesel generator systems (SSC-CDM)

ENERGY BASELINE

$E_{B\ (PLF\ 47\%)}$ =5940 h/yr x 60 kW / 0.8 = 445500 kWh/yr

$E_{B\ (PLF\ 61\%)}$ =5940 h/yr x 75 kW / 0.8 = 556900 kWh/yr

EMISSION BASELINE

Emission factor **0.9**: **$E_{0.9\ (PLF\ 47\%)}$ = 445500 kWh/yr x 0.9 kg CO_2/kWh = 401 t CO_2/yr**
$E_{0.9\ (PLF\ 61\%)}$ = 556900 kWh/yr x 0.9 kg CO_2/kWh = 501 t CO_2/yr

Emission factor **1.4**: **$E_{1.4\ (PLF\ 47\%)}$ = 445500 kWh/yr x 1.4 CO_2/kWh = 624 t CO_2/yr**
$E_{1.4\ (PLF\ 61\%)}$ = 556900 kWh/yr x 1.4 CO_2/kWh = 780 t CO_2/yr

Emission factor **2.4**: **$E_{2.4\ (PLF\ 47\%)}$ = 445500 kWh/yr x 2.4 CO_2/kWh = 1069 t CO_2/yr**
$E_{2.4\ (PLF\ 61\%)}$ = 556900 kWh/yr x 2.4 CO_2/kWh = 1337 t CO_2/yr

Production/Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Annual average load (kWe)	70	75	80	85	90	90	90	90	90	90	
Int. Consumption and distribution loss [%]	16	16	16	16	16	16	16	16	16	16	
Average Output [kWe/h]	60	63	67	71	75	75	75	75	75	75	
Plant annual operation hours [hr/yr]	5940	5940	5940	5940	5940	5940	5940	5940	5940	5940	
Plant Load Factor (PLF) [%]	47	51	54	58	61	61	61	61	61	61	
$E_{0.9}$ [t CO_2e]	401	426	451	476	501	501	501	501	501	501	**4760**
$E_{1.4}$ [t CO_2e]	624	663	702	741	780	780	780	780	780	780	**7410**
$E_{2.4}$ [t CO_2e]	1069	1136	1203	1270	1337	1337	1337	1337	1337	1337	**12700**

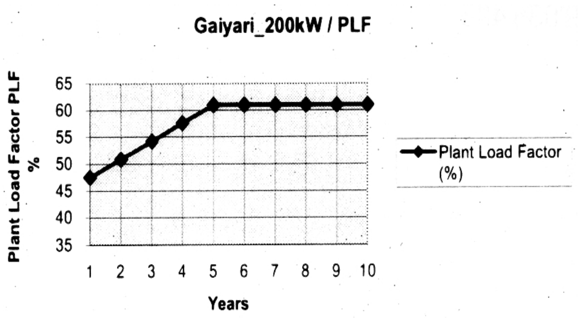
Fig.2 Table of Generation Schedule and CO_2-Mitigation Potential

Appendix III

Spreadsheet on Unit Price

BIOMASS GASIFIER PROJECT ACTIVITY GAIYARI

Generation cost per unit (kWh):	Start of period:	INR 2.90 - 4.20
	End of period:	INR 5.5/kWh
Sale price per unit (kWh):	Start of period:	less than INR 5.00
	End of period:	INR 7.50



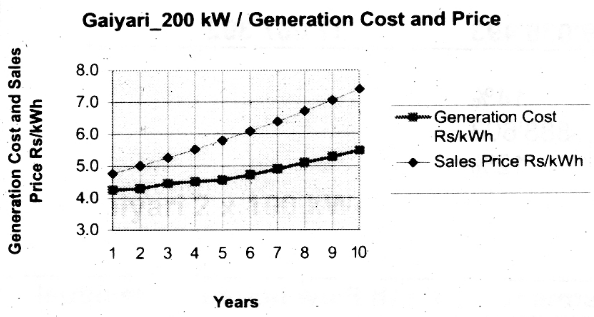
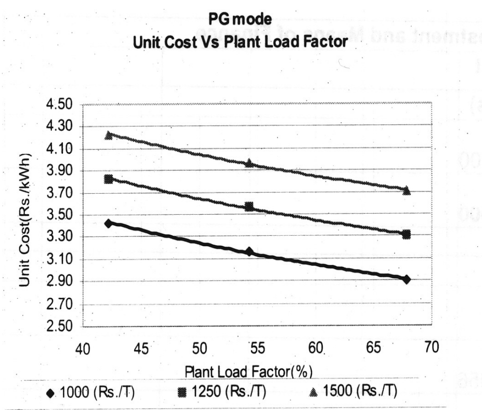


