Waste to Energy for Urban India through Co-fermentation of Organic Waste and Septage

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Introduction

India is one of the largest consumers of energy worldwide. The per capita energy consumption of the growing middle class in India is increasing day by day. On the other hand, improper solid waste management and deficiencies in sanitation form a major environmental and health threat in Indian cities. An estimated 5.5 million (approx. 8%) urban households who do not have individual toilets depend on community toilet complexes (CTC's) for their daily sanitation needs. The often used septic tanks in the CTC's lack a proper environmentally sound disposal system.

Within the framework of the "International Climate Change Initiative" of the Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU), Govt. of Germany, GTZ-ASEM, the environment program of GTZ in India, intends to demonstrate in India an innovative waste to energy project through production of biogas. The main objective of this "Waste to Energy" project is to reduce GHG emissions by demonstrating a viable anaerobic digestion technology through co-digestion of septage (waste from septic tanks) and organic fractions of solid waste.

The demonstration project will attempt to bring together various players for collectively planning, building and operating the plant. The project will be implemented in a phased manner (fig.1).

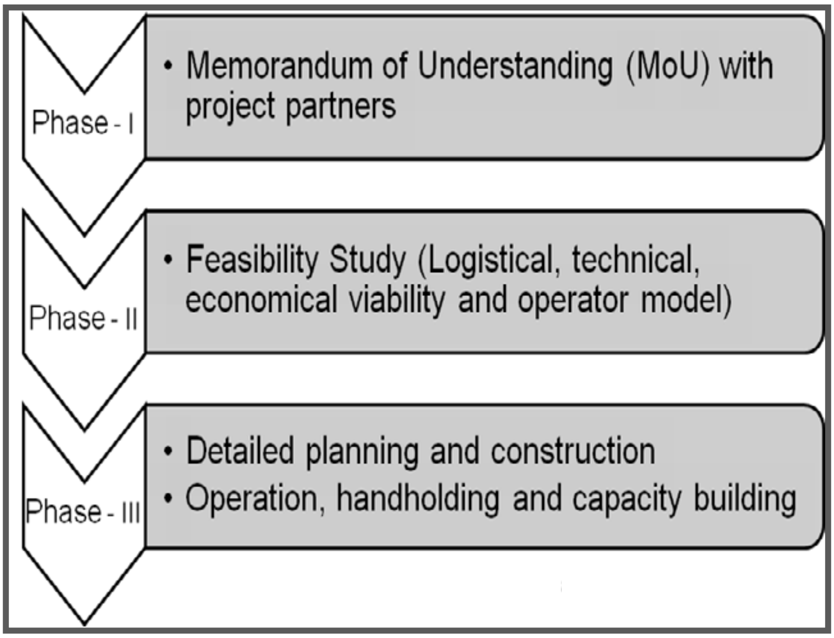

Fig. 1 Project Phases

It is expected that the project will not only reduce the GHG emissions but will also contribute to the improvement of current inappropriate practices in solid waste management and sanitation by demonstrating financially viable and technically feasible solutions in line with the climate change goals of the Government of India.
HAMBURG WASSER, represented by Hamburger Stadtentwässerung (HSE), compiled a feasibility study for GTZ showing the possibilities to bundle urban organic flows in fast growing cities in order to allow material and energy recovery. By means of the HAMBURG WATER Cycle® specifically developed by HAMBURG WASSER it is possible to put solutions into practice in urban environments. Aim of the 'waste to energy' project developed within the scope of this study is the demonstration of the technical feasibility of a pilot plant and the illustration of the general framework for a financially viable operation of the plant.