Fig. 1 and 2: Performance of 2 x 100 kWe EmPP plant over 10 years period
(source: Project Feasibility Report)



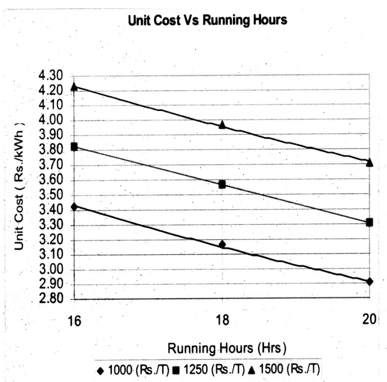


Fig. 3 and 4: Dedendency of the unit price from PLF and biomass price
(source: Project Feasibility Report)

No	Type of Bio-mass	Source	Current price per ton	Present users	Average distance
1.	Dhaincha	Farmer	Rs. 1000 – 1200 /-	Farmers	Near the site
2.	Rice husk briquette	BOVS	Rs. 1200 – 1400/-	BOVS	Near the site
3	Ipomea	Farmers	Rs.1200 – 1400/-	Farmers	1-2 km
4	Wheat straws briquette	Farmers	Rs.1200 – 1400/-	Farmers	1-2 km
5	Wood pieces	Saw mill	Rs. 1000 - 1250/-	Farmers and local people	Near the site
6	Plywood pieces	Plywood mill	Rs.1200 – 1400/-	Farmers and local people	Near the site

Fig. 5: Current price of biomass in Gaiyari
(source: Project Feasibility Report)

DIESEL

Sale price per unit (kWh):		
Project Feasibility Report:	Start of period:	INR 11.00
	End of period:	INR 16.50 [(1)]
Indian Oil Cooperation Limited:	Start of period:	INR 8.00 [(2)]
	End of period:	INR 12.00 [(1)]

[(1)] Tendency by taking an inflation of 4.5% in account
[(2)]On the basis of conservative INR 35/- per litre and SFC of 0.23

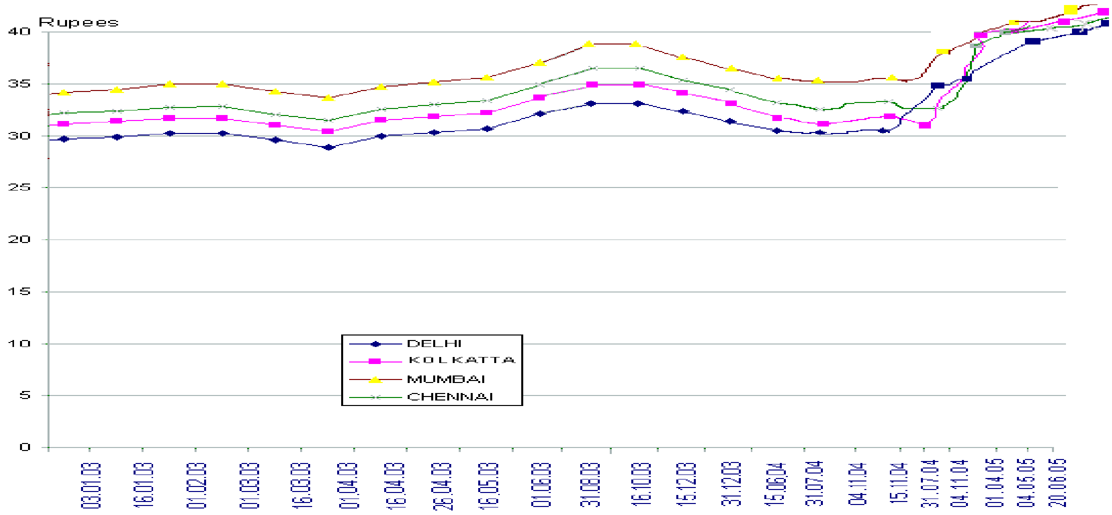


Fig. 6: Development of diesel price development in India over the last 2.5 years [42]

Grid Power

Tariff [(3)] per unit (kWh) under the Electricity Act of the Bihar State Electricity Board [43]:

[(3)] Stand: 31.05.2001

Non Domestic Service III Shop and Guesthouse lighting:	INR 4.00 and 4.40 plus fixed cost per kW capacity
Tension Industrial Services including rice mills, sawmills, plywood mills etc.	INR 3.90 and 4.10 plus fixed charge of INR 60-80 per HP/month
Irrigation and Agricultural Services for unmetered supply:	INR 70 per HP/month