Objectives of the Project

The International Climate Initiative (IKI) of the German Federal Environment Ministry (BMU) forms the framework of the considerations with following objectives:

- Contribution to environmental protection
- Use of renewable energies
- Increase of energy efficiency

Based on this, further important aspects were developed:

- Closing local material loops
- Production of bioenergy
- Recovery of nutrients
- Solid waste treatment (pathogen reduction)
- Transferability of results

Approach

For the project the innovative approach of the HAMBURG WATER Cycle® was particularly tailored to the local conditions in India. The combined treatment of concentrated wastewater, so-called blackwater (septage), from community-toilet-complexes (CTC) and organic waste from restaurants and hotels can generate a range of advantages. In addition to the energy production, this treatment allows the pasteurisation and material recovery of urban material flows. An uncontrolled methane exposition as well as an energetically intensive treatment as is the case in conventional disposal systems is avoided.

Concept Development

The concept provides for a combined anaerobic treatment of the mentioned flows and an energetic use of the methane on-site. Material recovery is provided for by agricultural use of the residues.

This decentralised approach for fast growing cities offers following advantages:

- Prevention of uncontrolled methane emissions
- Energy production instead of energy use
- Reduction of energetic shortfalls by own energy production
- Integration of existing structures
- Safe pasteurisation and stabilization of sewage and organic waste
- Recovery of nutrients and substitution of mineral fertiliser
- Avoidance of landfills and polluted areas

Key Issues

The analysis of the operation of existing plants in India allows the identification of shortfalls and the development of room for improvements.

- Input substrate
  A reliable supply of input material for the plants needs to be available on a sustained basis. The access to these flows and a well-operating logistic system are crucial for the operation of these plants. There needs to be a close coordination between the operation of the collection and the operation of the treatment plant.

- Plant installation and operation
  A ‚waste to energy' plant should be robust and not too sophisticated. Construction should be based on local components. For a reliable and sustained biogas production, co-digestion should be temperature-controlled. This ensures a stable production of biogas and a long-term basis for the required revenues for the financially viable operation of the plant.

- Final products
  In addition to the availability of input material the permanent and reliable marketing of the final products is one of the main prerequisites for a profitable operation of the plant. Particularly the marketing of the generated energy is important. Also the safe disposal of the digested slurry needs to be guaranteed.

- Operating scheme
  A very close connection between collection and transport, plant operation and disposal of the products is required. Up to now, the schemes have failed particularly

as a result of the multitude of responsibilities and stakeholders. Provision of services should be "one-stop-solutions" if possible. Also, the institutional connection to the local responsible bodies needs to be provided for.

- Capacity building
  - An effective capacity building is needed in the fields of human resource development and organisational development.

An implementation that suits the local conditions and the involvement of all stakeholders is crucial for the success of the project.

Site selection and availability of mass flows

Out of the considered project areas Delhi, Raipur and Nashik, the city of Nashik offers the best conditions for project implementation due to the availability of input material flows and their utilisation as well as the existing infrastructure.

Nashik Municipal Corporation (NMC) owned by the municipality could be found as project partner. NMC operates a number of toilet facilities in Nashik (approximately 2.700 toilet seats in communal facilities and is responsible for sewage treatment and for the collection, transport, treatment (composting and RDF) as well as safe disposal of domestic waste. NMC is going to ensure the collection and the transport of the required flows. For this, NMC can resort to available vehicles and logistics and will contribute this to the project.
Particularly advantageous is the site of the composting facilities for municipal solid waste operated by NMC. The staff is trained in managing waste and there is a considerable demand for electric energy of the existing plant. By converting the methane from the ‚waste to energy'-plant to electricity in a combined heat and power plant (CHP), part of this demand can be covered. Furthermore, the utilisation of the digested slurry (digestate) can be done on-site in the composting facility. Open space is available on the premises of the facility, too.

Short description of the pilot plant

The key component of the projected plant is a stirred anaerobic reactor with following components (fig. 3):

- Receiving station for organic waste
- Pretreatment
- Pasteurisation (optional)
- Gas storage with flare (in case of excess gas)
- CHP with gas pretreatment
- Heat distribution system
- Transfer of digestate

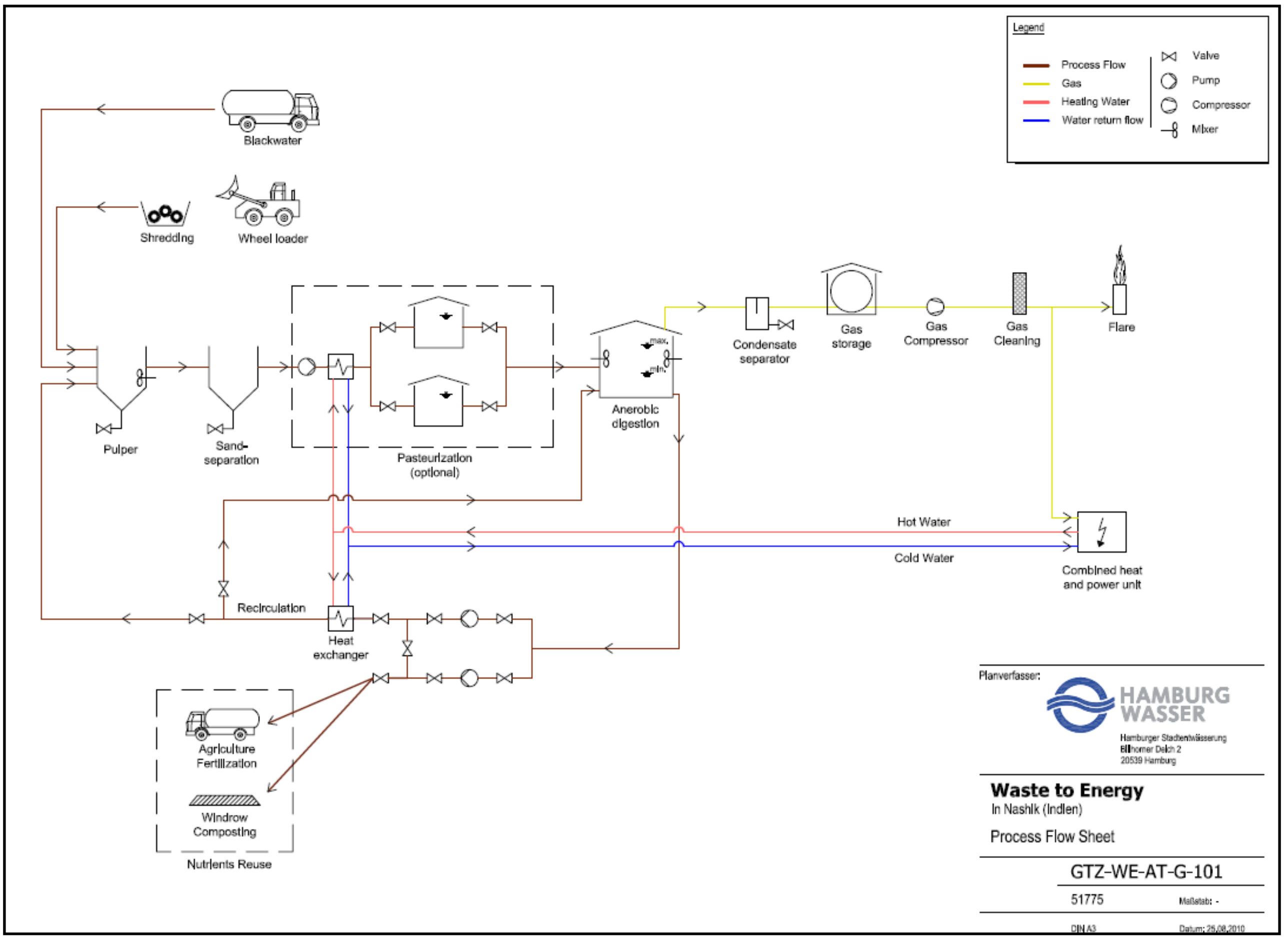

Fig. 3 Process Flow Sheet

The plant is designed for a daily input of 20 m^3 blackwater per day and 10 tonnes organic waste per day. The daily amount of digested slurry is about 30 m^3. The digestate can be safely post-treated in the existing aerobic composting facility. The required addition of water to the composting process could then be made redundant. Alternatively, the direct application on nearby agricultural areas is feasible. The methane produced in the plant is converted to electricity in the combined heat and power plant. The daily production of 2,100 m^3 biogas can generate 3,200 kWh electricity per day with the power for internal use already deducted. This energy generation can supply the existing waste treatment facilities and, thus, reduce the withdrawal from the local electricity grid.

Economic aspects

The operation of the pilot plant results on the one hand in expenses, and on the other hand generates returns. Expenses originate from the actual operation (staff, material, maintenance) as well as from efforts for transport and use of the digested slurry. Revenues for a financially viable operation are generated by the acceptance of organic waste and particularly by the feeding-in of electrical energy into the company grid of NMC. A possible feeding-in into the public grid is deliberately not projected, because, first, the demand is not always guaranteed and, second, possible revenues would be considerably less than the presumed sale of 5 Rs. per kilowatt hour (8,3 ct/kWh). As a result of the interaction with the existing facilities, a close connection between plant operation and composting needs to be assured.

Investment costs for all plant components are about 50 million Rs (approx. 830 T€). For the cost estimation machinery and equipment are assumed to be from India. Operating costs are about 5,500 Rs. (approx. 91 €)per day.
Optimum operation of the plant and 90% use of the generated electricity (disposed energy) can result in revenues of about 14,000 Rs. (approx. 230 €) per day; at average conditions the revenues are about 9,000 Rs. (approx. 150 €) per day. The minimum electricity use/sale, that covers the operation costs is about 1,200 kWh per day.

Relevance for climate protection

The selective treatment of waste flows can prevent certain emissions of greenhouse gases (fig. 4).
Converted to CO_2-equivalents totally about 4,700 tonnes per year can be avoided by the operation of the pilot plant. Particularly the electricity generation from renewable flows and the avoided methane emissions due to the treatment contribute to this value.
Emissions from the transport of the flows play only a secondary role. Regarding the avoided methane emissions, it is assumed that in case of inadequate treatment 50% of the produced methane escapes into the atmosphere.

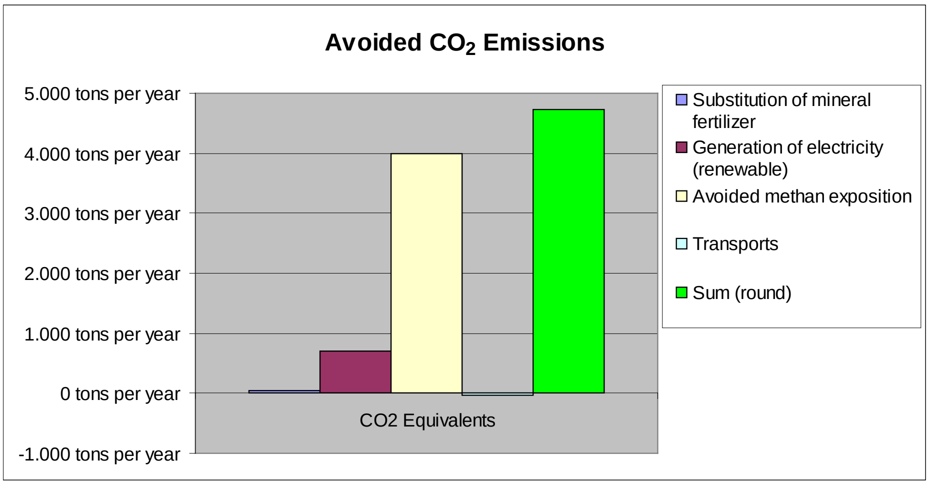

Fig. 4 Avoided CO_2-Emissions of the Demonstration Plant

Further steps

Next steps will be as follows:

- Finalisation of the operator model
- Preparation of tender documents
- Tendering
- Construction
- Capacity Building and operation